MIMWEP | Flintshire County Council

Mynydd Isa Campus, Flintshire

Energy Assessment and Environmental Strategy

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Contents

1 Introduction

This report is intended to provide Environmental Strategy support for the proposed Mynydd Isa Campus school, Flintshire. This report is written for MIMWEP stage 1 (corresponding to Stage 2 of the RIBA Plan of Works).

Figure 1 – Site Layout Option – Sketch plan

1.1 Project Description

The proposed site for the new Mynydd Isa Campus project is located on the grounds of the existing Argoed High School in the village of Mynydd Isa, Flintshire.

Mynydd Isa campus will consist of a nursey, primary and secondary school with SEN facilities.

The proposed building is generally two storey, it is shallow plan in nature with a central spine with protruding 'fingers'. This building form will maximise natural ventilation and daylight while achieving the client's adjacency requirements.

The new school campus is based on approximately 10,300m^2 gross internal area and will accommodate 1,400 pupils of various ages. The proposed building will accommodate Art, Food Technology, ICT, Science, Music and general classroom spaces.

Figure 2 – School Sample Floor Layout

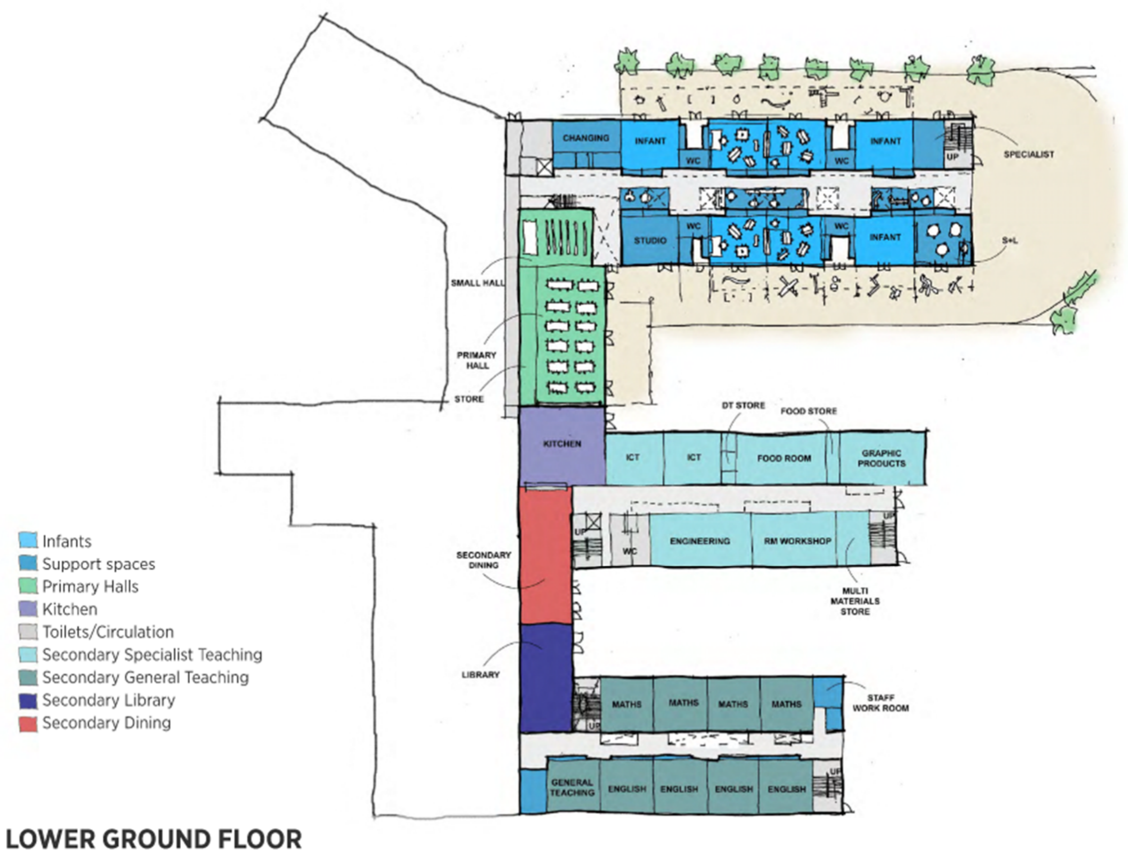


Figure 3 –School Sample Floor Layout

1.2 Project Aspirations

The Client and Project Team have the following aspirations:

- Provide a functional and comfortable environment for both students, visitors and staff alike.
- Provide a sustainable development and achieve a BREEAM Excellent rating under the 2018 Education assessment.
- Recognising the energy usage of the facility, review and adopt practical energy efficient solutions across all MEP systems in order to minimise operational energy consumption and achieve the energy targets outlined in the Core Energy Hours (CEH) metric.
- There is a project aspiration that goes beyond the base build design in order to demonstrate achievement of net zero carbon in operation. This report is written on the basis of achieving NZC in operation..

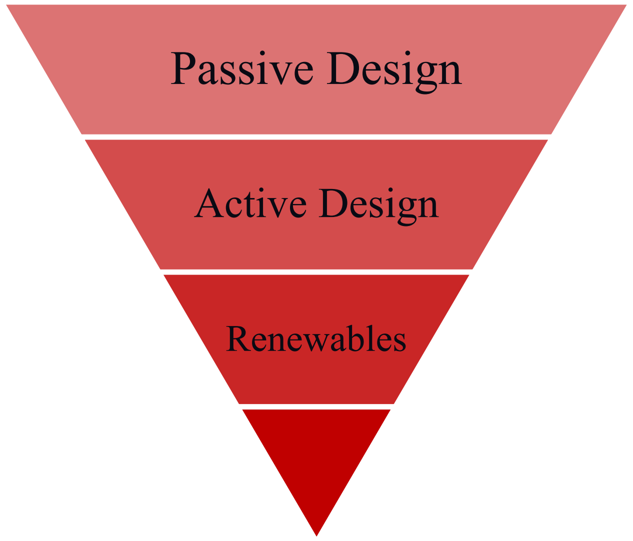
1.3 Basis of the Report

The information in this report is based on Architectural plants received on the 19th of February 2021 including feedback from discussions with the Welsh Government Technical Advisor Team.

2 Sustainability & Low Energy Design

In order to minimise the buildings overall energy usage and CO_2 emissions a three-stage approach has been adopted to the design of the schools and their associated systems. The three stages are:

1. Passive design – reduce the need for energy
2. Active Design - supply energy efficiently and recover energy wherever practical
3. Use of renewable technologies



2.1 Passive Design

The passive design stage is crucial in helping to achieve a low energy building as it looks to reduce the need for energy to be generated in the first instance. During the early stages of design development, close attention was paid to co-ordinating and integrating the structure and the occupied areas to:

- Minimise internal areas requiring mechanical ventilation.
- Minimise direct solar gain to reduce unwanted overheating.
- Maximise daylight factors in all areas.
- Maximise utilisation of plant and systems.
- Maximise control and flexibility of the installations.
- Improve the performance of the building thermal envelope (reducing fabric u-values and glazing g-values).
- Reduce air permeability.
- Maximise the potential to use the mass of the structure to reduce potential overheating particularly in naturally ventilated spaces and provide a thermal damper to help stabilise conditions throughout the building.

A full parametric study was undertaken to fully understand the effect of changing various parameters on the building. A full description of the analysis and outcomes can be found in this report. The parametric analysis studied the effects of changing the following input parameters;

- the window to wall ratio,
- external wall u-value,
- glazing u-value,
- glazing g-value,
- air permeability of the building envelope, and
- thermal mass.

Every possible combination of inputs was simulated leading to a total of 729 independent energy simulations. Each design option was measured on its resulting energy consumption and tendency for overheating classrooms.

The key findings of the study are as follows: -

- The dominant input variable influencing energy consumption in this assessment is the air permeability of the building envelope. Increasing the air permeability is strongly correlated with increases in energy consumption.
- Higher glazing u-value, and to a lesser extent the wall u-value, increase energy consumption.
- Decreasing the window to wall ratio, g-value and thermal mass result in higher energy consumption.
- Window to wall ratio and thermal mass have the largest influence on overheating. A larger glazed area and lower thermal mass correlate with more occupied hours exceeding 28°C.
- Decreasing the g-value and increasing the air permeability reduce the tendency to overheat.
- External wall and glazing u-values have a negligible impact on the likelihood of overheating within the classrooms.

2.2 Active Design

Systems that allow the generation and delivery of energy in an efficient way have been incorporated, strategies include:

- High efficiency lighting systems.
- Use of LED lighting
- Lighting controls with perimeter areas switched separately from internal areas possibly with daylight linking.
- Absence detection for lighting control rather than presence detection.
- Low velocity pipework and ductwork where possible to reduce fan and pump power consumption.
- High efficiency motors with variable speed drives.
- Specification of high-performance MEP plant where required.

- Local control of heating systems to prevent overheating.
- Equipment will be zoned in such a way as to allow plant to be turned off or enable out of hours setback in appropriate unoccupied spaces.
- Heat recovery systems on mechanical ventilation systems. Heat recovery sources will be considered during the next design stage to recover heat from ICT servers/transformers/catering equipment etc. This will also consider advantages of recovering heat against acoustic, fire and contributing to overheating in summer modes. An exercise will be undertaken to prove that they are economically viable.
- Separate metering on power and lighting systems.
- Central building management control system (BMS) with monitoring of key system parameters.

2.3 Use of Renewable Technologies

The final stage is then to review and assess the potential benefits that would be realised through the integration of Low and Zero Carbon (LZC) technologies into the building. Separate studies looking at the potential use of LZC technologies have been produced. The report in Appendix A outline the practicality and benefits realised from technologies such as those listed below.

- Solar Photovoltaic electrical generation
- Solar Thermal
- Combined Heat & Power
- Ground Source Heat Pumps
- Air Source Heat pumps
- Biomass Boilers
- Wind turbines
- Battery storage

Air source heat pumps (ASHPs) and a photovoltaic (PV) array were found to be the most beneficial systems at this stage. Since the removal of the renewable heat incentives for ASHPs, the technology was not found to pay back financially under the current electricity tariffs, they do however have a significant effect on reducing CO_2 emissions due to their favourable coefficient of performance. It is likely that the cost factors used for analysing this performance will change in the future as the Government looks to decarbonise the grid and potentially introduce financial penalties against fossil fuel usage.

The photovoltaic array required to achieve net zero carbon (NZC) is likely to be substantial in size for this project and will likely occupy a large percentage of the roof space. Refer to separate Arup LZC Technologies report in Appendix A for further information on the use of renewable technologies.

2.4 Building Zoning

It is anticipated that the engineering services installations will be fully zoned for the individual spaces contained within the building. Design solutions will be chosen, incorporating the capital and revenue expenditure, together with the operational considerations, with energy recovery and general energy conservation being paramount.

Sub metering of all major services to each area/function will be required as described in the Building Regulations and that this will be interfaced with the site Building Management System (BMS) as appropriate.

2.5 Water Efficiency Plan

There is an environmental and carbon footprint associated with potable water consumption, this is attributed to the energy and resources that are required to extract, treat, and pump this water from its source to where it is needed.

The first priority is to reduce the demand for water through the use of water economic fittings and fixtures, the second is to match demand to use. Not all uses require water to drinking standards and some demands can be met using rainwater or greywater, depending on its quality.

To meet the BREEAM requirements, the following demand management and water efficiency measures will be considered to develop a water conservation strategy that is sustainable and reduces the economic, environmental and social impacts of developing water sources and waste stream discharges:

- Match non-potable supply to non-potable demand
- Consider supply of water from local sources
- Conservation measures e.g. WCs with low water volume dual flush cisterns, low water use appliances and fittings, flow restrictors, automated supply shut-off where practical
- Rainwater harvesting
- Grey water re-cycling
- Management of water consumption through metering & monitoring via the BMS – such as leak identification

As defined in the Civils report, a hierarchical approach has been used to define the storm water drainage strategy for the proposed development's runoff in compliance with 'Statutory standards for sustainable drainage systems - designing, constructing, operating and maintaining surface water drainage systems 2018'.

Demand for WC flushing is distributed around the building and the efficiency of the additional RWH system requirements are not considered as financially feasible with other civils measures detailed and discussed with FCC to meet the requirements

Grey water heat recovery has been discounted due to the limited hot water demand within the building.

3 BREEAM

3.1 Building Research Establishment Environmental Assessment Method

In line with the Client's requirements both schools will be assessed for their sustainability using the Building Research Establishment Environmental Assessment Method (BREEAM).

BREEAM is the BRE (Building Research Establishment) Environmental Assessment Method which has a number of different schemes for differing building types.

Building projects are assessed at the design and post-construction stages using a system of environmental issues grouped within the following categories: Management, Health and Well Being, Energy, Transport, Water, Materials, Waste, Land Use and Ecology, and Pollution.

3.2 BREEAM Pre-Assessment

A BREEAM pre-assessment workshop has been held to set out the scoring strategy to achieve a rating of Excellent under both the Baseline and the Net Zero Carbon scenarios. Refer to Appendix B for further detail.

The *Baseline* scenario identifies credits which are expected to be achieved through compliance with the project brief or those which provide to most cost-efficient scoring uplift.

The *Net Zero Carbon* scenario reflects the baseline score, but with additional Energy and Materials credits resulting from studies and performance associated with achieving net zero.

The *Potential* scenario identifies credits which could feasibly be achieved by the project, but which are likely to result in additional cost uplift and/or Contractor risk, or where current site information (e.g. Pol 03 Surface Water Run-off) is insufficient for these credits to robustly sit in the baseline scenario.

The baseline and potential credits should also be reviewed by relevant specialists to ensure that the scoring strategy is robust and feasible, and to identify any opportunities for scoring uplift. A scoring margin of 5% over the required rating threshold should be targeted and maintained.

The table below provides an overview of target scoring. A full breakdown of credits, as well as key issues, early warnings and risks, is provided in the BREEAM Pre-Assessment Report in Annex F.

Baseline	**Net Zero Carbon**	**Potential**
73.18%	82.80%	90.08%
Excellent	Excellent	Outstanding

Workshops (passive design and materials & waste) have been held to ensure that the team are aware of Stage 1 (RIBA Stage 2) time-bound deliverables and to ensure that the BREEAM assessment is closely coordinated with the Net Zero Carbon design approach

3.2.1 Next Steps

The team have incorporated the necessary requirements into the Stage 1 design proposals and compile the necessary documentation to sign off early stage BREEAM deliverables.

Optioneering has been undertaken to ensure that embodied carbon is considered in the selection of frame and external wall materials, alongside other factors affecting decision-making, and this process will contribute to the award of Mat 01 credits at Stage 1.

A number of credit requirements need to be reviewed by specialist consultants, and early actions taken, to ensure that the targeted credits are achievable and that any necessary early actions are taken. Credits identified as 'potential' should be reviewed and, where possible (particularly those which are considered to be cost-neutral), moved into the baseline target scenario in order to increase the scoring margins over the required thresholds.

A score of >75% (for Excellent) should be targeted at the design stage submission in order to protect the final score at completion against the potential loss of credits during design development, construction and auditing.

4

4 Initial Energy Modelling

Initial models have been developed from the preliminary layouts provided by the Architects. Analysis has taken place in various software packages, including IES:VE, Rhino/Grasshopper and Radiance. At this stage of development with the building design going through rapid changes in development several small models have been developed to best test trends that will be evaluated further in due course.

The modelling will be progressed into a full building model during the next stage of design to include a full energy prediction model and an assessment of compliance against other competing energy targets (such as BREEAM ENE01 and Part L Compliance).

4.1 Assessments

4.1.1 Energy Categorisation

Figure 4 - Preliminary Energy Categorisation – Basebuild

By conducting an early estimate of energy demands (over a simulated year) as shown in Figure 4, this should assist in design development by ensuring a key focus on each of the categories and subsequently aiming to reduce energy consumption in each.

4.1.2 Passive Design

The approach to passive design at Mynydd Isa is discussed in more detail in Appendix C, however to reiterate that the modelling has supported the development of several aspects of the design, including (but not limited to):

- Building layout and form
  - Leading to the consistent alignment of the fingers so that glazing treatment can be similar for each.
- Orientation
  - By locating adjacent spaces to the West (e.g. assembly hall and sports hall) this minimises the need for any teaching spaces to be West facing which are locations that traditionally struggle with low sun angle glare and overheating.
- Microclimate
  - Assessment of the local weather conditions indicates the prevailing winds are from North to South, which aligns closely with the fingers. This could cause issues with cross flow ventilation through roof cowls so will be developed in the next design stage.

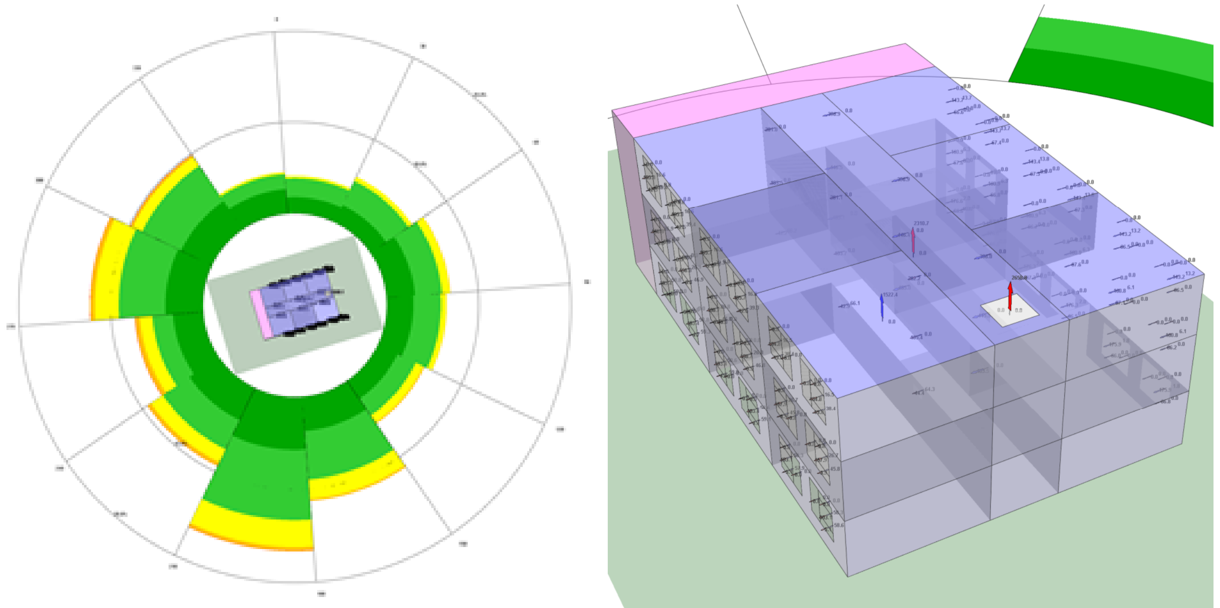


Figure 5 - Wind Rose for Mynydd Isa & Initial Comfort Model Testing

4.1.2.1 Daylighting

Passive design of daylighting has been prioritised initially to reduce the requirement for artificial lighting and reduce energy consumption. This has been a result of climate-based daylight modelling (CBDM), using the Useful Daylight Index (UDI) metric. Design utilising CBDM ensures that optimum levels of daylight are achieved.

An early assessment of the building has indicated that the overall building form and split fingers approach is yielding spaces that are likely to comply with the UDI limits prescribed for the project. The daylighting scheme will be developed continually as the design progresses. Refer to section 7 and Appendix D for further detail.

4.1.2.2 Parametric Modelling

A parametric energy & comfort model was conducted for a single finger of the building. Further details are available in Section 5.

A parametric model has major advantages over iterative modelling as multiple parameters can be tested in combination. This approach is computationally intensive, but once all models have been run it is possible to identify trends, data outliers and competing goals which allow the design to be shaped to maximise energy and thermal comfort.

This analysis shall be shaped further as the design progresses.

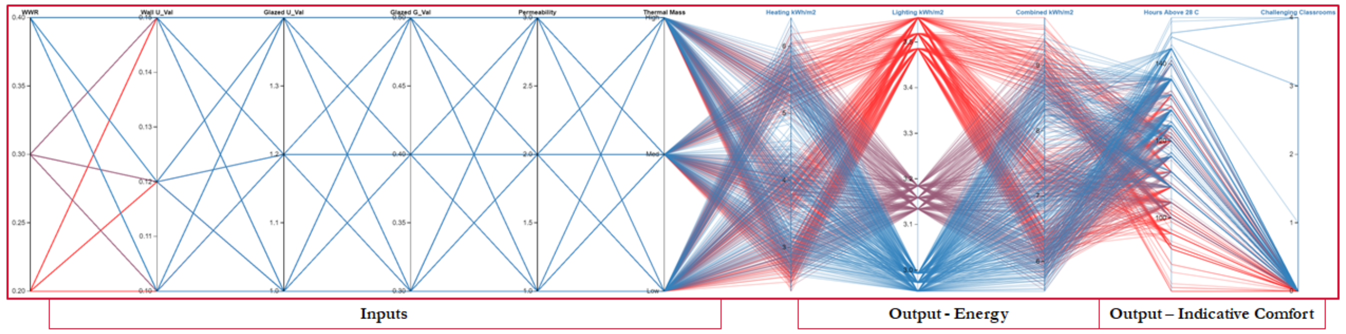


Figure 6 - Parametric Analysis Results

4.1.3 Active Design

4.1.3.1 Ventilation

Thermal modelling was conducted to input into the ventilation selection for the typical classrooms discussed in Annex E MEP Section 1.

4.1.4 Renewables / Low Zero Carbon Technologies

As discussed in section 2.3 of this report, further detail on the renewable/LZC technologies considered is presented in Appendix A.

4.2 Initial Specification

An initial specification for both the basebuild and Net Zero Carbon design options has been created and is presented in Table 1. Further development shall hone these figures in the next design stage.

Table 1 - Initial Mynydd Isa Design Specification and Energy Consumption

	Attribute Detail:	Basebuild Design	NZC Design
U-value (W/m².K)	**Roof**	0.15	0.10
	Wall	0.15	0.10
	Ground	0.15	0.10
	Windows (inc frame)	1.4 (Double glazed)	1 (Triple glazed)
	Window to wall ratio	Circa 30% (including frame)	
	Air permeability ($m^3/(m^2.hr)$ @50Pa)	3	1
	Thermal mass	Medium	
	Primary heating system	Gas Boiler	Electric Heat Pump
	DHW heating	Electric Point of Use	Electric Heat Pump for shower and catering Electric Point of Use elsewhere
	Ventilation - Winter	Mechanical Ventilation with Heat Recycling (NVHR)	Mechanical Ventilation with Heat Recovery (MVHR)
	Ventilation - Summer	Cross flow natural ventilation	Cross flow natural ventilation
	Lighting	High efficiency LED Fittings	
	Lighting control	Auto on-off - 'unowned spaces' 'Manual on-auto off' plus daylight dimming in main occupied spaces	
	Renewables contribution	PV Circa 600-1,000m²	PV Circa 3,000-3,400m²
	Energy Consumption:		
kWh/year	**Gas Consumption**	206,000*	0*
	Electricity Consumption	448,050	412,000
	Electricity Generation	72,000	408,000

*excluding science lab and food room usage, better understanding of lessons required to quantify

4.3 Next Steps

In terms of modelling, the next steps that shall occur moving into the next design stage are:

- Development of a full energy prediction model (i.e. following CIBSE TM:54 with additional detailing as necessary to meet project brief).
- Pareto analysis of building fabric (expansion of the parametric modelling).

5 Parametric Modelling

A detailed parametric analysis studying the effects of adjusting the window to wall ratio, wall U-value, glazing U-value, glazing g-value, building envelope infiltration, and thermal mass. For each set of possible inputs, the resulting implications on energy consumption (both heating and lighting) and tendency for classrooms to overheat has been reported.

5.1.1 Case Study Geometry

A sample section of the building has been chosen to form the basis of the parametric analysis. Using only a sample of the building was necessary to reduce model complexity and hence simulation time. However, due to the modular nature of the initial design, it is expected that the analysed building section would be representative of all North/South facing classroom areas.

This sample section represents a single two-storey 'finger' with a set of eight 7.7m by 7.8m classrooms per storey with a central 4m width corridor. The geometry modelled in Rhino is shown in *Figure 8*. The western surfaces have been modelled as 'adiabatic' to model the fact that these surfaces will be internal walls, adjacent to spaces at similar temperatures.

Note that this geometry is intended to be an approximation of the intended design that is generalised enough to be resilient to future architectural changes, but specific enough to be representative of the eventual building performance.

5.1.2 Baseline Assumptions

The following model properties are consistent across every parametric simulation. These model inputs are not considered as design variables and are specific to classroom spaces.

The classrooms are assumed to be occupied from 9am to 4pm with a 1-hour break for lunch. During this occupied period, internal heat gains are produced by the occupants, lighting, and electrical equipment. The holiday schedule associated with the academic term calendar for 2021 has been implemented. The building is not occupied or heated during holiday periods.

The building is modelled with a heating setpoint of 19°C on schooldays with a night-time setback temperature of 12°C. The building is assumed to have no mechanical cooling or mechanical ventilation. It will be cooled via openable windows when the internal temperature exceeds 22°C. The openable area is consistent across all simulations regardless of the glazed area.

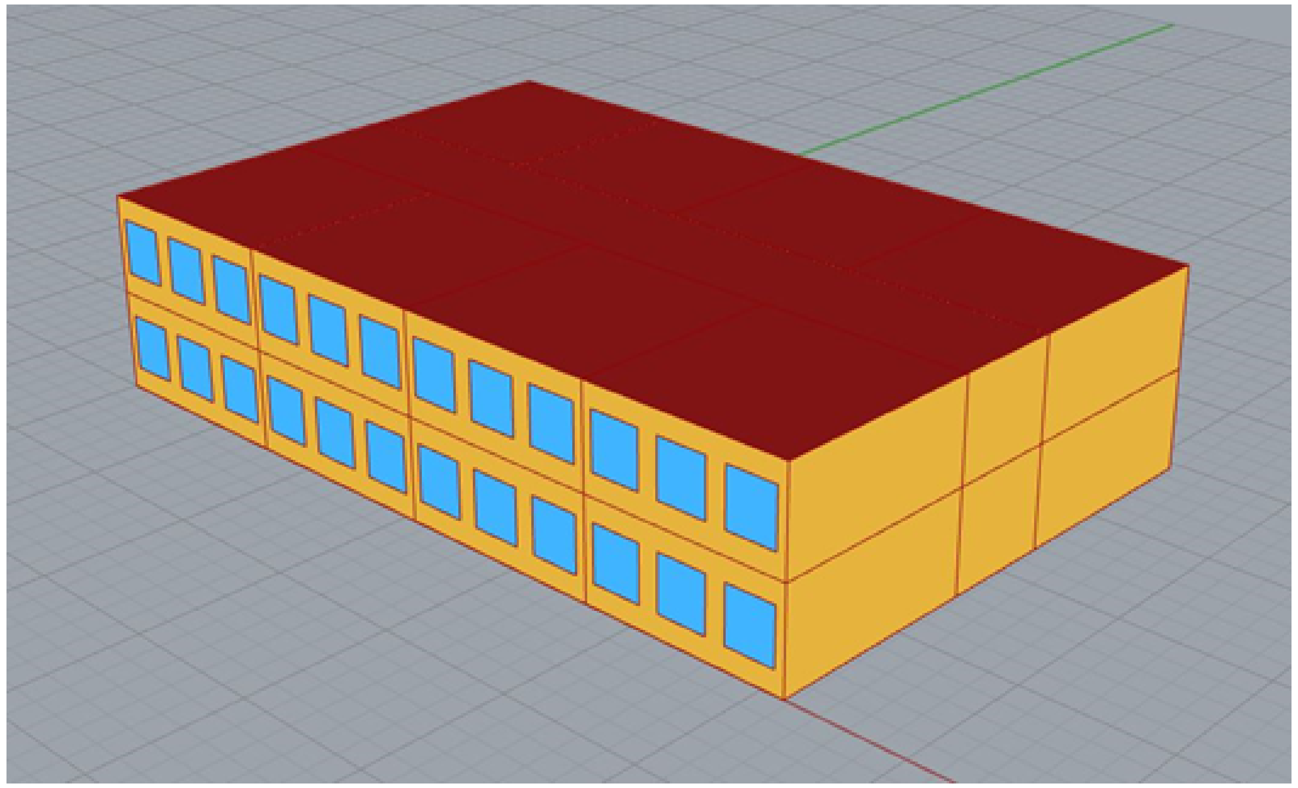


Figure 7 - Sample geometry for parametric analysis modelled in Rhino

5.1.3 Parametric Inputs

Where available, the minimum design requirements outlined in the ACR's have been modelled as the base parametric input. The effect of improving upon these minimum design criteria can then be assessed. The range of possible inputs is given in *Table 2*.

Table 2 – Parametric Inputs

Parameter	Input 1 Value	Input 2 Value	Input 3 Value
Window to Wall Ratio	**20%**	**30%**	**40%**
Wall U Value (W/m^2K)	**0.15**	**0.12**	**0.10**
Glazing U Value (W/ m^2K)	**1.40**	**1.20**	**1.00**
Glazing G Value (-)	**0.5**	**0.4**	**0.3**
Air Permeability ($m^3/m^2.hr$ @ 50Pa)	**3**	**2**	**1**
Thermal Mass (-)	**High***	**Medium***	**Low***

* Thermal mass is altered by changing the internal floor slab construction: High – concrete slab, Medium – concrete plank, Low – CLT.

Every combination of the parameter inputs listed above has been simulated, resulting in a total of 729 independent energy simulations.

5.1.4 Outcome

Assessing the effect of single parameters alone is challenging as the outcomes are likely to be dependent on combinations of inputs. For example, the glazing U value is likely to become more important when the window to wall ratio is higher. Therefore, reviewing results in their totality is likely to yield greater understanding. The entirety of the results can be viewed and dynamically interacted with at the following link:

http://tt-acm.github.io/DesignExplorer/?ID=BL_3dLxD63

However, to give an indication of the general implications of each parameter, the linear correlation between the individual parametric inputs and the objective outputs (energy consumption and hours over 28°C) are given in the sections below.

A positive correlation suggests that as the input increases, so does the output. A negative correlation suggests that as the input increases the output decreases. A value closer to the extremes (1 or -1) indicates a strong correlation, meaning the variables are closely linked. A value closer to 0 indicates the input variable has little effect on the output.

5.1.4.1 Energy Consumption

As shown in *Figure 8*, the dominant input parameter is the air permeability of the external envelope. The strong positive correlation shows that as the permeability increases, the energy consumption increases proportionally with it. To a much lesser extent, increasing the wall and glazing U values (lowering performance) also increases energy consumption.

Increasing the window to wall ratio and the glazing G value will increase the solar gains to the space and hence reduce the heating required to the space. Therefore, we see a negative correlation. The thermal mass also has a negative correlation with energy consumption, showing that solutions with a higher thermal mass are likely to reduce energy consumption. This is likely caused by a greater retention of internal temperature overnight which reduces the heat energy required to warm the space the following morning.

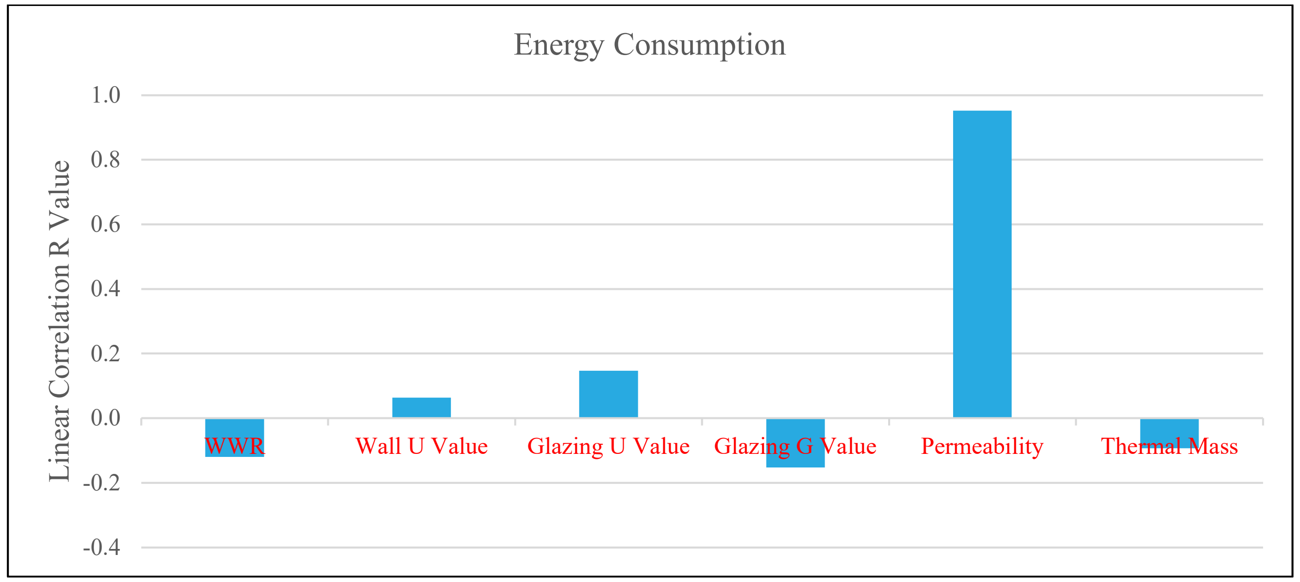


Figure 8 - Linear correlation between input parameters and energy consumption

5.1.4.2 Overheating Tendency

The output to measure the tendency to overheat is the sum total number of occupied hours where a classroom is above 28°C. The outcome of the analysis is shown in *Figure 9*.

For this objective, the results demonstrate that the two most important inputs are the window to wall ratio and the thermal mass. The window to wall ratio has a strong positive correlation, suggesting that an increased glazed area increases the number of hours over 28°C. Whereas there is a strong negative correlation between thermal mass and overheating hours, demonstrating that high thermal mass solutions lead to lower overheating.

Inputs of secondary importance are the glazing G value and the air permeability. Higher G values allow higher solar gains and hence increase the tendency to overheat. A more permeable thermal envelope introduces larger quantities of cooler outdoor air and hence reduces the number of overheating hours.

Wall and glazing U values are shown to have a negligible effect on the tendency for classrooms to overheat in this analysis.

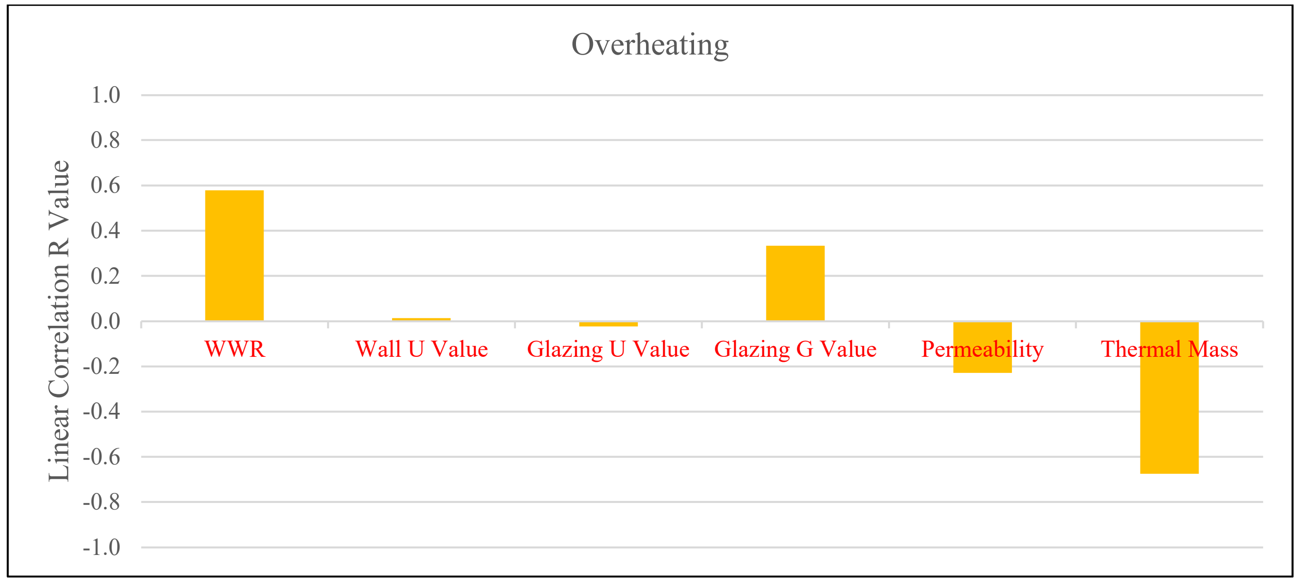


Figure 9 - Linear correlation between input parameters and classroom overheating

5.1.5 Summary

The exhaustive number of simulations aim to guide the decision-making process by demonstrating the most important features with regard to energy consumption and overheating. This analysis suggests that the air tightness / envelope permeability is the most important variable when considering energy consumption. Higher infiltration leads to a near linear increase in the energy consumption required. To minimise the potential for overheating, a higher thermal mass is beneficial as is a lower window to wall ratio and lower glazing G value.

This analysis only aims to measure outcomes related to heating and lighting energy consumption, and tendency to overheat. Therefore, this parametric study should be read in conjunction with analysis around the most appropriate façade design from a daylighting perspective, optioneering around the ventilation strategy from both an energy and indoor air quality perspective, and cost implications of the various parametric inputs. The resulting design outcome should be an appropriate trade-off between these conflicting objectives (such as in the example pareto graph in *Figure 10*). This analysis shall be expanded upon in the next design stage.

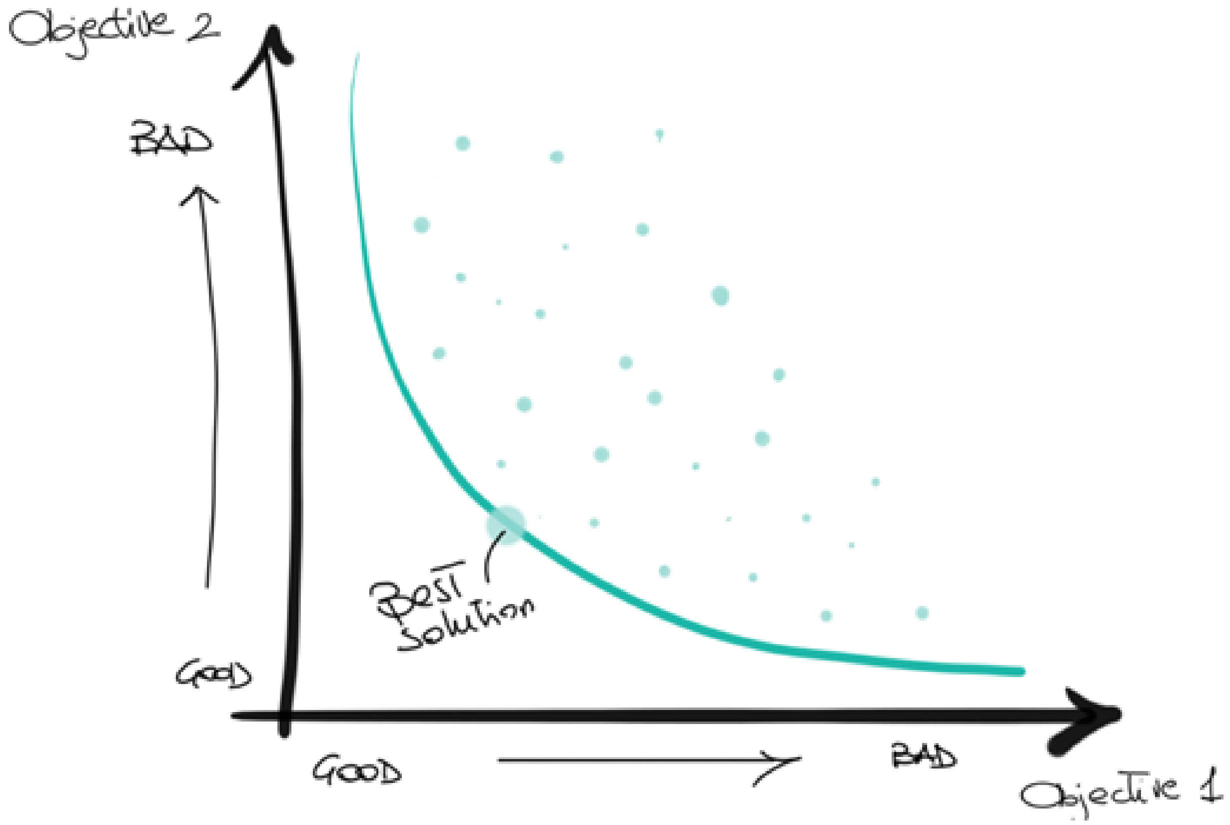


Figure 10 - Pareto graph example

6 Control and Metering

As detailed in Annex E, the Building Management and Energy Metering strategy proposed shall be developed based on the outline strategy.

6.1 Building Management System

A Building Management Systems (BMS) will be provided to control and monitor the school's ventilation, heating, cooling and electrical systems. All control functions will be performed by direct digital control (DDC) technology with the exception of safety and fire / fireman's override interlocks which will be hardwired. The BMS will include standard features such as alarm logging, trend logging, optimum start and fault reporting.

A single manufacturer's system will control and monitor the mechanical/electrical systems with all data points mapped back to a windows based personal computer (PC) in a location to be confirmed, for interrogation and monitoring by an operator. The backbone for the controls system should be based on a reputable controls manufacturer to prevent systems becoming obsolete over time. A PC complete with visual display unit (VDU) keyboard and mouse will form an operator's station. This will enable an operator access to the system for viewing plant operation, monitoring, set point adjustment, modifying controller software, alarm handling, trend logging, and historical data storage. The operator's station will be simple to use and highlight the basic functions of the building.

Mechanical / Electrical systems connected to the BMS system will include the following:

- Incoming mains cold water utility meter(s)
- Incoming mains gas utility meter(s)
- Gas safety interlock(s)
- Incoming electrical supply utility meter(s)
- Electrical sub-metering
- PV export meter
- Heat metering
- Domestic hot and cold-water services
- Heating plant
- Heating distribution systems
- Mechanical ventilation systems
- Natural ventilation systems
- Fire/smoke damper interface
- Cooling systems
- Security interface
- Fire alarm interface
- Fire Operation

The BMS will incorporate the normal "fireman's control panel" to provide the fire service with full control of the ventilation plant. This will include the facility to reset any compartment smoke dampers within the ventilation systems.

The BMS will monitor the hours run for the fans and pumps enabled from the BMS. This information will be available at the BMS supervisor. A maintenance interval (adjustable) will be set-up for each common plant type and when a plant has exceeded this maintenance interval, an alarm will be raised by the BMS. The hours run accumulator can be reset at any time via a password protected software switch on the BMS.

The BMS will also be provided with energy and water use targeting and monitoring software.

The BMS will be interfaced with the existing Flintshire County Council system over an IP system so that it can be monitored an adjusted remotely.

6.2 Energy Metering

An automated energy data collection system will be utilised to collect and manage energy usage data from the building. The system will interface with the BMS system to collect the following data

Utility Meters

Sub-metered data

- Heating energy
- Hot water heating energy
- Cooling energy
- Fan Energy
- Lighting energy
- Small power
- Catering energy
- Energy generated by PV array

Other feedback data

- External temperature/weather
- Internal room temperatures
- Internal CO2 levels
- Heating and domestic water flow and return temperatures

All of the above will be collected on a 30 minute basis, the energy monitoring system will collate and output the data via a k2N portal, this will enable comparison between the projects predicted/targeted energy demands and its actual operational demands. This will allow the building estates team to optimise the building when it is in use as well as detect out of range issues associated with faults with the building.

7 Daylight Strategy

Passive design of daylighting has been prioritised initially to reduce the requirement for artificial lighting and reduce energy consumption. This has been a result of climate-based daylight modelling (CBDM), using the Useful Daylight Index (UDI) metric. Design utilising CBDM ensures that optimum levels of daylight are achieved.

An early assessment of the building has indicated that the overall building form and split fingers approach is yielding spaces that are likely to comply with the UDI limits prescribed for the project. The daylighting scheme will be developed continually as the design progresses. Refer to Appendix D for further detail.

7.1.1 Anticipated Compliance

An initial pass on anticipated daylighting compliance has been completed based on concept design drawings which will be developed in Stage 2.

7.1.1.1 L1 Spaces (Target 80%)

- Good capability to comply. With a range of between 84-98% compliance within those spaces. (Target 80%)

7.1.1.2 L2 Spaces (Target 75%)

- Currently approx. 44% compliance; could be possible to achieve 100% compliance in this category, at the moment we've identified a number of spaces as amber but this is mainly as a result of developing a suitable rooflight strategy. Resolve 3 more spaces to achieve 75% target.
- It is often desirable for schools to let a few of the spaces not achieve. Examples of this are over reliance on rooflights (expense and long term reliability/maintenance requirements) but the biggest reason is when looking to meet blackout requirements for school performances in halls – to get black out will require horizontal blinds in runners on a cable system. Can result in expensive and difficult to access shades and therefore the majority of schools have looked for to avoid the requirement where possible.
- Sports hall should pass – the standard solution is a rooflight between each badminton court with a diffuse/opaque interlayer (as opposed to clear) for solar control.

7.1.1.3 L3 Spaces (Target 60%)

- Current compliance is 30%, but even if we got all amber spaces to have daylight we can only get to 67%. This is a tricky category and compliance in all these spaces is not a given when the scheme is developed.
- Compliance can be achieved through introduction of rooflights on the upper floors, but this can get very expensive, increase long term maintenance reliability. Glare can be difficult to control, but normally our solution is a relatively small punched rooflight set in a ceiling void with diffuse interlayer to capture direct sunlight and reduce direct visibility of the diffuse glass.

7.1.2 Clarification

There are a couple of anomalies in the ADS classification requiring clarification:

- Primary dining store is L2 – this is usually where they keep the tables and chairs when the hall is not being used for dining – should it be L4?
- Science/food/multi-mat preps are all L4 – typically L3 but L1 for science as there is someone in there all day, so recommend providing windows in those spaces.

Appendix A

Low and Zero Carbon (LZC)
Technologies Assessment

MIMWEP | Flintshire County Council

Mynydd Isa Campus, Flintshire

Annex F - Low and Zero Carbon Technologies Assessment

Stage 1 Issue | 8 March 2021

Job number 280340-00

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Contents

Tables

Figures

1 Executive Summary

The Low and Zero Carbon (LZC) report is an early stage indicator and high-level assessment of possible technologies that have been considered suitable for the development of the new Mynydd Isa Campus.

This report has considered the use of a number of LZC technologies (shown in *Table 1*) as part of the overall energy strategy for the proposed development. In each case the feasibility has been assessed in terms of energy produced; cost; payback period (simple and life cycle); carbon savings and logistics including site constraints. Grey water heat recovery and batteries are also discussed.

Table 1 - Comparison of LZC Technologies. A positive Life Cycle Saving means money saved compared to a similar non-LZC Technology

Technology	Recommended?	Annual Energy Generated	Annual CO2 saved	Simple Payback	Life Cycle Saving	£ per tCO2 saved
		(kWh)	(tonnes)	(years)	(30 years)	
Solar Hot Water	No	61,859	11	>30	-£126,364	£606
Biomass	No	190,690	71	>30	-£1,103,019	£177
Photovoltaic Panels	Yes	309,375	72	8	£2,134,395	£186
Ground Source Heat Pumps	No	624,000	85	>30	-£913,828	£492
Air Source Heat Pumps	Yes	624,000	72	>30	-£1,025,506	£494
Wind Turbine	No	100,887	24	11	£828,872	£242
Combined Heat & Power	No	149,760	None	12	£95,602	None
Small scale Hydropower	No	192,192	45	4	£1,793,427	£150

1.1 Summary and Recommendations

Many of the technologies considered have been discounted. For the Mynydd Isa Campus, it is recommended to proceed with Photovoltaic Panels (PV) and Air Source Heat Pumps (ASHP) to provide an efficient method of heating energy to the buildings.

2 Introduction

The project is to provide a new English-Medium 3-16 age range campus on the existing Argoed High School site in the village of Mynydd Isa. Mynydd Isa Campus will be accommodate 1,300 Full Time (FT) learners.

Low and Zero Carbon (LZC) technologies can be utilised to lower a buildings overall carbon and energy requirements to enhance their sustainable credentials and to lower a building's running costs. The purpose of this report is to assess a series of LZC technologies and determine their suitability for deployment on the Mynydd Isa Campus.

The report will help to assess the plausibility of achieving Net Zero Carbon and is intended to satisfy the requirements of the BREEAM ENE 04 (LZC Feasibility Study) through completion before RIBA Stage 2.

The following LZC technologies are discussed in detail:

- Solar Hot Water
- Biomass Boiler Systems
- Photovoltaic Panels
- Ground Source Heat Pumps
- Air Source Heat Pumps
- Wind Turbine
- Combined Heat and Power
- Small Scale Hydro Power

Grey water heat recovery has also been assessed.

3 Design Approach

An energy hierarchy with three clear stages has been followed to provide a structured approach to reducing energy consumption of the building, as shown below.

Figure 1 - Energy Hierarchy

Minimizing energy consumption for the new building has been accommodated by driving down energy demand through passive building design and operation techniques prior to focusing on energy efficient plant and controls, in doing so challenging existing conditions and solutions by adopting a design audit to achieve a low carbon building.

- Building form and orientation
- Passive ventilation strategy
- Lighting controls
- Reduced air leakage
- Exposed thermal mass
- Glazing specification
- Increased shading
- Increased insulation
- ***Solar hot water generators***
- ***Air source heat pumps***
- ***Ground source heat pump***
- ***Wind Turbines***
- ***Photovoltaics'***
- ***Biomass boilers***
- ***Hydropower***

The passive design of the building has been developed holistically by the design team to minimise the carbon footprint of the new development and are excluded from the content of this report.

The items highlighted in bold italics, technology options, are discussed further from Section 7 onwards in this report.

4 Site Overview

The geographical location, layout and accessibility of the site are an important consideration in developing the energy strategy. This is owing to requirements and parameters which can be necessary for certain technologies or make one strategy particularly more effective than the other.

4.1 The Site

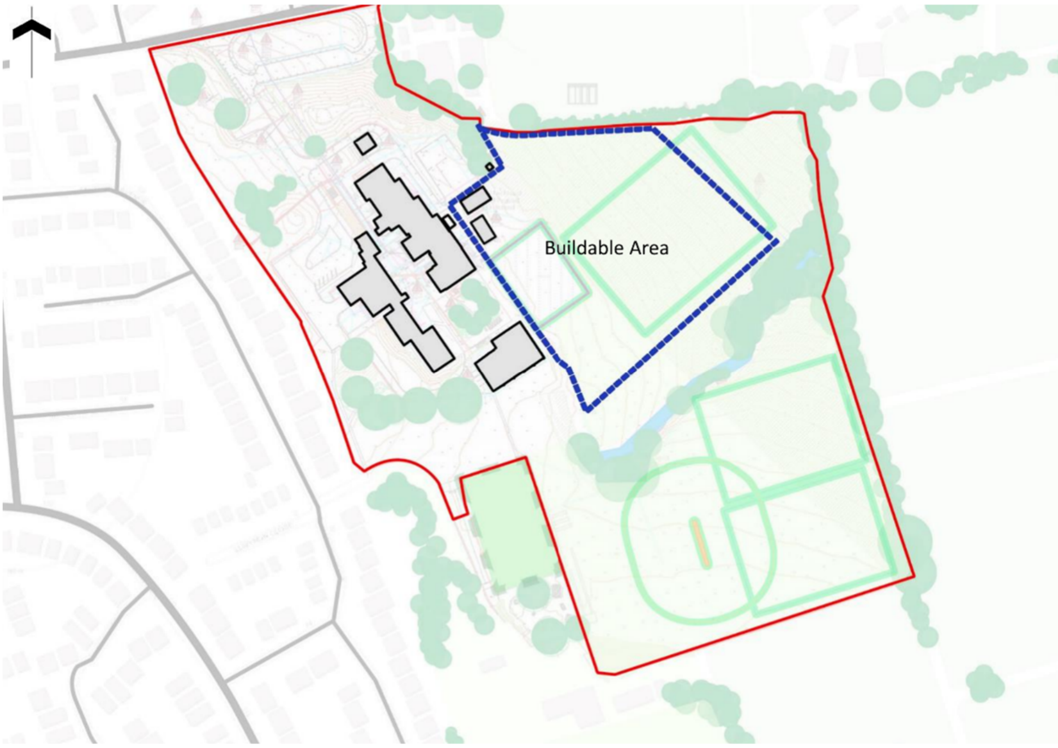

Figure 2 - Site overview showing the buildable area.

A plan view of the site is shown in *Figure 2*. The site consists of the existing Argoed High School which will continue to operate from the site during the construction of the new build.

The site constraints must be taken into consideration when assessing the LZC technologies. The main site constraints are displayed in *Figure 3* and include:

- Existing Coal mines
- Narrow site access
- Underground water pipe
- The existing school still operating

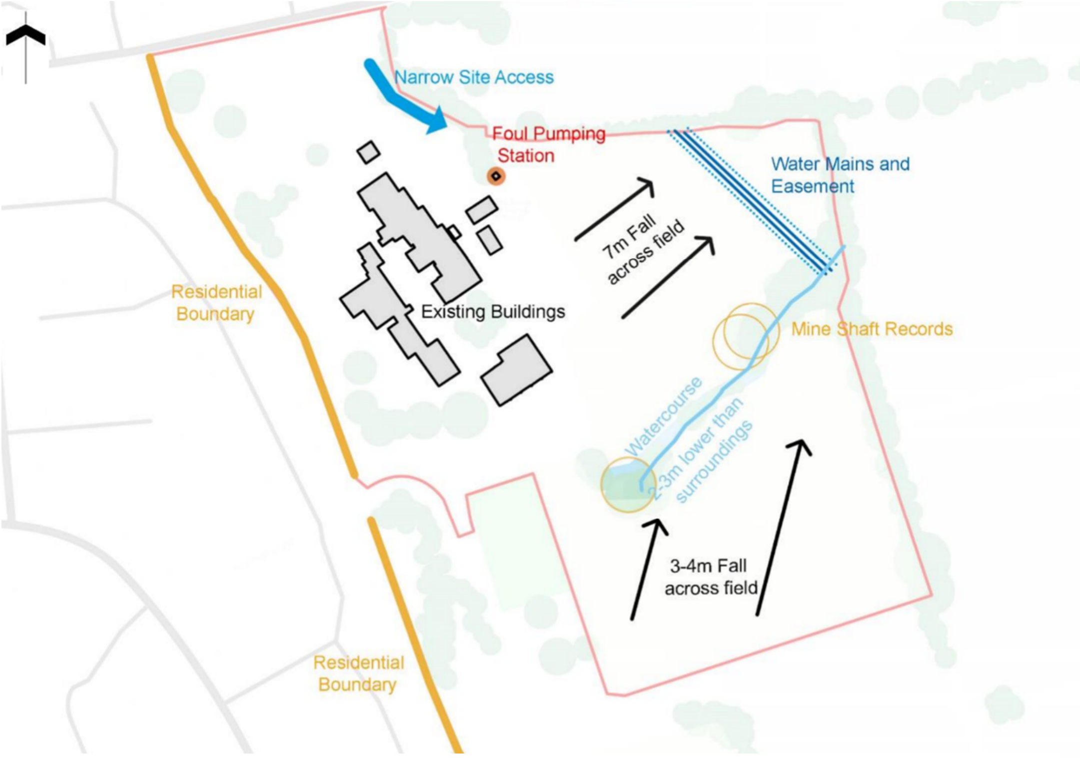

Figure 3 - Site constraints.

4.2 Weather Conditions

The weather is an important variable to consider as many of the LZC technologies rely on or are affected by it. The nearest weather station is in Hawarden, Flintshire. Data is taken from ASHRAE and Met Office climate averages and is summarised in *Table 2*.

Table 2 - Weather Conditions in Hawarden, Flintshire compared to average UK.

	Hawarden	UK
Average temperature (℃)	14	12.2
Average wind speed (mph)	8 mph	-
Annual rainfall (mm)	726.2	1154

5 Feasibility Overview

5.1 Available Incentives

Described below are the incentives available to low and zero carbon technologies.

5.1.1 Important Changes to the Renewable Heat Incentive (RHI) Scheme

There has recently been changes to the renewable heat incentive (RHI) Scheme. After 31st March 2022 the RHI will be discontinued, meaning new projects will not be able to apply. It is unclear whether a new scheme will replace the existing RHI. However, it is expected that the government will not go ahead with a new scheme as the current scheme has shown to not be financially sustainable. For the calculations in this report it is assumed that the RHI scheme will ***not*** be available.

As the National Grid continues to decarbonise, this will promote the electrification of heat as the most efficient way to use electricity for heating. As government polices strive towards a Net Zero future, this creates more potential to incentivise cleaner technologies and penalise traditional burning of fossil fuels. Whilst speculative, it is possible that future schemes will provide financial incentives to utilise renewable technologies.

5.1.2 Renewable Heat Incentive

The RHI is intended to allow individuals, communities and businesses to play their part in reducing CO_2 emissions through the generation of renewable energy. It aims to reduce our use of fossil fuels and increase the use of renewable technologies by proving financial incentives. Participants who install these renewable systems will be paid for the heat that they generate.

Technologies *currently* included in the RHI are:

- Water and ground source heat pumps, and air source heat pumps in heating mode only.
- Solar thermal.
- Biomass or biogas boilers.
- Liquid biofuel boilers only where the biofuel replaces the use of domestic heating oil. The biofuel will need to be certified as renewable.
- Biomass or, biogas CHP.
- Biogas injection into the gas grid.

Heat used to generate electricity, heat used for cooling and useful heat produced by renewable CHP plants are exceptions and are not eligible for the scheme.

5.1.3 Feed in Tariffs

Since April 1st 2019 Feed-in Tariffs (FiTs) have been discontinued.

6 Building Loads

The following section describes how the space heating load, electrical load and domestic hot water (DHW) load have been estimated for the Campus.

These has been based on:

- BSRIA Rule of Thumb
- Previous Arup school design projects (Benchmark data)

For the calculations in this report, the proposed Mynydd Isa Campus development will consist of:

- Total (occupied) floor area estimated at approximately 10,319 m^2.
- 1,300 full time learners.

Table 3 lists a number of schools previously designed by Arup. The energy usage numbers shown for gas and electric fit with targets for kWhe that are required for each particular schools' framework.

Table 3 - Energy usage data for a number of schools. The kWhe/m^2 values are energy targets for each schools framework.

		kWh/m²		kWhe/m²
School	DEC Grade	Gas	Elec	**Total**
Llantwit Major - Primary	B - 47	46	26	**44.4**
Llantwit Major	C - 51	52	30	**50.8**
Llanwern High School	C - 57	31	41	**53.4**
Magor CiW Primary	C - 59	52	35	**55.8**
Cowbridge Comp School	C - 56	35	47	**61**
Newport High School	C - 58	11	67	**71.4**
G2V	C - 68	67	45	**71.8**
Marion Centre	D - 78	99	35	**74.6**
PLC - Main Build	C - 74	97	42	**80.8**
Archbishop McGrath	D - 80	46	69	**87.4**
Ysgol Gymraeg Nant Talwg	D - 83	98	39	**78.2**

The particular target for the Mynydd Isa Campus is 38 kWhe/m^2. This is comparatively low to reflect the aim to be a net zero carbon school. The worst-case scenario to still be compliant with the overall target gives a gas benchmark of 20 kWh/m^2 and an electricity benchmark of 30 kWh/m^2. Assuming the heating load contributes 75% and the DHW load 25% to the overall gas load, the benchmark values are estimated to be the following.

- Electrical load benchmark: 30 kWh/m^2
- Heating load benchmark: 15 kWh/m^2
- DHW load benchmark: 5 kWh/m^2

6.1 Electrical Load

The electrical load is based off the benchmark values from analysing previous school projects as described above.

- Energy benchmark: 30 kWh/m^2

Using the total floor area of the school, an electrical load of **309,570** kWh/year is estimated for Mynydd Isa Campus.

6.2 Heating Load

The heating load is based off the benchmark values from analysing previous school projects as described above. This heating energy benchmark was increased to the following.

- Energy benchmark: 20 kWh/m^2

Using the total floor area of the school, a heating load of **206,380** kWh/year is estimated for Mynydd Isa Campus.

6.3 Domestic Hot Water (DHW) Load

The DHW load is based off BSRIA Rule of Thumb maximum daily hot water consumption values for educational buildings.

- Energy benchmark: 15 l/person

Taking the number of learners (1300) and assuming the school is open for 190 days a year, the school consumes an estimated 3,705,000 l/year. Assuming the water needs to be heated from 10℃ to 60℃, this gives a DHW load of 216,125 kWh/year.

From the investigation into previous schools a DHW benchmark value of 5 kWh/m^2 was given. Using the total floor area of the school, this gives a DHW load of 51,595 kWh/year.

Taking both values into consideration, a domestic hot water load of **175,000** kWh is estimated for Mynydd Isa Campus.

6.4 Final Estimated Energy Load

Building loads for the development have been estimated as:

Annual Electrical Load	kWh/yr	309,570
Annual Hot water Load	kWh/yr	175,000
Annual Space Heating Load	kWh/yr	206,380

6.5 Utility Rates

The following utility rates, based on the DECC quarterly energy prices in December 2020, have been used in any calculations presented:

- Electricity: 15.10 p/kWh (assuming 'small' size band)
- Gas: 2.76 p/kWh (assuming 'small' size band)

It should be noted that gas and electricity prices are subject to variation over time. As such, the actual price at the time of use may vary from the rates presented above. It is anticipated that the client may be able to precure their energy at alternative rates, however, these rates are suitable for comparison use at this stage.

6.6 Carbon Factors

The following carbon factors are taken from the UK Government Conversion Factors for Company Reporting 2020 and have been used in any calculations presented:

- Electricity: 0.233 $kgCO_2/kWh$
- Natural gas: 0.185 $kgCO_2/kWh$
- Biomass: 0.015 $kgCO_2/kWh$

7 Solar Hot Water

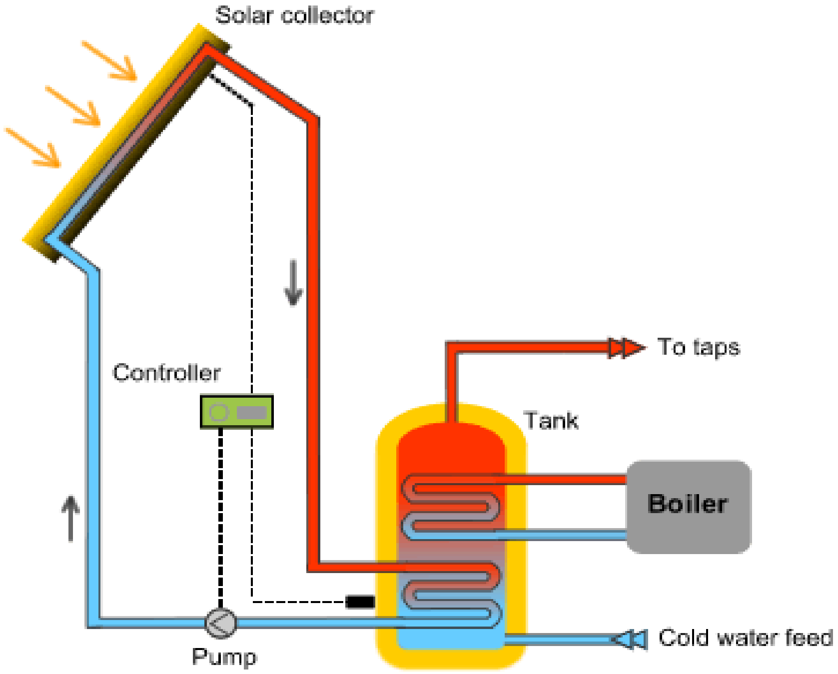

Figure 4 - Example of a typical solar hot water system © Payless Solar System

Solar water heating systems utilise solar collectors to gather solar radiation. The solar energy absorbed by the collectors is most commonly used for the generation of domestic hot water in commercial, industrial and domestic applications.

There are two main types of solar collector, namely:

- Flat plate collector
- Evacuated tube collector

Evacuated tube solar collectors are generally more efficient than flat plate collectors but require additional maintenance.

Solar collectors should, where possible, be mounted on south-facing roofs at an elevation angle of between 10° and 60°.

For the volume of domestic hot water that will be required the most appropriate system will be to integrate the solar water heating system with the main domestic hot water generation plant to provide pre-heating of the incoming cold feed supply via a secondary hot water storage calorifier (or calorifiers). During periods of high solar radiation, the solar water heating system should be capable of providing the majority of domestic hot water with little need for temperature boost from the main storage plant.

Domestic hot water needs to be generated and stored at 60°C - 65°C to eliminate the growth of legionella bacteria. Solar collectors cannot generate water at such temperatures all year round and need to be backed up with low-temperature hot water, oil or gas-fired water heaters/calorifiers.

Plant space for location of pre heat cylinders needs to be provided in close proximity to solar collectors.

7.1 Solar Hot Water Feasibility Assessment

The solar hot water system is generally sized to accommodate the pre heating of the annual domestic hot water load. For the school, this had been estimated at 200.00 m², producing circa 30% of the annual domestic hot water consumption. There is a risk that the system will be oversized in off-peak periods if the system is not sized in this way.

Based on 200m² Solar Panel & Calorifier		
Capital Costs	£900 /m²	£180,000
Fuel Costs	No Fuel Required	-
Operating & Maintenance Costs	£4.5 /m²	£900 per annum
CO2 Reduction Potential	-	11.4 tCO_2 per annum
Offset Gas Saving	2.76 p/kWh	£1707 per annum
RHI Income	0 p/kWh	£0 per annum

Table 4 – Solar Hot Water System Analysis

Once installed, the annual running costs will be governed by the cost of any maintenance or repair work and the circulation pumps. The fuel, solar energy, will be free.

The solar hot water system does not pay back within 30 years. This is compared to a payback time of 26 years if financial incentives are included.

7.2 Solar Hot Water Whole Life Cycle Assessment

Whole life cycle cost analysis for solar hot water has been completed based on net present values, in comparison with full gas heating over a period of 30 years. Financial incentives have not been included in this calculation as the RHI Scheme is not available for this project.

Whole life cycle cost of solar hot water installation is estimated at £879,123 over 30 years versus £752,758 for a high efficiency gas-based system. Therefore, the solar hot water installation can be expected to cost £126,364 more over its 30-year life cycle.

Traditionally, the domestic hot water system sources heat from the building's boiler. For the purpose of calculating payback costs, it is assumed that the boiler is gas-fired. As the boiler will already be installed to meet the heating demand, total installation costs need only account for ancillary equipment and labour.

Whole life cycle carbon emission analysis highlights a reduction of 341 tonnes CO_2 over 30 years.

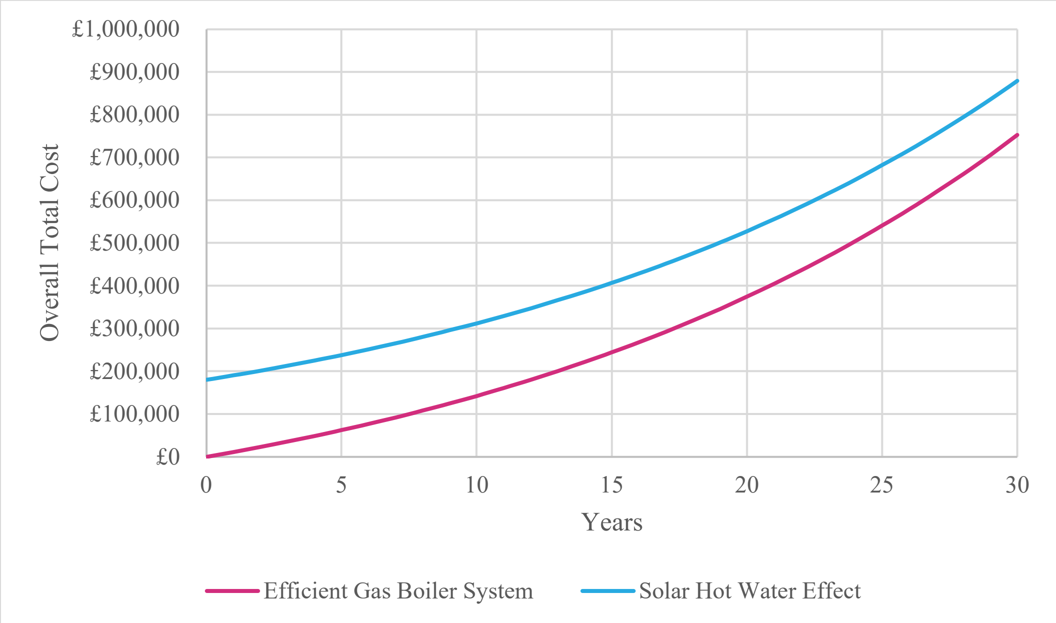

Figure 5 - Solar Hot Water Whole Life Cycle Cost Analysis

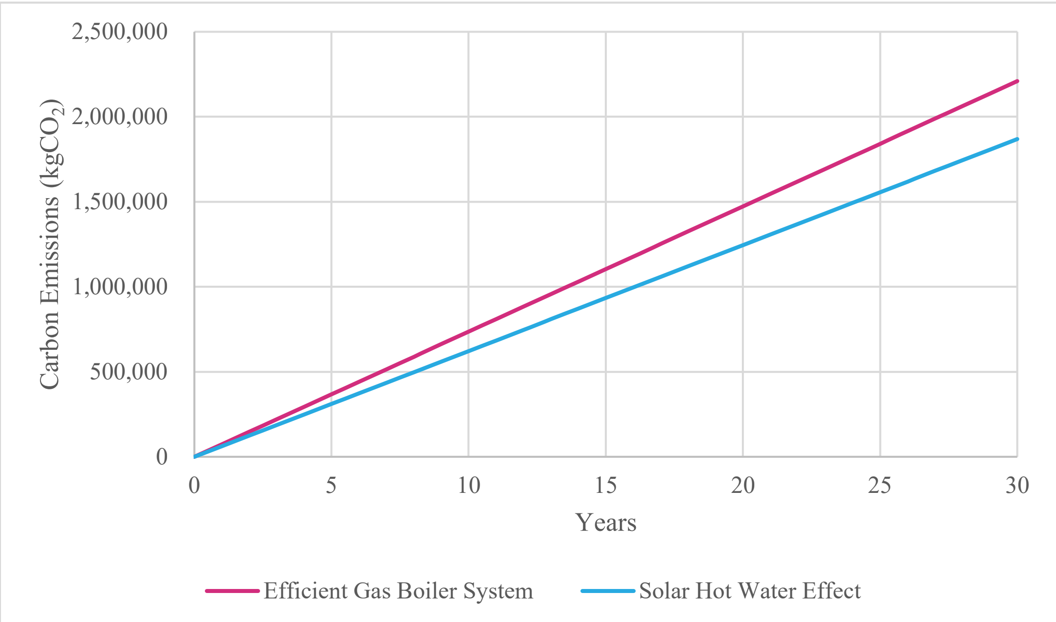

Figure 6 - Solar Hot Water Whole Life Cycle Carbon Analysis

7.3 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction assumptions as detailed in Approved Document Part L2A have been used.

7.3.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a solar hot water system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + (Lifetime * (Fuel\ Cost + Maintenance))}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£606}{Tonne\ CO_2}$$

7.4 Land Use

In order to maximise incident solar radiation, it is normal to locate solar hot water panels on the roof area of a building and to optimise orientation. The location of solar hot water panels will need to be closely coordinated with other low carbon technologies, such as PV and rainwater harvesting.

7.5 Local Planning Requirement

Planning permission would be required due to the visual impact of the panels on the roof.

7.6 Resource Availability

Wales has a reasonable solar resource. This is assumed to be 1100 hours per year for the following calculations. Output can vary in relation to local weather conditions. If roof mounted, this could compete with solar PV for space.

7.7 Environmental Considerations

Air quality: No emissions.

Noise: No noise during operation.

Ground Pollution: None.

Visual impact: Minimal when roof mounted.

7.8 Maintenance

Solar collectors require occasional cleaning, the frequency of which depends on local conditions (air quality, dust, pollen, wildlife, etc.).

Tubes can break, or the seals can fail, and if this happens individual tubes can be easily removed and replaced.

7.9 Recommendations

The domestic hot water demand profile is unlikely to be constant owing to school working hours and summer holiday period. As there is no constant demand, the solar hot water system would either be oversized leading to hot water being stored for long periods of time causing legionella risk, or it would be undersized thus reducing its benefit significantly.

The technology will not be investigated further because of the following reasons:

- Without financial incentives, the solar hot water panels will not pay back over their life time.
- *Figure 5* also shows that the total overall cost is higher compared to an efficient gas boiler system.
- The cost per tonne of CO_2 reduction is also high compared to other technologies.
- The solar hot water collectors will take up space on the roof meaning less PV can be installed.

8 Biomass

Figure 7 - Typical Biomass Boiler and Auger © Hoval

Biomass is the burning of biological matter to produce heat and/or power. Biomass is considered carbon neutral, since the carbon emitted when the fuel is burned is re-established during the growing cycle of new plant material via the process of photosynthesis.

Carbon emissions associated with cultivating, harvesting and transporting biomass need to be considered and minimised, where possible, in order to ensure carbon neutrality.

Capital costs associated with the installation of biomass plant can be high in comparison with traditional gas-fired or oil-fired boilers. These costs are not recovered when compared to traditional gas boilers, however when compared to oil fired boilers the difference in fuel price can recover the capital cost within the lifetime of the boiler system.

8.1.1 Biomass Boiler Advantages

Biomass heating is an effective method of reducing carbon emissions on sites where the heating demand constitutes a high proportion of the site energy demand.

Protection from gas fuel price volatility, as biomass is a relatively stable market.

Reduced exposure to climate-change related legislation; biomass fuels do not register as part of an organisation's overall carbon emissions (or fossil fuel consumption), thus reducing exposure to the Carbon Reduction Commitment (CRC) and the EU Emissions Trading Scheme (EU ETS), if the organisation is subject to these schemes. A biomass heating system can also help organisations to meet their Climate Change Agreements (CCAs) by reducing emissions of greenhouse gases and consumption of fossil fuels.

8.1.2 Biomass Boiler Limitations

Larger plant and energy centre installation means that space and fuel storage is required.

Security of deliveries would need to be addressed with the client setting up a biomass supply contract to ensure plentiful supply.

Quality of biomass fuel; for example, wood chip fuel quality, in terms of moisture content, is more variable than wood pellet and could lead to variable system efficiencies.

Back up fuel/plant is required.

Flue height and filtration; increased capital cost for installation. Odour of wood smoke will be present in the final emissions.

Fuel deliveries and ash removal to be supervised, including periodic ash removal from fire tubes and regular inspections of the boiler, fuel supply and ash removal systems.

8.2 Fuel Type

There are several different bio-fuels available for use. Among these are:

- Wood fuel in the form of wood chip or wood pellets.
- Energy crops.
- Agricultural and forestry residues.

Wood pellets and wood chips are the most commonly used bio-fuels in the UK. The choice of which fuel source to use is project specific and should be investigated in detail to ensure a local, reliable supply is available that can meet the heating demand of the onsite boiler. The relative merits of each fuel source are discussed in more detail in *Table 5,* below.

Measure of Performance	Wood Chip	Wood Pellet
Cost (p/kWh)	3.43	4.38
Energy Density (kWh/m³)	880	3000
Availability	Widely available in Europe & UK	Limited UK supply, widely available in Europe
Use	Wood chips boilers only	Wood chip and wood pellet boilers
Moisture Content (%)	20-50	8-12

Table 5 - Comparison of biomass fuels

Wood pellets are formed by compressing sawdust into regularly sized pellets (6-12mm typically) with a controlled moisture content. The benefit of this procedure is that the energy content per tonne is generally higher than the wood chip alternative. This means that required storage volume is minimised and the quality of fuel is guaranteed.

However, due to the processing costs involved, the cost per unit of energy is higher for wood pellets than for wood chips. Therefore, if there is adequate storage space available onsite (required storage for wood chips at least 3 times that of wood pellets for the same quantity of stored energy), the use of wood chips could prove more cost effective over time. In addition, the availability of wood chip fuel within the UK is significantly more reliable than that of wood pellets.

It is therefore recommended that any decision to proceed with biomass at the campus allows for a boiler that can be fuelled with wood chip (i.e. can take fuel with a moisture content up to 70%) so as not to limit the source of fuel. Since the moisture content of wood pellets is in the region of 10%, this boiler selection would allow the use of either fuel type.

8.3 Operation and Maintenance

The biomass boiler plant can be sized to meet the entire heating demand within a building or can be sized to match the base load with additional top-up from conventional gas-fired boiler plant. The benefits of this mechanism are two-fold. Firstly, running the biomass boiler at full capacity (in this case the base load) is highly recommended since efficiency significantly reduces if the boiler is over-sized. The gas-fired boiler may then be used to meet peak demands in winter months. Secondly, a suitably sized gas-fired boiler provides the system with a degree of redundancy. This can be used to provide a higher proportion (or all) of heat during maintenance to the biomass boiler. It also provides reassurance of heat if, for example, biomass fuel supplies were compromised for any reason in the future.

A compromise is achieved with the installation of a buffer vessel, which will partially absorb peaks, and allow the biomass boiler to be running at high efficiency when the demand is low or inexistent.

Users of biomass systems need to be aware of the increased need for maintenance as compared with traditional boiler systems. A maintenance programme must be in place to clean and remove ash from the boiler to prevent system failures. The supply of fuel also needs to be closely managed to ensure timely delivery and that fuel quality is sufficient to meet the requirements of the boiler. This ideally calls for a contract to be in place between the user and a reliable local supplier of wood chips and/or wood pellets.

8.4 ESCo Approach

As an alternative, the user could employ an Energy Service Company (ESCo). ESCo's exist in a wide variety of forms, providing a range of comprehensive energy solutions for buildings and/or local communities. Whilst the role of an ESCo often varies from project to project, their level of involvement typically includes the design, build, finance, operation and maintenance of energy schemes. In each case, the ESCo is often contracted to supply heat for a minimum period. In addition, the majority of ESCo's operate with a strong emphasis on energy efficiency and sustainability.

8.4.1 Role of ESCo

Several ESCo's either specialise in, or have a strong reputation for, delivering complete biomass heating solutions throughout the UK. As an indication, the level of service offered by an ESCo in relation to the scheme may include all - or part of - the following:

- Study to support the feasibility of a biomass system;
- Grants or funding towards the system installation;
- Fuel supply logistics;
- Design and build of the energy centre;
- Delivery of fuel supply from processing plant/supplier;
- Operation and maintenance of boiler throughout lifetime.

8.4.2 Potential Benefits

The primary advantage of undertaking an ESCo partnership is that it allows the end user to enjoy the benefits of an energy efficient/sustainable heating system, without taking responsibility for its operation. This is often an attractive option given the complexities and potential logistical issues inherent in the design and use of biomass heating systems. In addition, by assigning complete responsibility to one organisation, it removes the likelihood of communication breakdowns between designers/contractors/suppliers. The ESCo is typically contracted to 'supply heat' for a given period (e.g. 10-15 years), during which time they accept complete responsibility for its operation. This means that during maintenance periods (or perhaps if fuel supply is compromised) the ESCo will guarantee heat by an alternative means (e.g. back-up natural gas boilers). Whilst this provides assurance to the end user, the agreement may also need to be managed to ensure adequate levels of biomass fuel supply in compliance with BREEAM requirements.

The main disadvantage of an ESCo partnership is that the user must pay for the service it receives, meaning the total cost is generally higher than the alternative. However, it is worth noting that the user is essentially paying to transfer all associated risks to the ESCo. In certain situations, the diminished responsibility of the end user could also be seen as a disadvantage. For example, the ESCo agreement inhibits the end user from shopping around to find the lowest price for its fuel supply.

8.5 Land Use

Early planning is the key to mitigating the inherent practical risks associated with biomass systems. Onsite, the location of the boiler plant and storage vessel are paramount since it is likely to require a large floor area and frequent fuel delivery in winter months. Projected delivery requirements are shown below for wood chip and wood pellet fuels over a range of storage volumes.

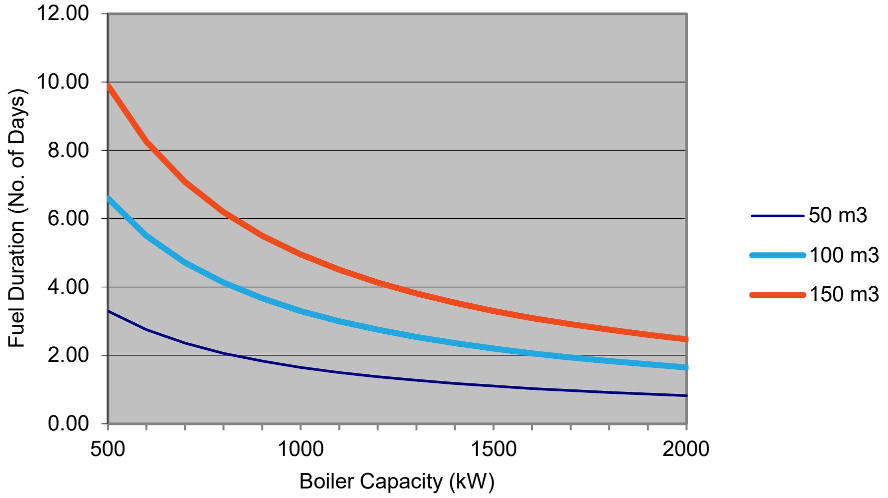

Figure 8 - Fuel duration as a measure of boiler capacity and storage volume

An area for the delivery lorry to manoeuvre and a fuel transportation system are also required. Access routes for delivery vehicles need to be adequately sized to allow for manoeuvring and considerate of the safety of building users. In general, biomass boilers are no suitable in inner city areas, and more suited to locations with more space.

8.6 Local Planning Requirements

The flue from the wood boiler will need to be co-ordinated with the massing of the building. It is likely to fall under the requirements of the clean air act and will need to be extended 3m above any area to which there is general access.

8.7 Resource Availability

There are several biomass suppliers in Wales. Ability to reliably supply fuel of consistently high quality will need to be investigated further. A local fuel source is important in minimising embodied carbon in mileage.

8.8 Environmental Considerations

8.8.1 Air quality

- Local nitrogen oxide (NOx) emissions from these technologies can be high.
- Particulate matter ca be reduced to sub 2.5 microns with inexpensive catalytic filters. An SCR could be integrated to reduce NOx emissions.

8.8.2 Noise

The noise generated by biomass boilers is comparable to that generated by a traditional gas-fired or oil-fired boiler and, therefore, requires no additional consideration. However, given the frequency of fuel delivery in winter months, access routes for delivery vehicles need to be carefully designed to reduce the transmittance of noise to education spaces. Delivery times should also be carefully planned to minimise noise and disturbance during visiting times.

8.8.3 Visual impact

A biomass boiler requires an enclosed area in which fuel can be stored. This can either be an above ground building or silo, or an underground bunker which reduces visual impact and space requirements but is more expensive.

8.9 Energy Requirements

The estimated heat loads for the building are as follows:

- Space Heating Load 206,380 kWh/year
- Domestic Hot Water Load 175,000 kWh/year
- **Total Boiler Load 381,380 kWh/year**

8.10 Biomass Feasibility Assessment

In larger properties it is usually appropriate to size a biomass boiler based on a proportion of the building load and utilise a gas boiler to deal with the peak energy demands of the building. The reason for this is due to biomass boilers being less suited to on/off peak demand operation (hence often being coupled with a thermal store to maximise the amount of time that the boiler is running). For the Campus the boiler has been sized to meet 50% of the demand.

Based on 50% of heat demand		
Capital Costs	-	£64,786
Fuel Costs	4.375 p/kWh wood pellet	£9068 per annum
Offset Gas Saving	2.76 p/kWh	£-5263 per annum
Operating & Maintenance Costs	2% of Capital Cost	£1296 per annum
CO2 Reduction Potential	-	70.7 tCO_2 per annum
RHI Income	0 p/kWh	£0 per annum

Table 6 - Biomass feasibility study

8.11 Biomass Whole Life Cycle Assessment

Whole life cycle cost analysis for biomass has been completed based on net present values, in comparison with full gas heating over a period of 30 years. Financial incentives have not been included in this calculation as the RHI Scheme is not available for this project.

The analysis demonstrates that the biomass installation would not pay back within 30 years, even if the RHI is taken onboard. Whole life cycle cost of biomass installation is estimated at £1,855,777 over 30 years, in comparison with £752,758 for a totally gas installation. Therefore, the biomass installation can be expected to cost £1,103,019 more over its 30-year life cycle.

For the purpose of calculating payback costs, it is assumed that the boiler is gas-fired. As the boiler would have to be installed to meet the heating demand, total installation costs need only account for ancillary equipment and labour.

Whole life cycle carbon emission analysis highlights a reduction of 2122 tonnes CO_2 over 30 years.

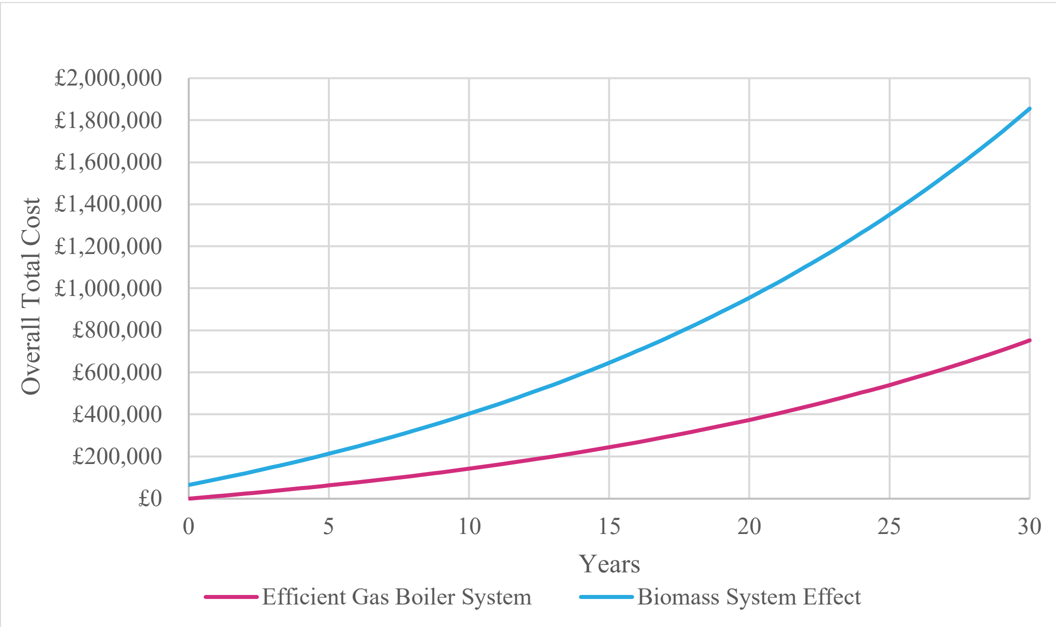

Figure 9 - Biomass Whole Life Cycle Cost Analysis

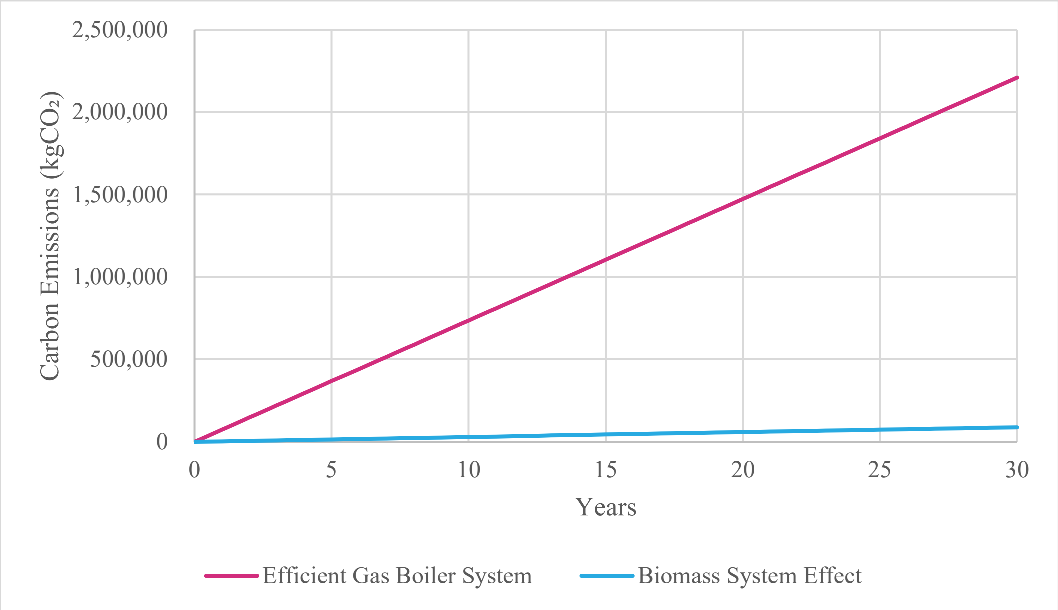

Figure 10 - Biomass Whole Life Cycle Carbon Analysis

8.12 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

8.12.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a biomass heating system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + (Lifetime * (Fuel\ Cost + Maintenance))}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£177}{Tonne\ CO_2}$$

8.13 Recommendations

Despite the large carbon saving, it is not recommended that a biomass boiler is used on the development. There are a number of reasons that contribute to this:

- The space required for a biomass boiler along with the associated volume required for a wood storage area would be significant for 7 days of fuel storage.
- System installation would be difficult due to site constraints, including delivery access.
- The technology does not payback financially.

- Security of supply for fuel, the system requiring steady deliveries of wood chip over its lifetime.
- Biomass boilers require significant maintenance and be subject to reliability issues.
- There is narrow access to into the site which may cause issues for delivery vehicles. A large number of deliveries are necessary to cope with the large volumes of fuel need. The noise from delivery vehicles could be disturbing for the students in the school.

As the heating demand for the school will not be constant, there will be load matching issues. As the school cannot provide a constant demand, the biomass boiler will either be oversized leading to large losses in efficiency, or undersized which reduces its benefit significantly.

9 Photovoltaic Panels

Figure 11 - Example of photovoltaic system

Solar photovoltaic systems enable sunlight to be transformed directly into electrical power. The photovoltaic effect or interaction between radiating sunlight and the semiconductor material of the solar cell makes this transformation. This generates electrical charges that are conducted away by metal contacts. The direct current produced can be transformed into alternating current by connecting a DC/AC inverter. The most important element of a photovoltaic generator is the solar photovoltaic cell. Several solar cells are combined in series or parallel into an electrical unit, solar module.

A solar cell consists of a very thin layer of semiconductor material (usually silicon). This is doped with impurities (other elements) on both sides. As a result, one side acquires a negative charge (a surplus of electrons) and the other a positive charge (electron deficiency). When sunlight falls on the material that has been changed in this way, electrons are forced from one side to the other by the sun’s energy. This produces direct current at the terminals.

PV arrays should, where possible, be mounted to face between south east and south west at an elevation of between 30° and 40°. PV arrays can be designed to integrate with roofing and vertical glazing/cladding systems.

The system should ideally be connected to the mains electricity grid and should be capable of drawing energy from the grid and exporting energy produced by the PV cells to the grid. The main advantages are:

- Part of the electrical supply would be produced on site thus reducing the amount of electricity that would need to be imported.
- By connecting the system to the grid, the cost of storage can be avoided, and security of supply is guaranteed.

The photovoltaic cell array size that shall be required is dependent upon the overall contribution to the electrical load, available budget and available area that can be utilised for installation.

With the high capital cost for the installation of PV's, the relatively small amount of electrical energy generated and the expiry of Clear-Skies government grant funding, PVs, based on payback period alone, are unlikely to constitute a sound investment. The incorporation of PVs into the scheme will however assist in lowering the building's overall carbon emission rating.

Due to the poor efficiency of PV cells, typically 15%, large areas of PV array area are required to generate relatively small amounts of electrical energy.

Partial cost of PV array installation can be offset against the cost of rain screen cladding for example, however capital investment is still high. Integration of PV panels into the buildings cladding could be investigated but it is more cost effective to utilise roof space in the first instance.

9.1 Land Use

Solar PV panels require a significant amount of space; however, they can be in various locations provided there is unobstructed areas to direct sunlight. The PV arrays can be located on the roof of the building, taking advantage of the Southerly aspect.

Access to the roof will have to be accounted for to access the PV Arrays for maintenance and cleaning.

9.2 Local Planning Requirements

Planning permission is likely to be required due to the visual impact of the panels, however this is unlikely to be a problem as the only viable position for the panels is on the roof, out of sight from the ground.

9.3 Resource Availability

Solar photovoltaic arrays make use of both direct and indirect solar radiation. Wales has a reasonable solar resource. This is assumed to be 1100 hours per year for the following calculations. Output can vary in relation to local weather conditions.

9.4 Environmental Considerations

Air quality: No emissions.

Noise: No noise during operation.

Ground pollution: None.

Visual impact: Minimal when roof mounted.

9.5 Maintenance

Photovoltaic panels require occasional cleaning, the frequency of which depends upon local conditions (air quality, dust, pollen, wildlife, etc.). It is common for the inverter system to fail prior to the panels themselves and require replacing at considerable cost. If an individual panel becomes damaged or degrades faster than expected, it can be removed and replaced.

9.6 Battery Storage

Battery storage could prove beneficial on a scheme such as this. Large portions of power generation by the PV arrays will occur when the building is not in operation and has very low power usage resulting in power generation excess. This generation excess could be directly exported to the grid or it could be stored for use by the school or to export 'on demand' to the grid during evening or weekend periods. Sizing batteries to store power for the entire summer period for re-use in the school is likely to be excessive in size, cost and maintenance and is unlikely to yield tangible benefits. Discussions with the utility provider will identify the best approach for dealing with any excess power generation.

9.7 Exporting Electricity from the System

For this report it is assumed that all electricity generated by the PV array is used within the building i.e. not exported back to the grid.

9.8 PV Feasibility Assessment.

Estimated Electrical Energy Requirements for the site = 309,570 kWh.

Due to the estimated size required for the PV panels and the anticipated roof area available, it is assumed that all the PV cells will be south facing (on average the solar incidence is 1,100 kWh/year per kWp).

A photovoltaic array that can be suitably accommodated on the roof of the building would have an active panel area of circa 2500 m².

Based on 2500m² PV Array		
Capital Costs	-	£346,750
Fuel Costs	No Fuel Cost	-
Operating & Maintenance Costs	0.6 p/kWh	£1856 per annum
CO_2 Reduction Potential	-	72.1 tCO_2 per annum

Table 7 - PV Feasibility Cost Summary

9.9 PV Whole Life Cycle Assessment

A whole life cycle cost analysis for the PV system has been completed based on net present values, in comparison with grid electric over a period of 30 years.

The analysis demonstrates that payback for the PV installation is achieved within 8 years. The whole life cost of a PV installation is estimated at £971,294 over 30 years, in comparison with £3,105,689 for electric installation. Therefore, the PV installation can be expected to save £2,134,395 over its 30-year life cycle.

The life cycle costs include for replacing the inverters every 10 years.

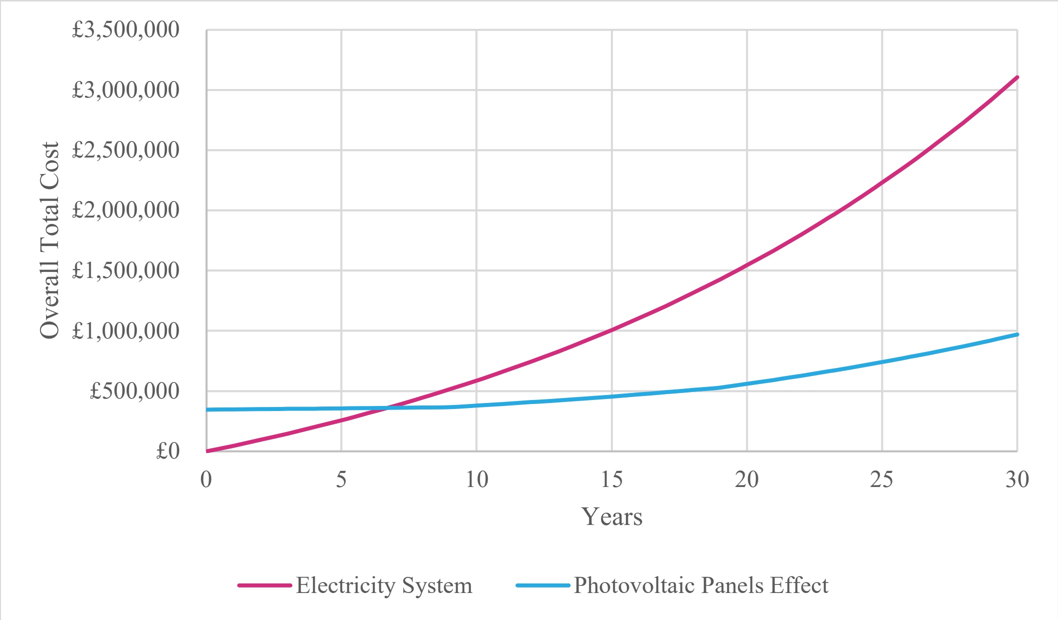

Figure 12 - PV Whole Life Cycle Cost Analysis

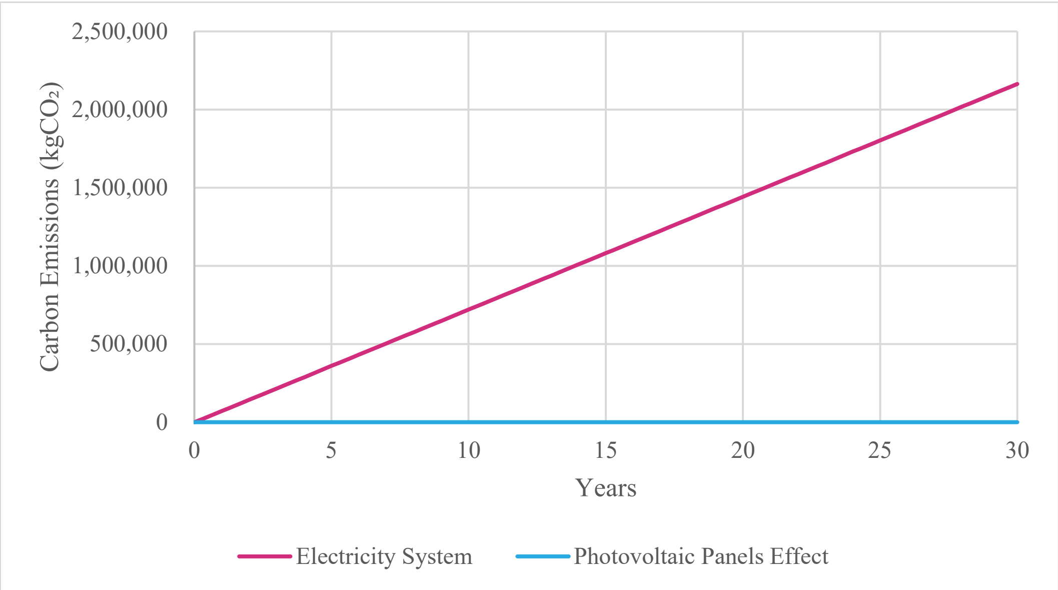

Figure 13 - PV Whole Life Cycle Carbon Analysis

9.10 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

9.10.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a photovoltaic system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + \left(Lifetime * (Fuel\ Cost + Maintenance)\right)}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£186}{Tonne\ CO_2}$$

9.11 Building Integrated PV

Building-integrated PV is an alternative approach for integration of PV into the building envelope.

Figure 14 - BIPVco thin film flexible solar cells.

Thin film flexible solar cells, as shown in *Figure 14*, are infused directly into contemporary building envelope of metals such as steel and aluminium or non-metals such as polycarbonate sheets.

Building-integrated PV has benefits over conventional PV panels including:

- Less bulky and flexible – they are able to take the form of the building envelope.
- Avoids the need for ballasting on flat roofs.
- Light weight.

- No secondary structure to support the modules, saving on materials and cost of installation.

9.12 Recommendations

The current Architectural strategy is a 2-storey building which means that a large roof area is available. This could be used to facilitate a large area of PV installation. A large installation has been considered in this report to help drive through the zero-carbon requirement.

Despite comparatively large capital cost, the technology will pay for itself in 8 years. PV installation has a low cost per tonne of CO_2 saved compared to other LZC technologies and it is estimated that installing PV can save 2163 tonnes of CO_2 over 30 years.

PV panels can be easily integrated to this building with minimal impact to the surrounding areas. The low maintenance costs are also beneficial to this technology in comparison to other renewable alternatives.

To achieve net zero carbon, the amount of PV used will need to be maximised. One option to make the most use of the roof area available would be to use building integrated PV as described in Section 9.11. Building integrated PV is less bulky and flexible meaning a larger area of PV can be installed on the building. This will increase the amount of energy produced on site, reducing the amount of imported electricity.

A large portion of the power generated by the PV array will occur in the summer when the building is not in operation. Batteries should be considered as described in Section 9.6 to store this excess energy for use by the school or to export the energy 'on demand' to the grid.

10 Ground Source Heat Pumps

Ground-coupled heat pump systems are generally used in conjunction with closed loop pipework systems installed either horizontally approximately 2 metres below ground level or vertically in bore holes with bore hole depths varying between 15 and 100 metres depending upon particular site ground conditions. Systems are available at present where vertical pipe loops can also be accommodated within pile foundations providing a more economical method of installation.

Figure 15 - Typical GSHP Installation Image

The optimum use for ground-coupled heat pumps is in the generation of low temperature hot water to serve systems which are more suited to the use of lower flow temperatures (approximately 40°C). Such systems are underfloor heating systems.

Ground-coupled heat pumps are not considered wholly renewable due to electrical energy required to generate heating/cooling, but when utilised can reduce building carbon emissions by between 30% and 35%.

10.1 GSHP Advantages

- Can be used for space heating and domestic hot water pre-heating.
- Can be reversible to provide cooling to maximise capital investment.
- Relatively few moving parts.
- Proven technology and long-life expectancy.

10.2 GSHP Limitations

- To get the most out of this type of system, the year-round heating loads and cooling loads need to be approximately equal to ensure there is no net increase/decrease in ground temperature.
- The achievement of high coefficient of performance will require relatively low supply temperatures in heating mode.
- Cost of installing the ground boreholes/coil may be prohibitively high.

- Favourable ground conditions may not exist. A thorough study of these conditions must be carried out to assess the feasibility of the system.
- Changes in ground conditions could change heating/cooling capability of installation.

10.3 Energy Requirements

The estimated heat loads for the building are as follows:

- Space Heating Load 206,380 kWh/year
- Domestic Hot Water Load 175,000 kWh/year
- **Total Boiler Load 381,380 kWh/year**

10.4 GSHP Feasibility Assessment

A 400kWth heat pump has been used to test the feasibility of using a GSHP at the Campus. The old working mines on the school site make horizontal boreholes a more suitable solution, and hence they been used for this test.

Based on 400kWth of heat capacity		
Capital Costs	Pump + Loop	£530,000
Fuel Costs	15.1 p/kWh	£23556 per annum
Offset Gas Saving	2.76 p/kWh	£18129 per annum
Operating & Maintenance Costs		£350 per annum
CO_2 Reduction Potential	-	84.5 tCO_2 per annum
RHI Income	0 p/kWh	£0 per annum

Table 8 - GSHP feasibility study

10.5 Land Use

GSHPs require a large land mass to be available for heat extraction. The land mass required can vary substantially depending on the ground conditions and the pipe layout (horizonal/vertical boreholes). A specific geothermal study is required to determine if the land is suitable for this system. With this study, the size of the boreholes can be determined, and therefore the required area.

10.6 Environmental Considerations

Air quality: Heat pumps do not release pollutants commonly associated with degrading air quality such as nitrous oxides, sulphides or particulates. However, heat pumps depend on refrigerants which tend to be based on HFCs associated with high global warming potential.

Noise: The noise generated by ground source heat pumps is comparable to that generated by a traditional water heat and therefore requires no additional consideration.

Ground & water pollution: Potential short- and long-term effects GSHPs could have on the ground, and the effect of these temperature changes on ecology, must be further examined. Rejecting heat to the ground when heat pumps are used for cooling could have an adverse effect on ecology.

Visual impact: No visual impact.

10.7 Exporting Heat and Electricity from the System

For heating to be exported from the site the GSHP system will need to be oversized to take account of the additional load and this may prove to be prohibitive if there are limitations on available space.

10.8 GSHP Whole Life Cycle Assessment

The payback for the GSHP system is not achievable within 30 years. Prior to the RHI being removed, the payback could be as low as 5 years.

Whole life cycle cost analysis for GSHP has been completed based on net present values, in comparison with an efficient gas boiler system over a period of 30 years. Financial incentives have not been included in this calculation as the RHI Scheme is not available for this project.

Whole life cycle cost of a GSHP installation is estimated at £1,666,586 over 30 years, in comparison with £752,758 for an efficient gas boiler installation. Therefore, the GSHP installation can be expected to cost £913,828 more over its 30-year life cycle.

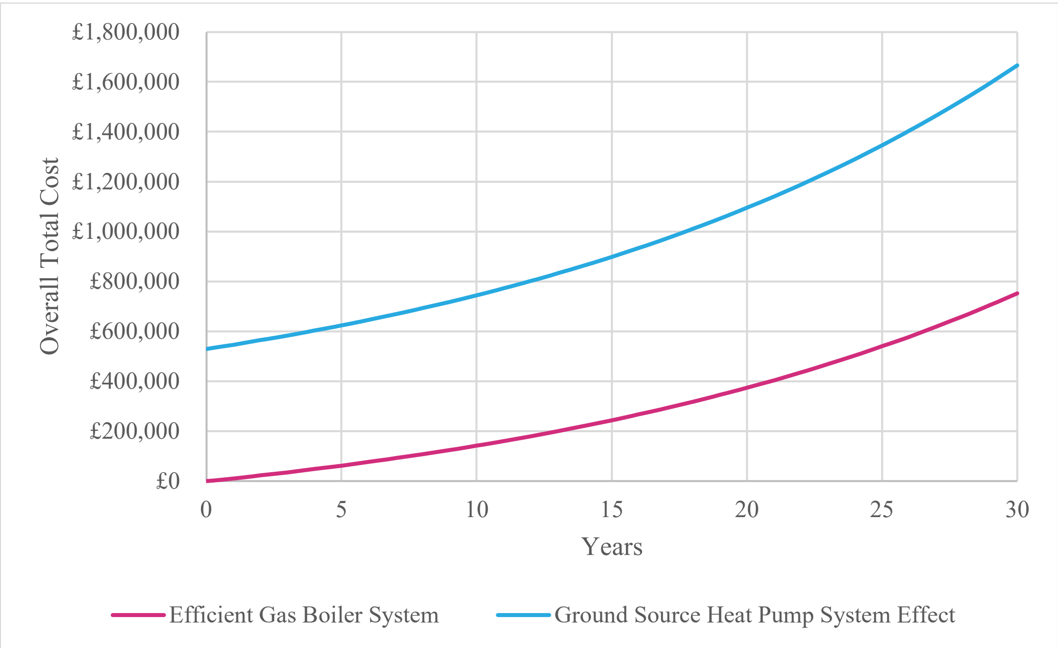

Figure 16 - GSHP Whole Life Cycle Cost Analysis

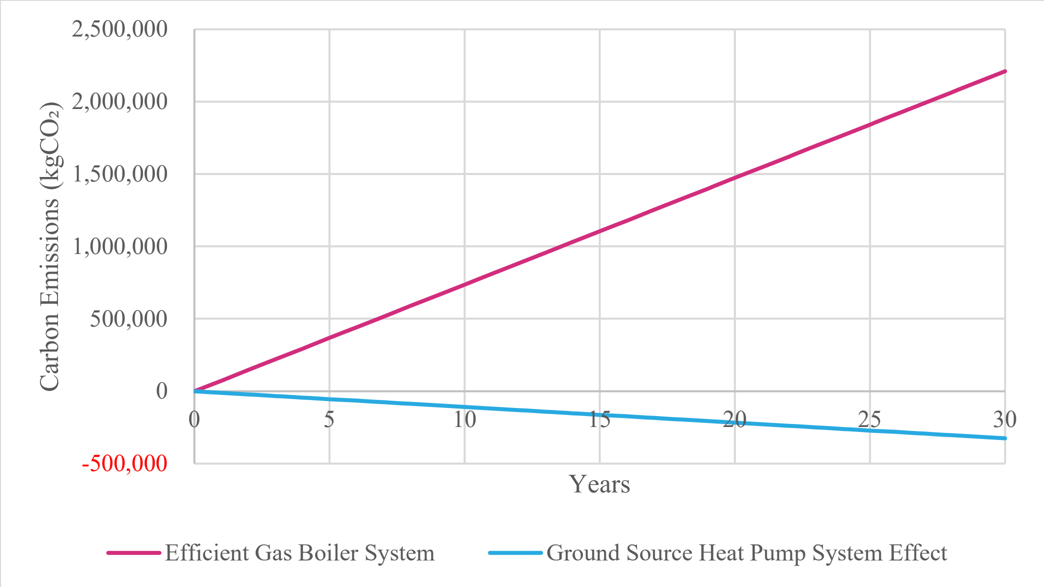

Figure 17 - GSHP Whole Life Cycle Carbon Analysis

10.9 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

10.9.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a ground source heat pump heating system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + \big(Lifetime * (Fuel\ Cost + Maintenance)\big)}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£492}{Tonne\ CO_2}$$

10.10 Recommendations

There is sufficient undeveloped area on this site to use a ground source heat pump. Initial studies on ground investigation work suggest that there were existing coal mines in the vicinity. Horizontal bore holes would therefore be recommended over vertical boreholes.

There is a large carbon reduction potential when using this technology, but this comes with a high financial cost. The technology will not pay for itself without the RHI scheme. In this case, the technology is not financially viable.

There is also a risk that the ground conditions will not be compatible with the site needs. Perhaps more crucially, the school has no cooling load, the heat pump will not operate in cooling mode to put any heat back into the ground, which would run the risk of freezing the ground gradually. The technology has been discounted on this basis.

11 Air Source Heat Pumps

Air source heat pumps (ASHP) operate by absorbing energy from outside air and utilising the refrigeration cycle to boost the recovered energy as heat. This heat can then be used to meet the building heating demand or provide a pre-heat to domestic hot water.

ASHP can operate on two principles, air-to-water or air-to-air. Both principles relate to the medium by which the absorbed energy is transmitted.

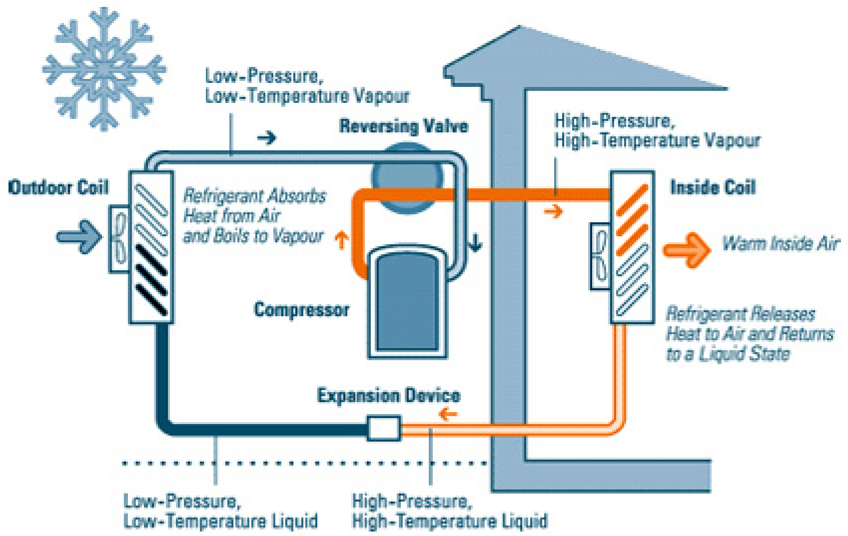

Figure 18 - Typical ASHP Installation Image

ASHP technology has been increasing in efficiency for many years (itself an offshoot from many manufacturers of refrigerant based air conditioning system) so the technology is well established and robust and is beginning to challenge standalone gas fired boilers for costs, efficiency and carbon emissions.

The key consideration when selecting an ASHP over a traditional boiler is that typically in an air to water heat pump the heat tends to be of low grade and as such requires internal heat emitters to be oversized. Furthermore, for DHW applications an additional boost (either via electric, gas or smaller ASHP) is required to overcome legionella risk and deliver at higher temperatures (reducing the overall system efficiency).

If an ASHP system was employed for DHW, it is likely that the system would be kept separate from the space heating system to ensure operating temperatures can be optimised.

11.1 ASHP Advantages

- ASHPs are an established technology and a generally considered to be efficient and reliable.
- Furthermore, they generally don't have onerous maintenance requirements.
- Can help to improve air quality.

11.2 ASHP Limitations

- A key limitation of ASHPs as an LZC technology is that despite harnessing heat from outside air, they still require electricity to power the system. However, large ASHP's used for commercial buildings are very efficient and use variable speed compressors that optimise the operation. Typically, in the region of COP up to 300% and SEER up to 400% are achieved.
- There can be acoustic considerations as ASHPs have associated noise emissions. However, heat pumps can be provided with noise attenuation, or be located carefully to avoid acoustic issues.
- For heating mode, ASHP operate most effectively in warmer conditions and can start to de-rate or even freeze up during coldest conditions. The heat pumps must be sized effectively with spare capacity or even fossil fuel back-up to ensure continuity of heat supply during winter conditions.

11.3 Energy Requirements

The estimated heat loads for the building are as follows:

- Space Heating Load 206,380 kWh/year
- Domestic Hot Water Load 175,000 kWh/year
- **Total Boiler Load 381,380 kWh/year**

11.4 ASHP Feasibility Assessment

A 400kWth heat pump has been used to test the feasibility of using an ASHP at the Campus. In the following calculations it is assumed that the cost associated with providing electricity to power the ASHP is not included.

Based on 400 kWth of heat capacity		
Capital Costs	Heat Pump	£120,000
Fuel Costs	15.1 p/kWh	£31408 per annum
Offset Gas Saving	2.76 p/kWh	£18129 per annum
Operating & Maintenance Costs		£350 per annum
CO_2 Reduction Potential	-	72.4 tCO_2 per annum
RHI Income	0 p/kWh	£0 per annum

Table 9 - ASHP feasibility study

11.5 Land Use

ASHPs require a space for a heat exchanger where there is a good convection of air for heat. They could be mounted on the building roof or in a remote compound. The effect on planning would be minimal but the units should be accounted for in the planning submission.

11.6 Environmental Considerations

Air quality: Heat pumps do not release pollutants commonly associated with degrading air quality such as nitrous oxides, sulphides or particulates. However, heat pumps depend on refrigerants which tend to be based on HFCs associated with high global warming potential.

Noise: The external condenser units for ASHPs can be noisy and will need to be situated to minimise breakout noise.

Visual impact: Discrete locations for the ASHPs will have to be considered.

11.7 ASHP Whole Life Cycle Assessment

Whole life cycle cost analysis for ASHP has been completed based on net present values, in comparison with an efficient gas boiler system over a period of 30 years. Financial incentives have not been included in these calculations.

The analysis demonstrates that payback for the ASHP installation is not achievable within 30 years without the renewable heat incentive. Before the renewable heat incentive was removed, an ASHP could be expected to payback within 6 years.

Whole life cycle cost of an ASHP installation is estimated at £1,778,264 over 30 years, in comparison with £752,758 for an efficient gas boiler installation. Therefore, the ASHP installation can be expected to cost £1,025,506 more over its 30-year life cycle.

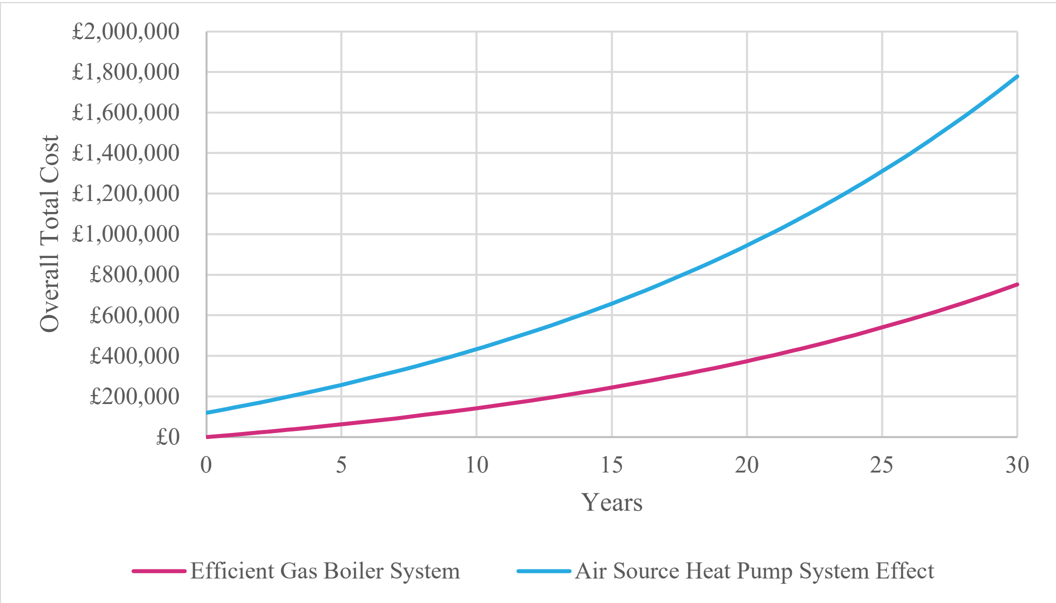

Figure 19 - ASHP Whole Life Cycle Cost Analysis

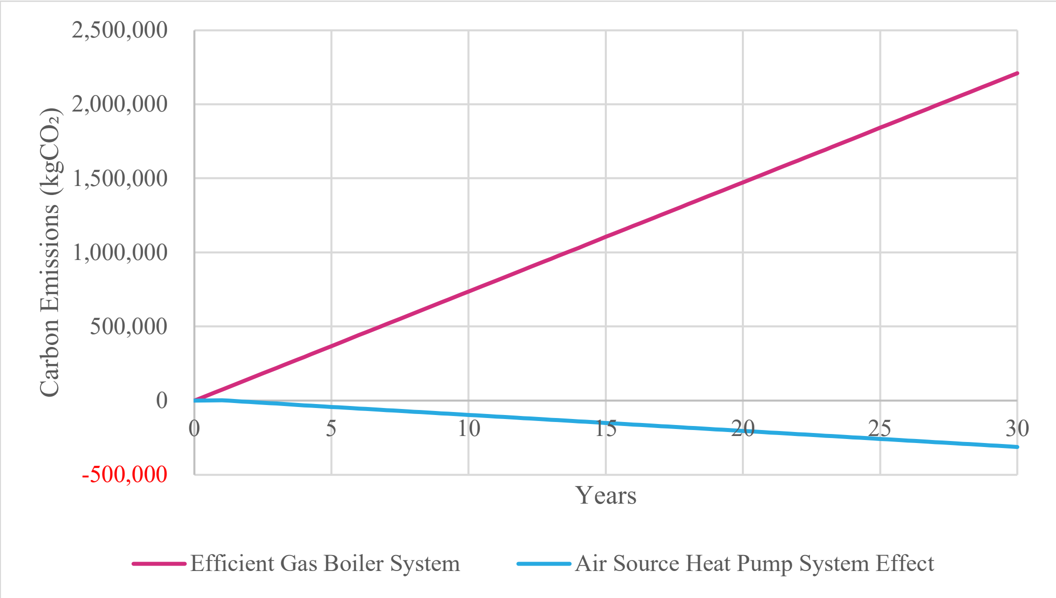

Figure 20 - GSHP Whole Life Cycle Carbon Analysis

11.8 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

11.8.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a ground source heat pump heating system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + \left(Lifetime * (Fuel\ Cost + Maintenance)\right)}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£494}{Tonne\ CO_2}$$

11.9 Recommendations

Air source heat pumps are an efficient and reliable technology and provide large carbon reduction potential. Although they do not pay back financially following the removal of the renewable heat incentive, they do result in a large CO_2 saving and will make a significant contribution to achieving the zero carbon requirements for the school. It is estimated that installing ASHP technology can save 2,523 tonnes of CO_2 over 30 years.

The air source heat pump is the preferred solution for providing heat and will be developed further as design progresses.

Air source heat pumps can improve the air quality of the premises including reducing humidity, improving oxygen distribution and preventing build-up of germs. This is especially important with the recent Covid-19 pandemic and the need for clean, ventilated air - especially in schools.

As the external condenser units for ASHPs can generate noise, it is recommended that their location is chosen suitably to not cause any noise disturbance to the building occupants.

12 Wind

Figure 21 - Typical Wind Turbine Image

Wind power is one of the most promising renewable energy resources for electricity generation. The UK has some of the highest average wind speeds in Europe and subsequently has a suitable environment for wind turbines.

A Wind turbine is a machine that converts kinetic energy (wind) into mechanical energy. Modern wind turbines are tough durable machines and efficient at transferring the energy from a natural source. If the mechanical energy is used directly i.e. to turn wheels etc it would be known as a windmill. However, if the kinetic energy was used to generate electricity it is known as a wind generator or wind turbine.

12.1 Wind Advantages

Wind turbines have the potential to provide large benefits in the form of carbon savings from either supplying the building with power, or simply selling back to the grid. Financial incentives are available to generate income.

12.2 Wind Limitations

The disadvantages of wind turbines are that it can be difficult to get planning permission and there can be local public opposition to the potential issues with noise and light flicker. There are also physical limitations to the location and space available to install the turbine.

12.3 Wind Feasibility Assessment

To assess the suitability of the site for Wind technology the site must have an average wind speed of greater than 5m/s to ensure sufficient wind strength to generate the energy required.

12.4 Energy Generated

The amount of energy generated depends on the size of the wind turbine and the height of the mast. Based on 1No. 40kW wind turbine at a medium head would generate 100.887 kWh/yr of electricity. These figures are based on an average wind speed of 5m/s.

12.5 Costs

According to Beco Solar the cost of a wind turbine system, including equipment, installation, testing and commissioning are shown below:

1 x 12kW system capital cost = £160,000

As wind turbines don't require any fuel the only running costs are those associated with maintenance. Beco Solar quotes the following amount for maintenance:

Annual maintenance costs = £350

12.6 Simple Payback Periods

The payback period is calculated as the difference between the installation cost of a wind turbine system and the existing grid supply, divided by the savings in running costs and maintenance costs. The cost of a unit of grid supplied electricity is 15.10 p/kWh.

$$Simple\ Payback = \frac{Installation\ Cost}{(Offset\ Enegy\ Saving)}$$

$$Simple\ Payback = \frac{£160{,}000}{(£14{,}884)} = 10.7\ years$$

12.7 Land Use

The size and position of the turbine would need to be discussed further in the design process.

12.8 Local Planning Requirements

Planning permission would be required as wind turbines cannot be located within close proximity of a residential area.

12.9 Environmental Considerations

Air quality: No emissions from wind power during operation.

Noise: This type of technology does generate some acoustic issues that would need to be considered when looking at its size and location.

Visual impact: High visual impact caused by medium and large-scale ground mounted turbines. Potentially less visual impact associated with smaller scale building mounted turbines.

Wildlife: There is potential for impact on wildlife and, in particular, birds living near to the site.

12.10 Maintenance

Wind turbines require routine maintenance, and the gearboxes often require replacing prior to the end of the turbine's life.

Newer turbine designs opt for directly driven generators, removing the need for a gearbox and allowing higher efficiencies; however these systems are still being proven at scale over their operational lifetimes.

12.11 Exporting Electricity from the System

It is not viable to export the limited amount of electricity generated.

12.12 Wind Turbine Whole Life Cycle Assessment

Whole life cycle cost analysis for a wind turbine has been completed based on net present values, in comparison with grid electric over a period of 30 years.

The analysis demonstrates that payback for the wind installation is achieved within 10.7 years. Whole life cycle cost of a wind installation is estimated at £2,276,817 over 30 years, in comparison with £3,105,689 for electric installation. Therefore, the wind turbine installation can be expected to save £828,872 over its 30-year life cycle.

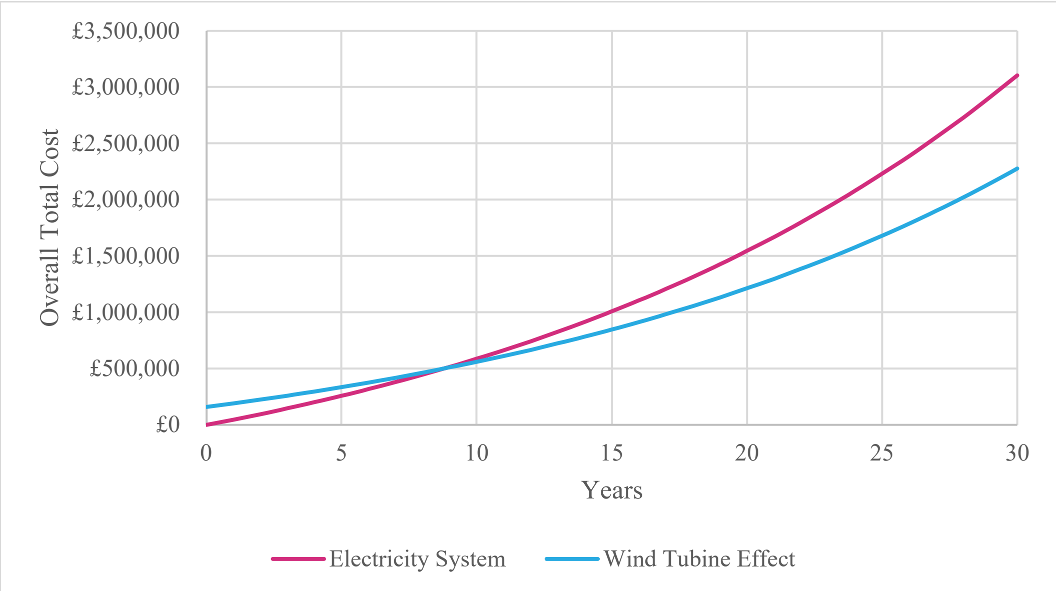

Figure 22 - Wind Turbine Whole Life Cycle Cost Analysis

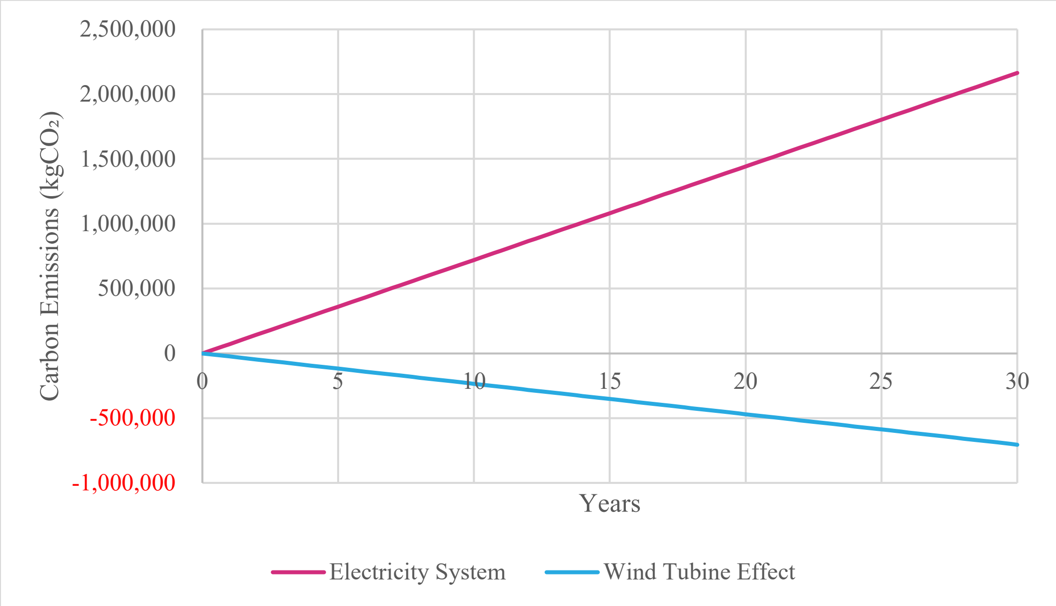

Figure 23 - Wind Turbine Whole Life Cycle Carbon Analysis

12.13 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

12.13.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a wind turbine system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + \left(Lifetime * (Fuel\ Cost + Maintenance)\right)}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£242}{Tonne\ CO_2}$$

12.14 Recommendations

Wind turbines have a payback time of 10.7 years and a comparatively low cost per tonne of CO_2 saved. However, because of the location limitations on the site, it is unlikely that planning permission would be granted. It is highly likely that the wind turbine would create significant noise and would interfere with teaching given the aspirations to naturally ventilate the school. Wind turbines are a valid technology, but they should be sited remotely. Therefore, it is not recommended to proceed with the installation of a wind turbine within the site.

13 Combined Heat and Power

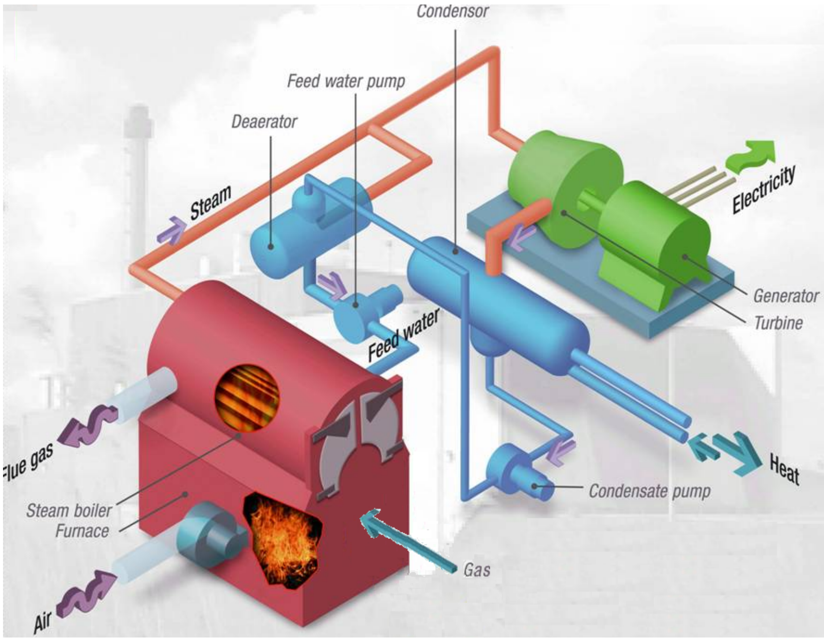

Figure 24 - Typical Gas Fired CHP Plant providing both Electricity and Heating

Combined Heat and Power (CHP) is the generation of electricity and useful heat in one process. CHP plants generate electricity using fossil fuels while using the waste heat to provide heating and hot water.

Combined Heat and Power plant use a single piece of equipment to generate heat and electrical power. In order for the CHP solution to be sustainable and cost effective it must be used all year around at full (or close to full) capacity. As a result, the CHP plant is usually sized at the heating base load. Electrical power is produced, which may be used by the museum, removing the need to purchase electricity from the Grid.

Sizing the CHP plant at full load is generally seen as uneconomical, since the excess heat from the CHP plant would have to be rejected to atmosphere during some months of the year. The CHP unit would then be operating as a power station and the efficiencies are significantly reduced. In this case a more sustainable solution would be to buy electricity from the "Green Grid".

At this time consideration should be given to operate the CHP plant on Natural Gas from the grid, as biomass CHP is not yet fully developed and commercially viable.

CHP generally produces heat and electricity in the ratio of 5:3. Any excess electricity produced by the plant can potentially be transported short distances for use on other sites or, alternatively, sold back the Grid at an agreed price.

13.1 CHP Feasibility Assessment

The combined heat and power system is generally sized at the base heating load. The school will be occupied for around 10 hours a day Monday to Friday for around 190 days a year, so the building heating profile will vary considerably, and the base load will be minimal. Because of this, the base load is assumed to be around 25% of the total load (heating and DHW). This can be achieved by using a 61 kW_{th} unit.

Based on 61 kWp_{th} / 35kWp_e CHP System		
Capital Costs	CHP Alone	£60,000
Fuel Costs	2.76 p/kWh gas	£5296 per annum
Offset Electricity	15.1 p/kWh electricity	£8245 per annum
Operating & Maintenance Costs	-	£952 per annum
CO_2 Reduction Potential	-	None
RHI Income	0 p/kWh	£0 per annum

Table 10 - CHP System analysis

The CHP systems simple payback is estimated at 12 years.

13.2 CHP Whole Life Cycle Assessment

Whole life cycle cost analysis for a CHP system has been completed based on net present values, in comparison with full gas heating over a period of 30 years.

The analysis demonstrates that payback for the installation would pay back within 12 years. Whole life cycle cost of the installation is estimated at £3,762,844 over 30 years, in comparison with £3,858,447 for a totally gas installation. Therefore, the CHP installation can be expected to save £95,602 over its 30-year life cycle.

Traditionally, the heating system sources heat from the building's boiler. For the purpose of calculating payback costs, it is assumed that the boiler is gas-fired. As the boiler will already be installed to meet the heating demand, total installation costs need only account for ancillary equipment and labour.

Whole life cycle carbon emission analysis highlights an increase of 125 tonnes CO_2 over 30 years. This is due to the latest available carbon emissions factors where electricity is now much closer to natural gas than it had been in the past. Therefore, this makes the CHP system to have greater carbon emissions than a standalone gas boiler system.

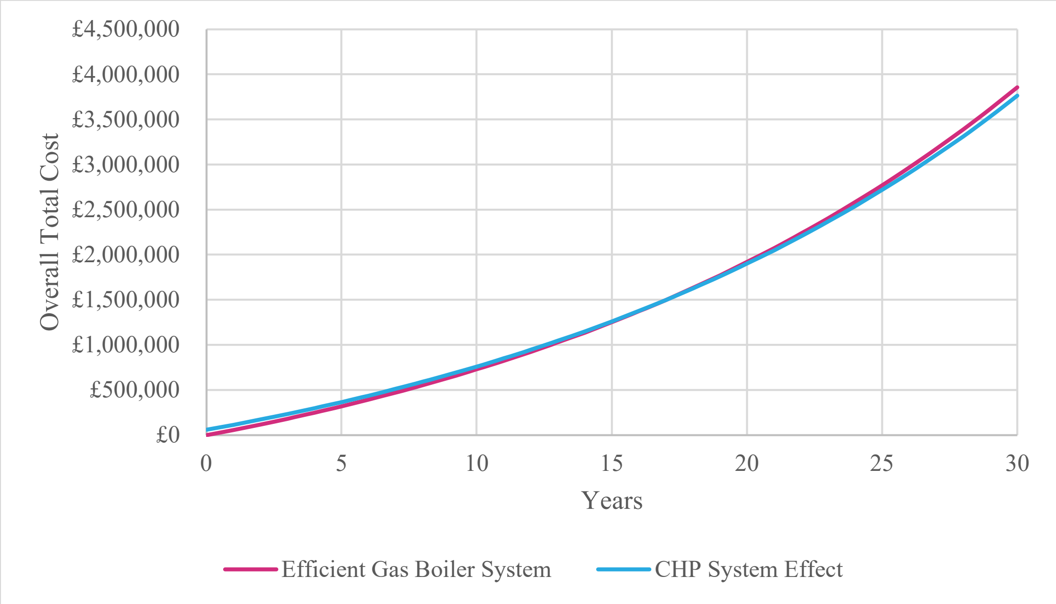

Figure 25 - CHP Whole Life Cycle Cost Analysis

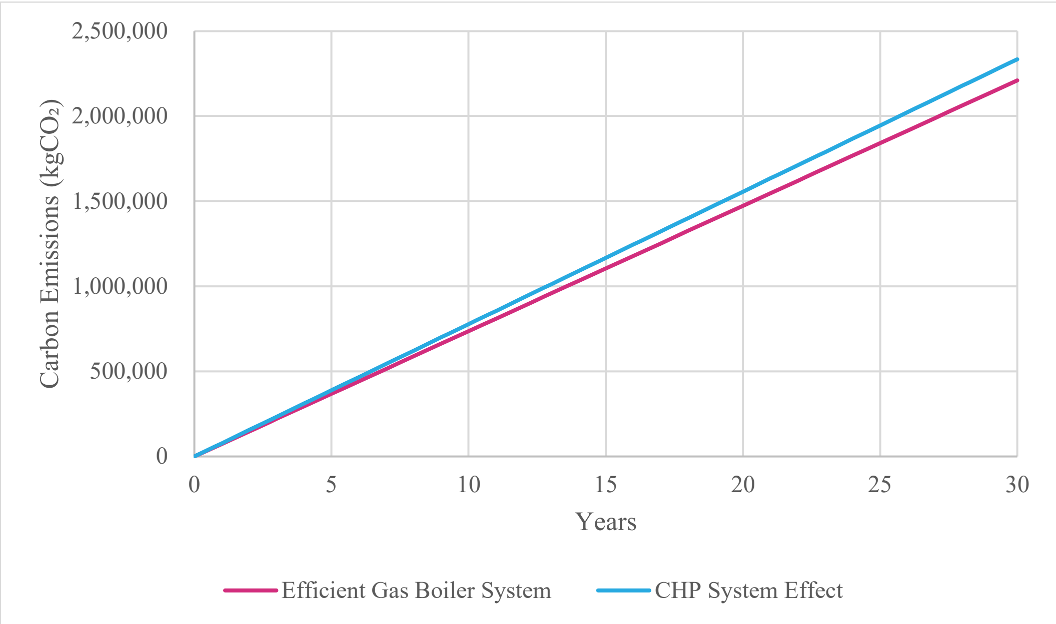

Figure 26 - CHP Whole Life Cycle Carbon Analysis

13.3 Carbon Emissions

Carbon emissions for the CHP system are greater than those of an efficient gas boiler system due to the effects of decarbonisation of the national grid, and the relative thermal inefficiency of the CHP.

13.4 Land Use

The CHP would need to be located within the plant room area of the new development. Exhaust Flue arrangements would need to be considered.

13.5 Local Planning Requirement

There are no additional local planning requirements with CHP.

13.6 Noise

All CHP systems have a prime mover/electrical generator which emits ambient noise into the adjacent area and exhaust noise from the exhaust stream. Most CHP systems also have items of auxiliary equipment which generate noise either continually or intermittently. Designing a CHP installation often involves investigating the effects of the plant room on the existing local noise profile. This should include surveying existing noise levels at relevant points around the site and assessing how each part of the system contributes to the total level.

13.7 Recommendations

Whilst the payback period is relatively short, CHP will not be considered further. The primary issue is that the school does not have the constant, year-round heating demand needed to make CHP an efficient and cost-effective technology. CHP does not perform as well as the other technologies considered at reducing CO_2.

14 Hydro Electric Generation

Figure 27 - Typical Hydro Electric Turbine Image – ©Nautilus Turbines

Hydroelectric power is one of the most promising renewable energy resources for electricity generation. Hydro turbines like their wind counterparts generate electricity from momentum. In this instance the momentum comes from naturally flowing rivers or streams. Hydroelectric turbines are a well-established technology with lower maintenance costs than some of the alternatives. However suitable waterways with appropriate head and flow rates rarely pass through a development site.

14.1 Hydro Advantages

Hydroelectric turbines have huge potential to generate electricity from a natural resource. They have quick payback times and are viable without the substantial feed in tariff that is available.

14.2 Hydro Limitations

Hydroelectric turbines are limited in their feasibility, only a handful of sites with waterways are suitable.

14.3 Hydro Feasibility Assessment

To assess the suitability of the site for hydro technology the site must have an adequate head of water with a suitable flow rate to ensure sufficient strength to generate the energy required. The environment and animals in the local waterway need to be taken into consideration.

Estimated Electrical Energy Requirements for the site = 309,570 kWh. A 22kW system size can generate 192,192 kWh/Year.

The body of water may not have sufficient current, or level difference to install a hydroelectric system.

Based on Hydroelectric System Size 22 kW		
Capital Costs	-	£134,694
Fuel Costs	No Fuel Cost	-
Operating & Maintenance Costs	1.7% of Capital Cost	£2245 per annum
CO_2 Reduction Potential	-	44.8 tCO_2 per annum

Table 11 – Hydroelectric feasibility study

14.4 Hydro Electric Whole Life Cycle Assessment

A whole life cycle cost analysis for the Hydroelectric system has been completed based on net present values, in comparison with grid electric over a period of 30 years.

The analysis demonstrates that payback for the Hydroelectric installation is achieved within 5 years. The whole life cost of a Hydroelectric installation is estimated at £1,312,261 over 30 years, in comparison with £3,105,689 for electric installation. Therefore, the hydroelectric installation can be expected to save £1,793,427 over its 30-year life cycle.

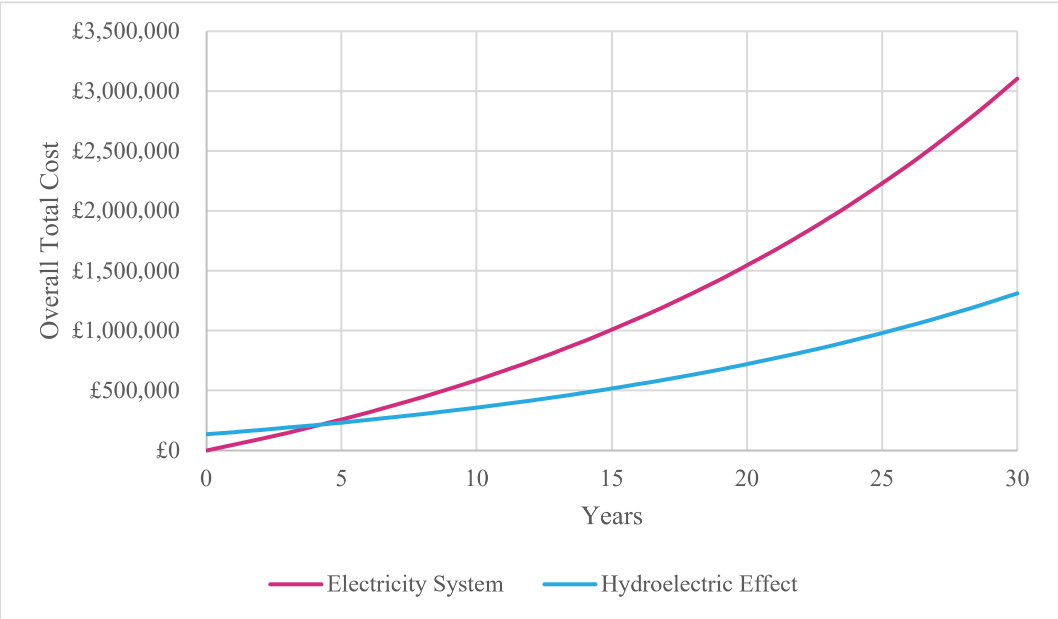

Figure 28 – Hydro Electric Whole Life Cycle Cost Analysis

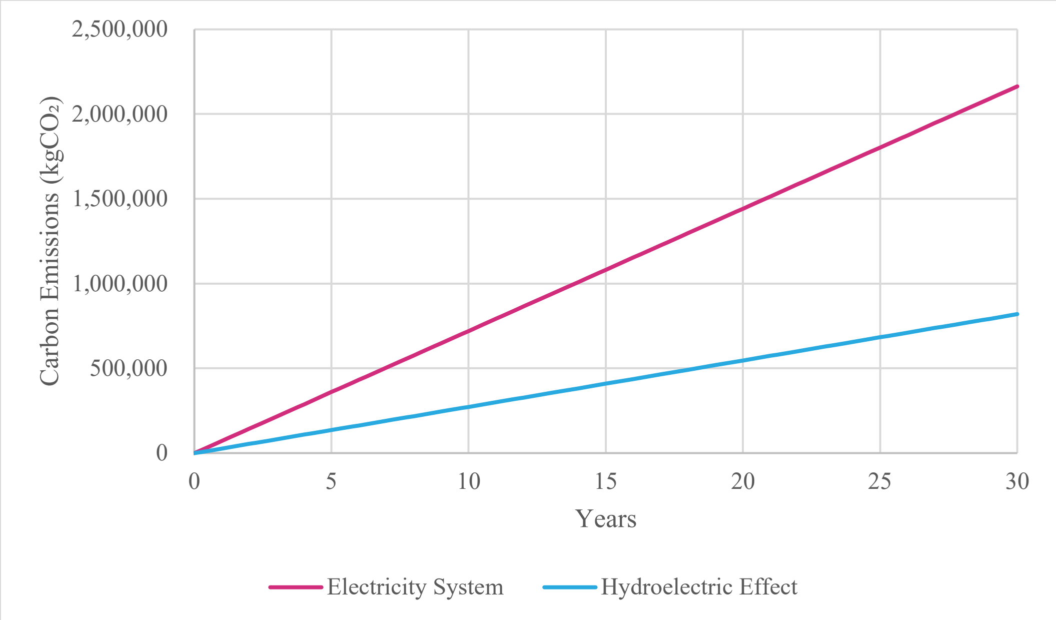

Figure 29 – Hydro Electric Whole Life Cycle Carbon Analysis

14.5 Carbon Emissions

The annual reduction in CO_2 emissions is calculated using estimations. To calculate the reduction, assumptions as detailed in Approved Document Part L2A have been used.

14.5.1 Cost/Tonne CO_2 Saved Over Lifetime

Assuming a life span of 30 years, the life cycle cost of a photovoltaic system is calculated as follows:

$$Cost\ per\ Tonne = \frac{Capital\ Cost + \left(Lifetime * (Fuel\ Cost + Maintenance)\right)}{Lifetime * CO_2\ Reduction}$$

$$Cost\ per\ Tonne = \frac{£150}{Tonne\ CO_2}$$

14.6 Land Use

The size and position of the turbine would need to be discussed further in the design process.

14.7 Local Planning Requirements

Planning permission would be required as hydro turbines can only be located within permitted water ways.

14.8 Noise

This type of technology does generate some acoustic issues that would need to be considered when looking at its size and location.

14.9 Exporting Electricity from the System

It is not viable to export the limited amount of electricity generated.

14.10 Recommendations

Although Hydroelectric has promising carbon reductions, there is not a significant body of water with a suitable flow to drive the turbine. Therefore, hydroelectric should not be taken further.

15 Grey Water Heat Recovery

Grey water is water that was originally supplied as wholesome water and has already been used for bathing, washing, laundry or washing dishes. It does not include wastewater from toilets or urinals – this is referred to as black water.

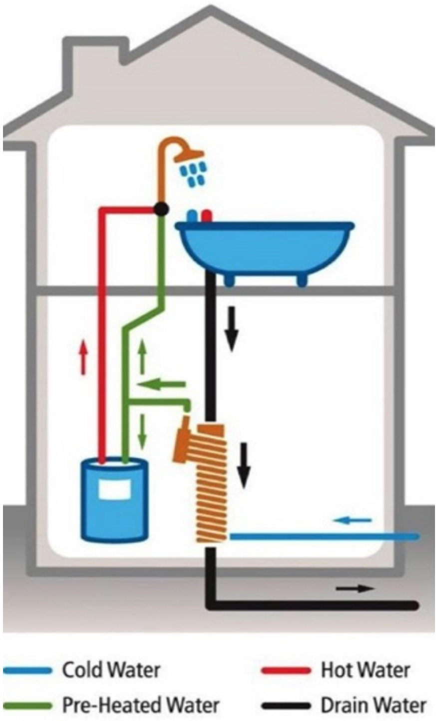

Figure 30 - Grey water heat recovery example

Grey water heat recovery is the process of extracting heat from grey water and using it to warm the incoming mains water. A heat exchanger is used to transfer the heat from warm drain water to the incoming flow of cold water heading towards the water heater (*Figure 30*). This means less energy is required to heat the cold mains water up to temperature.

Most applications of grey water systems are in buildings with a high domestic hot water load. This mainly includes those where bathing or showering takes place, as bathing water is the easiest to collect and treat. All buildings however produce some grey water from handwashing.

15.1 Grey Water Heat Recovery Advantages

- Grey water is only at useful temperatures when there is a hot water demand. This is an advantage as the technology is operational only when hot water is being used.
- The amount of energy needed to heat cold mains water up to temperature is reduced.
- Requires very little maintenance.

15.2 Grey Water Heat Recovery Limitations

- Generally only cost effective when the building uses a high volume of hot water, mainly bath and shower water.

15.3 Recommendations

The majority of grey water produced in the school will be from handwashing. There are shower facilities in the school, but it is unlikely that these will be used regularly. As there will not be sufficient waste bath and shower water, the technology is not cost effective. It is not recommended to investigate grey water heat recovery any further.

16 Summary and Recommendations

This report has considered the use of a number of LZC technologies as part of the overall energy strategy for the proposed Mynydd Isa Campus. In each case the feasibility has been assessed in terms of energy produced; cost; payback period (simple and life cycle); carbon savings and logistics including site constraints. A summary of the findings is presented below.

The reduction of energy consumption and carbon emissions for the new building has been considered by firstly driving down energy demand through passive measures, then by focusing on energy efficiency, and finally by assessing LZC technology options.

Figure 31 provides a summary of the capital costs and carbon savings for each LZC technology considered. The bars show the capital costs of each piece of equipment, and the blue dots shows the cost per tonne of CO_2 saving (note CHP does not save any CO_2).

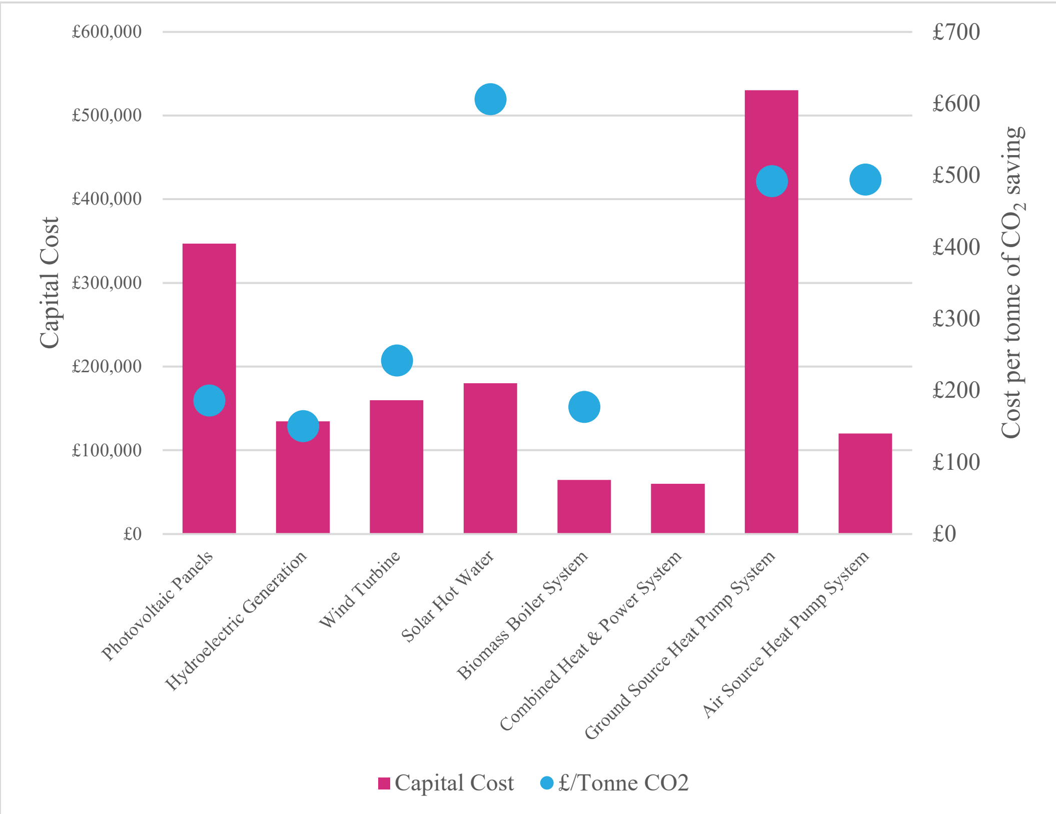

Figure 31 - Cost vs Carbon Savings Feasibility Summary.

The following technologies have been considered and discounted:

Solar hot water panels have been discounted as the system costs are relatively large and the payback time is high now that the renewable heat incentive has been discontinued. The DHW load could be more efficiently generated by an air source heat pump. The technology also has a very high cost per tonne of CO_2 saving.

The main issue with this technology is the load matching. The school does not provide a constant DHW demand meaning the system would either be oversized leading to hot water being stored for long periods of time causing legionella risk, or it would be undersized thus reducing its benefit significantly.

Not selecting SHW would have the added advantage of leaving valuable rooftop space free for a PV array.

A ***biomass boiler system*** has been shown to not pay for itself within the 30-year time period. Also, there needs to be a consideration for the space necessary for a biomass boiler, the storage needed for the wood pellets/chips within the building boundaries and the noise disruption from fuel deliveries.

Similarly to SHW, biomass boilers are less suited to on/off peak demand operation meaning there will be load matching issues.

A ***ground source heat pump*** will not be considered for the development as the associated capital costs are very high compared to other technologies. GSHP will not pay for itself within the 30-year time period with no RHI scheme. The coal mines on site also mean that only horizontal boreholes can be used.

Due to the location of the development, a ***wind turbine*** would be unfeasible, this is primarily due to the space available and acoustic impact of locating a wind turbine on the site.

A ***combined heat and power*** (CHP) system does not save any CO_2 in its life span. This is due to the nature of the plant, i.e. it uses gas to generate power (with low efficiency) and harvests waste heat to provide heat to the building. However, this issue has been further compounded by the decarbonisation of the electrical grid. This technology is also more suited to buildings with constant heat loads as the CHP is able to run more efficiently. The school does not provide this.

Hydropower would be unfeasible in this instance due to a lack of a suitable body of water.

As the school does not produce enough wastewater from baths and showers***, Grey Water Heat Recovery*** will not be investigated further.

The connection onto a ***Heat Network*** was not considered for this project as there is not currently one in the local vicinity.

16.1 Recommended Technologies

The following sections name the technologies that have been selected for further design development.

16.1.1 Photovoltaic Panels

Solar photovoltaics (PV) are recommended as part of the overall energy strategy for the development for the following reasons:

- PV panels will provide a reasonable reduction in the developments imported electrical power, and hence carbon emissions.

- The simple payback period is about 8 years. There is also a positive Life Cycle Saving (*Table 1*) which suggests installing PV will save £2,134,395 over 30 years when compared to installing an electricity system.
- Comparatively low cost per tonne of CO_2 saved. It is estimated that installing PV can save 2163 tonnes of CO_2 over 30 years.
- The current architectural strategy means that a large roof area is available to facilitate a large area of PV installation. Building Integrated PV is also an option to maximise the amount of PV on the roof.
- Currently for compliance with Part L and BREEAM the minimum coverage from a PV array is 60m^2.

Batteries should be considered to store the excess energy generated by the PV over the summer months.

16.1.2 Air Source Heat Pumps

Air source heat pumps are an efficient and reliable technology. From the LZC report, the air source heat pump is the preferred solution for providing heat to the development.

Although they do not pay back financially following the removal of the renewable heat incentive, they do result in a large CO_2 saving and will make a significant contribution to achieving the zero carbon requirements for the school. It is estimated that installing ASHP technology can save 2,523 tonnes of CO_2 over 30 years.

At the current fuel costs detailed in Section 6.5, ASHPs do not pay back financially. However, it is likely that this will change over time as the government look to decarbonise the grid and potentially introduce financial penalties for gas usage. It should be noted that it is still very unclear what will happen in the future but given the pressure to achieve zero carbon this type of shift seems likely.

This technology can also improve air quality, which is especially important in relation to the Covid-19 pandemic and the need for clean, ventilated air.

Appendix B

BREEAM 2018 Pre Assessment Report

MIMWEP | Flintshire County Council

Mynydd Isa Campus, Flintshire

Annex F - BREEAM 2018 Pre-Assessment Report

Appendix F

Final | 10 March 2021

Job number 280340

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ARUP

Contents

1 Introduction

Arup has been appointed by MIMWEP | Flintshire County Council to provide BREEAM Assessor and Advisory Professional (AP) services for the proposed development, **Mynydd Isa Campus, Flintshire** . This Pre-Assessment report summarises the agreed BREEAM scoring targets and highlights key early actions required of the project team to ensure that the target scoring can be achieved.

The project, located in the village of Mynydd Isa, Flintshire, is an education building which will combine Mynydd Isa Primary School and Argoed High School into a new building on a single site, with a gross internal area requirement of 10,319 m^2. Both the Primary School and the High School will remain as separate schools but will operate within a single building with some shared facilities.

The building will provide for the following:

- The new Primary School to accommodate 600 places with a 42 place Nursery and a 20 place Speech and Language Specially Resourced Provision facility
- The High School will accommodate 700 places with a 10 place Speech and Language Specially Resourced Provision facility and a 20 place Asperger's Specially Resourced Provision facility.

Argoed High School, currently situated on the site, will continue to operate during the construction of the new building.

The proposed development is required to achieve a BREEAM rating of *Excellent*. The purpose of this report is to set out how this will be achieved in line with the agreed scoring strategy and to highlight the design team's responsibilities in relation to achieving this.

An Initial Review of BREEAM scoring potential was undertaken during RIBA Stage 1 (October 2020) and a Pre-Assessment workshop has been carried out during RIBA Stage 2 in collaboration with WEPCo, Sheppard Robson and the Arup multidisciplinary team to formally agree the scoring target.

The building will be assessed as a **Public – Education** building type (according to the BREEAM non-domestic building type classifications) and with a **Full-fitted** assessment scope. The assessment has been registered with the BRE under the BREEAM 2018 UK NC scheme (reference number: BREEAM-0087-7563).

The Pre-Assessment assumes that the project will consist of one building – if the design is to result in separate buildings (i.e. separate distinct thermal envelopes) then an alternative assessment approach (e.g. 'similar buildings') may be required.

Following the Pre-Assessment Workshop on 7th January 2021, the team have finalised the BREEAM 2018 targets prior to the end of Concept Design (RIBA Stage 2).

This Pre-Assessment was undertaken by licensed BREEAM Assessor:

Ryan Blakeley BREEAM Assessor (RB78)

email: ryan.blakeley@arup.com

Arup's BREEAM AP has provided input to the Initial Review and Pre-Assessment process in order to identify risks and opportunities, and ensure that the assessment and target scoring strategy are robust and maximise performance against BREEAM:

Tom Slater BREEAM AP (BREEAMAP0588)

email: tom.slater@arup.com

This report contains estimated ratings with the assumption that equal importance will be applied to each of the BREEAM categories for the purposes of illustrating the credits which need to be achieved in each category.

This Pre-Assessment report is based on the **Mynydd Isa Campus, Flintshire** building being assessed using the BREEAM UK New Construction 2018 scheme as a single Public – Education building with a Fully-fitted scope.

1.1 About BREEAM

BREEAM UK New Construction 2018 is a performance-based assessment method and certification scheme for new buildings. The primary aim of BREEAM New Construction is to mitigate the life cycle impacts of new buildings on the environment in a robust and cost-effective manner. This is achieved through integration and use of the scheme by clients and their project teams at key stages in the design and procurement process.

It is important to recognise that BREEAM reflects the overall performance of the building rather than the opportunities or limitations placed on specific stakeholders involved in the procurement process. This means that the client, design team, principal contractor and BREEAM Assessor, as well as other specialist disciplines, have important roles to play if the desired performance levels are to be achieved and reflected through the certified BREEAM rating. However, the onus of orientating the brief towards sustainability needs to come first and foremost from the client.

Our early involvement will ensure that realistic targets are set, appropriate responsibilities can be defined and understood and low or 'zero cost' solutions to environmental impacts can be sought and applied wherever possible.

This certification process measures the performance of the building against the Building Research Establishment's established criteria; the results are quantified by a number of individual measures and associated criteria stretching across a range of sustainability issues:

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

Each category comprises a number of credits. Credits are achieved through satisfying the requirements of these credits.

Once all the credits have been assessed, a percentage score for each category is calculated, and an environmental weighting applied to give an overall percentage score and rating (*Pass* ≥30, *Good* ≥45, *Very Good* ≥55, *Excellent* ≥70 or *Outstanding* ≥85).

Following the Initial Review, the BREEAM assessment is to be undertaken at two main stages of the development process:

- Design & Procurement Assessment
- Post Construction Review

The design and construction at **Mynydd Isa Campus, Flintshire** will be assessed using the BREEAM UK New Construction 2018. Evidence will be provided by the project team to demonstrate compliance with the requirements of the targeted credits, including RIBA Stage-stipulated deliverables and final Stage 4 design information, and ultimately, final post-construction stage evidence.

1.2 The BREEAM Pre-Assessment

Given the wide scope of the BREEAM credits, it is useful to review the Pre-Assessment checklist at an early stage. The process will increase the familiarity of the design team with BREEAM requirements, and should help to achieve a higher BREEAM rating and reduce costs associated with retrofitting building systems, etc.

It is important to note that estimated ratings may differ from those obtained through a formal assessment, which requires the submission of robust evidence to support each credit claimed. This exercise is typically carried out upon completion of the tender stage documentation, for the Design & Procurement assessment.

The BREEAM Pre-Assessments for the proposed development identify how the scheme can secure the necessary percentage scoring in order to gain the required BREEAM ratings.

This Pre-Assessment is based on the Arup Initial Review and the subsequent Pre-Assessment workshop with the project team to identify the most appropriate route to achieving the BREEAM *Excellent* rating, and integrating sustainable solutions within the design process.

Summary of Pre-Assessment Scoring

Mynydd Isa Flintshire Campus		
Baseline	Net Zero Carbon	Potential
73.18%	**82.80%**	**90.08%**
Excellent	*Excellent*	*Outstanding*

Refer to Appendix A for the latest pre-assessment tracker document which includes a full breakdown of credits.

Scenarios

The *Baseline* scenario identifies credits which are expected to be achieved through compliance with the project brief or those which provide to most cost-efficient scoring uplift.

The *Net Zero Carbon* scenario reflects the baseline score, but with additional Energy and Materials credits resulting from studies and performance associated with achieving net zero.

The *Potential* scenario identifies credits which could feasibly be achieved by the project, but which are likely to result in additional cost uplift and/or Contractor risk, or where current site information (e.g. Pol 03 Surface Water Run-off) is insufficient for these credits to robustly sit in the baseline scenario.

The baseline and potential credits should also be reviewed by relevant specialists to ensure that the scoring strategy is robust and feasible, and to identify any opportunities for scoring uplift. A scoring margin of 5% over the required rating threshold should be targeted and maintained.

2 BREEAM New Construction 2018

The Pre-Assessment tracker below indicates the team member who is responsible for ensuring that each targeted credit is achieved. It should be noted that while this tracker indicates a design team member assigned responsibility for each credit, some credits will require input from several design team members. Design team members should therefore make themselves familiar with all credits that may require their input.

The project team during the Concept Design of the project includes:

Design Team Role	Company
Client	WEPCo
Project Manager	WEPCo
Cost Consultant	Glyndwr
Architect	Sheppard Robson
Mechanical and Electrical	Arup
Public Health	Arup
Civil and Structures	Arup
Transport	TTP Consulting
Acoustician	Arup
Ecologist	*TBC*
Landscape Architect	Ares
FM / Life Cycle	WSP
Sustainability (incl. BREEAM AP)	Arup
BREEAM	Arup

3 Design Team RIBA Stage 2 Actions

The Pre-Assessment workshop highlighted early concept stage actions and deliverables which need to be completed to ensure that time-bound credits can be achieved and that necessary actions enabling credits to be awarded later are undertaken. A RIBA Stage 2 BREEAM actions tracker document has also been issued to the team.

Outlined in the table below are the actions that need to be undertaken during RIBA Stage 2 of the design process to allow the BREEAM targets to be achieved.

Credit Issue	RIBA Stage 2 Requirement
Man 01 Project Delivery Planning	The project delivery stakeholders have met to identify and define their roles, responsibilities and contributions for each of the key phases of project delivery. Third party stakeholders have been consulted by the design team. Consultation feedback has been given to, and received by, all relevant parties. **Arup Sustainability** to liaise with **WEPCo** to collate the information to evidence the early stage consultation. A template document has been provided by Arup to WEPCo to assist in the compilation of evidence.
Man 01 Stakeholder Consultation	The design team consult with all interested parties on matters that cover the minimum consultation content. Note: **Sheppard Robson** to lead consultation and provide evidence to demonstrate independence of the consultation process.
Man 01 BREEAM Advisory Professional	**Arup Sustainability** have been involved in the project from inception (and since Framework level) to encourage and maximise potential for BREEAM scoring across the site.
Man 02 Elemental Life Cycle Cost (LCC)	**WSP** to carry out Stage 2 Elemental LLC deliverable: A ‘competent person’ carries out an outline, entire asset elemental life cycle cost plan together with any design options appraisals in line with ‘Standardised method of life cycle costing for construction procurement’ PD 156856:2008.
Hea 02 Indoor Air Quality	**Arup MEP** to produce a site-specific indoor air quality plan (in accordance with Guidance Note GN06.
Hea 06 Security	**Sheppard Robson** to engage a Suitably Qualified Security Specialist (SQSS) (e.g. an Architectural Liaison Officer from the local police force) to conduct an evidence-based Security Needs Assessment (SNA) and develop a set of security recommendations to be implemented into the design.
Ene 04 Low Carbon Design	**Arup MEP** to undertake a feasibility study into the use of Low and Zero Carbon energy technologies on site. **Arup MEP** should also document the passive design strategy developed during the RIBA Stage 2 passive design analysis workshop.
Tra 01 Travel Plan	A site-specific transport assessment (or travel statement) and draft travel plan must be prepared no later than RIBA Stage 2. The travel assessment must cover the Tra 01 minimum content.

Mat 01 Environmental Impacts from Construction Products - Building (LCA)	During Concept Design, four superstructure and six substructure/hard landscaping design options must be modelled in a BREEAM-approved LCA tool (OneClick LCA) and the results incorporated into decision-making. The design team have carried out initial studies of certain elements to inform the early design strategy. **Arup Sustainability** will undertake the modelling of a shortlist of options in OneClick LCA using Stage 2 design information provided by **Sheppard Robson, Ares** and **Arup Structures**.
Mat 03 Responsible Sourcing of Construction Products	A sustainable procurement plan was drafted by Arup Sustainability at RIBA Stage 1. This must be used by the **design team** to guide specification towards sustainable construction products to include sustainability aims, objectives and strategic targets to guide procurement activities. The procurement plan will be updated as necessary during subsequent RIBA Stages.
Mat 06 Material Efficiency	Arup Sustainability issued a Material Efficiency Framework during RIBA Stage 1 which established aims, objectives and targets, and set out a framework to guide material efficiency activities. During RIBA Stage 2, a Materials and Waste workshop has explored potential opportunities to maximise material efficiency in line with principles set out in BS 8895 Designing for material efficiency in buildings projects - Part 1 and WRAP Designing out Waste: A design team guide for Buildings. It has been agreed that the **design team** will provide a narrative in their RIBA Stage 2 reports summarising the measures taken to enhance material efficiency at Stage 2, and opportunities to explore in RIBA Stage 3.
Wst 01 Pre-demolition Audit	It is a requirement that a pre-demolition audit of existing structures and hard surfaces on the site is carried out at RIBA Stage 2 by a competent person (e.g. a demolition contractor). This timing requirement is relaxed where it can be demonstrated that the timing of the pre-demolition audit (where carried out after RIBA Stage 2) has not compromised its ability to influence the design, consideration of materials re-use and the setting of targets for wase management. Due to Covid-19 restrictions, and that demolition works on the site will not commence until after the new school is constructed, it has been agreed that the pre-demolition audit will be carried out at a later stage (to feed into landscaping design). The audit must cover the scope prescribed by Wst 01 and also guide the design, consider materials for reuse and set targets for waste management. Action: **WEPCo** to appoint a competent person to undertake pre-demolition audit when feasible.
Wst 05 Adaption to Climate Change	**Arup Structures** will undertake a climate change adaptation risk assessment and strategy appraisal to identify risks posed by a changing climate over the building's life cycle to the resilience of structure, fabric, building services and renewables, and to develop recommendations to mitigate risks. The design team, namely **Arup MEP** and **Sheppard Robson**, will provide input.
Wst 06 Design for Disassembly and Adaptability	**Sheppard Robson** to conduct a study, with input from **Arup MEP and Structures** to explore the ease of disassembly and the functional adaptation potential of different design scenarios, and develop recommendations that aim to enable and facilitate disassembly and functional adaptation, in line with the Wst 06 methodology.

LE 02-05 Ecological Impact	**Ecologist** to carry out a survey and evaluation of the site and provide specialist advice and recommendations in order to identify and manage risks to ecology, influence early decisions and support ecological enhancement in line with ecology assessment Route 2. The **Ecologist** shall also complete the GN40 Ecology Checklist.

4 Identified Key Issues, Early Warnings and Risks

In addition to the RIBA Stage 2 actions discussed in section 3, the credits below need to be investigated further by the project team in order to maximise the scoring that can be achieved during the design stage. These items relate to credits which are key issues to be tracked as the design develops, those which have actions to be aware of, potentially requiring early input and deliverables, credits requiring further investigation at an early stage to ensure that the target scoring is robust and realistic, and credits which have challenging technical/performance requirements or are considered to be risks which need to be considered early:

Credit Issue	Comment	Owner	Key Issue / Warning / Risk
Various (Man 03, Wst 01, Ecology)	**Demolition and Site Management** In addition to Employers Requirements for the main construction works, a number of BREEAM requirements will also need to be written into demolition contract documents. This includes requirements and procedures for construction site management and waste targets.	WEPCo	W
Hea 07 Safe Access	The requirements of the Safe Access credit should be reviewed and embedded into the early site and landscaping concepts.	Ares / Sheppard Robson	W
Ene 01 Reduction of Energy Use and Carbon Emissions	Throughout each RIBA Stage it is important to monitor the energy performance of the proposed building through dynamic modelling. The minimum requirements for BREEAM *Excellent* is four credits for this issue. Building performance as well as additional energy modelling (in accordance with TM54 and BREEAM GN32) will support the award of further Ene 01 credits.	Arup MEP	KI
Tra 02 Sustainable Transport Measures	The sustainable transport measures which make up the four-credit baseline score are: - >10% EV charging provision (1) - Car sharing group with priority spaces (1) - Cycle storage (1) - Existing amenities (1) A dedicated bus service, providing transfer to the local population centre, public transport interchange or a door-to-door service would provide an additional three credits.	WEPCo / Sheppard Robson / TTP Consulting	W
Mat 01 Environmental Impacts from	The embodied impacts of materials must be assessed in line with the BREEAM Mat 01 LCA methodology. This includes	Design Team / QS / Arup Sustainability	KI

Construction Products - Building Life Cycle Assessment (LCA)	undertaking an LCA of the requisite number of design options using a BREEAM-approved LCA tool. This exercise will be undertaken in coordination with early embodied carbon calculations carried out by the design team. The Mat 01 LCA options appraisal will provide robust environmental impact data to further embed embodied environmental impacts into the decision-making process during RIBA Stage 2. Information on materials and quantities for the options being appraised will need to be provided by the **design team** (and if necessary, the cost consultant) when the design is sufficiently fixed, to enable the options to be modelled and appraised.		
LE 02-05 Ecology	**Ecologist** to undertake site survey and evaluation in order to verify the target scoring for Ecology credits. Advice and recommendations should be given to the design team to ensure that the necessary scoring targets can be achieved and then any potential uplift can be capitalised on.	WEPCo / Ecologist (TBC)	**R**
Pol 03 Surface Water Run-Off	It is understood that under Welsh policy, a Flood Consequences Assessment (FCA) will not be required for this site. **Arup Civils** shall provide a note to confirm probability of flooding, confirm the BREEAM Pol 03 scoring position and support the design of any necessary drainage measures to achieve the target score. An early review of the Pol 03 requirements by the Civil engineer supports the current pre-assessment scoring (i.e. low risk of flooding (two credits), one Surface Water Run-off credit and one potential Surface Water Run-off credit.	Arup Civils	**W**

5 Overall BREEAM 2018 Target

This report has been prepared by Ryan Blakeley, with review and input from Tom Slater, during RIBA Stage 2 in order to facilitate the setting of highest BREEAM related performance targets for the project.

Building	Scheme	Baseline	Net Zero Carbon	Potential
Flintshire Campus Mynydd Isa	New Construction 2018: Education	73.18%	82.80%	90.08%
		Excellent	*Excellent*	*Outstanding*

To achieve these targets, the BREEAM process must be embedded into early design and decision-making, as well as through design development in order to ensure that the cost-neutral and time constrained credits are targeted and actioned during the necessary design stage. The design team will need to be aware of the key milestones and make sure that compliant evidence is provided to meet the requirements of each credit criteria.

Currently both the *Baseline* and the *Net Zero Carbon* scenario scores exceed the necessary scoring threshold required to achieve the target rating of *Excellent* (>70%).

A score of >75% (for *Excellent*) should be targeted at the design stage submission in order to protect the final score at completion against the potential loss of credits during design development, construction and auditing.

A number of credit requirements need to be reviewed by specialist consultants, and early actions taken, to ensure that the targeted credits are achievable and that any necessary early actions are taken. Credits identified as 'potential' should be reviewed and, where possible, moved into the baseline target scenario in order to increase the scoring margins over the required thresholds.

The potential score indicates that there may be additional credits achievable based on further investigation and design development, but feasibility will be based on further discussion with the design team and client.

Tracker Plus

Arup propose using the Tracker+ website as an online management portal to upload and collate all the information for the design and post construction phases from RIBA Stage 3 onwards.

The project will be set up online and the design team will be able to access the site and view the targeted credits and credit requirements. Lead design team members will receive an email that they can follow to the site http://tracker-plus.co.uk/index.php?p=breeam

Information and evidence can then be uploaded against specific credits and particular requirements.

Appendix A

BREEAM 2018 Pre-Assessment Tracker

ARUP

BREEAM 2018 Pre-Assessment
Public | Education
Fully Fitted

Project Name: Mynydd Isa Campus, Flintshire
Date: 09/03/2021
Project Number: 280340
Issue: Pre-Assessment
Stage: MIM WEP Stage 1
RIBA Stage 2
Revision: 1.4

Completed by: Ryan Blakeley
Reviewed by: Tom Slater
Tracker Version 1.0

* Reference must be made to the current Technical Manual (SD5078: 3.0) for full credit requirements *

Target
Very Good = 55%
Excellent = 70%
Outstanding = 85%

Mynydd Isa Campus, Flintshire		
Baseline	**Potential**	**Net Zero Carbon**
73.18%	90.08%	82.80%
Excellent	**Outstanding**	**Excellent**

Key
Risk Credit
Potential credit to target
Action/Input required at early stage
Credit not currently targeted
Mandatory credit to achieve Excellent rating

	Credit Issues	Ref	Credits					Design Team Member Responsible	Target Action Stage		Outline Design Stage Actions/Requirements * Reference must be made to the current 2018 Technical Manual (SD5078: 3.0) for full credit requirements *
			2018	Baseline	Potential	Net Zero Carbon	Weighting		RIBA Stage	MIM WEP Stage	
Management											
Management Section Weighting							**11.00%**				
Man 01	Project Delivery Planning	Criteria 1-3	1	1	1	1	0.52%	Project Manager	Stage 2	Stage 1	The design team will need to meet to identify and define their roles, responsibilities and contributions for each of the key phases of project delivery [Linked to Soft Landings]
	Stakeholder Consultation (Interested Parties)	Criteria 4-7	1	1	1	1	0.52%	Client, Project Manager	Stage 2	Stage 1	Initial Project Brief, Project Execution Plan, Communication Strategy to be provided Evidence of consultation meetings Demonstration of feedback from consultation **'Independent party' must carry out the consultation exercise for education schemes**
	BREEAM AP (Concept Design)	Criteria 8-9	1	1	1	1	0.52%	BREEAM AP	Stage 2	Stage 1	BREEAM AP to be appointed BREEAM to be regular agenda item at DT meetings and produce AP progress reports
	BREEAM AP (Developed Design)	Criteria 10-11	1	1	1	1	0.52%	BREEAM AP	Stage 3	Stage 2	BREEAM to be regular agenda item at DT meetings AP progress reports
Man 02	Elemental Life Cycle Cost (LCC)	Criteria 1-3	2	2	2	2	1.05%	Cost Consultant	Stage 2	Stage 1	An elemental life cycle cost (LCC) analysis has been carried out
	Component Level LCC Plan	Criteria 4-5	1	1	1	1	0.52%		Stage 4	Stage 2	A component level LCC plan has been developed
	Capital Cost Reporting	Criterion 6	1	1	1	1	0.52%		Stage 4	Stage 2	Report the capital cost for the building in pounds per square metre (£k/m2)
Man 03	Environmental Management	Criteria 1-4	1	1	1	1	0.52%	Contractor	Stage 3	Stage 2	The principal contractor operates an environmental management system (EMS) covering their main operations. A Sustainability Champion is appointed to monitor the project to ensure ongoing compliance. The principal contractor evaluates the risks (on site and off site), plans and implements actions to minimise the identified risks. Responsible construction management items to be considered and documented. Responsibility has been assigned to an individual(s) for monitoring, recording and reporting energy use, water consumption and transport data resulting from all on-site construction processes throughout the build programme.
	BREEAM AP (Site)	Criteria 5-6	1	0	1	0	0.00%		Stage 3	Stage 2	
	Responsible Construction Management	Criteria 7-9	2	2	2	2	1.05%		Stage 3	Stage 2	
	Monitoring of Construction Site Impacts	Criterion 10							Stage 3	Stage 2	
	Utility Consumption (Energy & Water)	Criteria 11-18	1	1	1	1	0.52%		Stage 3	Stage 2	
	Transport of Construction (Materials & Waste)	Criteria 19-22	1	1	1	1	0.52%		Stage 3	Stage 2	
Man 04	Testing Schedule and Responsibilities	Criteria 1-5	1	1	1	1	0.52%	MEP Contractor	Stage 3-4	Stage 2	A schedule of commissioning and testing
	Commissioning - Design and Preparation	Criteria 6-7	1	1	1	1	0.52%	MEP Contractor	Stage 3-4	Stage 2	A specialist commissioning manager is appointed
	Testing and Inspecting Building Fabric	Criteria 8-10	1	1	1	1	0.52%	Contractor	Stage 3-4	Stage 2	This can be demonstrated through the completion of a thermographic survey as well as an airtightness test and inspection
	Handover	Criteria 11-12	1	1	1	1	0.52%	Contractor	Stage 3-4	Stage 2	Building User Guide, Training Schedule
Man 05	Aftercare Support	Criteria 1-2	1	1	1	1	0.52%	Contractor	Stage 3	Stage 2	Operational infrastructure and resources in place to provide aftercare support to the building occupier
	Commissioning - Implementation	Criteria 3	1	1	1	1	0.52%	Contractor	Stage 3	Stage 2	Seasonal commissioning activities will be completed over a minimum 12-month period,
	Post Occupancy Evaluation	Criteria 4-7	1	1	1	1	0.52%	Client/Occupier	Stage 3	Stage 2	The client or building occupier makes a commitment to carry out a post-occupancy evaluation (POE) exercise one year after initial building occupation
Total			**21**	**20**	**21**	**20**					
Health and Wellbeing											
Health and Wellbeing Section Weighting							**14.00%**				
Hea 01	Control of Glare from Sunlight	Criteria 1-3	1	1	1	1	0.78%	Architect	Stage 2	Stage 1	Glare control strategy, building to include blinds
	Daylighting	Criterion 4	2	0	1	0	0.00%	Architect	Stage 2	Stage 1	The relevant building areas meet good practice daylight factor(s) **1 credit** (60%), **2 credits** (80%) of area has average daylight factor of 2% plus additional reqs Average daylight illuminance; at least 300 lux for 2000 hours per year or more and at least 90 lux for 2000 hours per year or more at worst lit point
	View Out	Criteria 5-6	1	1	1	1	0.78%	Architect	Stage 2	Stage 1	95% of the floor area in relevant building areas is within 8m of a wall which has a window or permanent opening that provides an adequate view out. The window/opening must be ≥ 20% of the surrounding wall area
	Internal & External Lighting Levels, Zoning & Control	Criteria 7-13	1	1	1	1	0.78%	MEP	Stage 3	Stage 2	Lighting design in compliance with BREEAM requirements
Hea 02	Indoor Air Quality (IAQ) Plan	Criterion 1	Pre-requisite					MEP	Stage 2	Stage 1	Copy of the Indoor Air Quality Plan
	Ventilation	Criterion 2	1	1	1	1	0.78%	MEP	Stage 3	Stage 2	The location of the building's air intakes and exhausts, in relation to each other and external sources of pollution, is designed in accordance with BS EN 13779:2007 Annex A2.
	VOC Emissions from Construction Products	Criterion 3	1	1	1	1	0.78%	Architect	Stage 3	Stage 2	Three out of the five product types meet the emission limits, testing requirements and any additional requirements
	VOC Emissions from Construction Products	Criterion 4	1	0	1	0	0.00%	Architect	Stage 3	Stage 2	All the product types meet the emission limits, testing requirements and any additional requirements
	Post-Construction Indoor Air Quality Measurement	Criteria 5-10	1	1	1	1	0.78%	Contractor	Stage 3	Stage 2	The formaldehyde and TVOC concentration in indoor air is measured post construction
Hea 04	Thermal Modelling	Criteria 1-4	1	1	1	1	0.78%	MEP	Stage 3	Stage 2	Thermal Model Results and thermal modelling analysis has informed the temperature control strategy for the building and its users.
	Design for Future Thermal Comfort	Criteria 5-8	1	1	1	1	0.78%	MEP	Stage 3	Stage 2	The thermal modelling demonstrates that the relevant requirements set out in criteria 3 are achieved for a projected climate change environment
	Thermal Zoning and Controls	Criteria 9-11	1	1	1	1	0.78%	MEP	Stage 3	Stage 2	The thermal modelling analysis has informed the temperature control strategy for the building and its users.
Hea 05	Mandatory Appointment of Acoustician	Criteria 1-2						Client	Stage 1	Stage 1	Acoustician appointed
	Acoustic Performance	Criteria 1-2	3	2	3	2	1.56%	Acoustician	Stage 2	Stage 1	The building meets the appropriate acoustic performance standards and testing requirements
Hea 06	Security of Site and Building	Criteria 1-3	1	1	1	1	0.78%	Architect Security Consultant	Stage 2	Stage 1	A Suitably Qualified Security Specialist (SQSS) conducts an evidence-based Security Needs Assessment and develops a set of security controls and recommendations for incorporation into the proposals.
Hea 07	Safe and Healthy Surroundings - Safe Access	Criteria 1-6	1	0	0	0	0.00%	Architect Transport Consultant	Stage 2-3	Stage 1-2	Dedicated and safe cycle paths and footpaths are provided from the site entrance to any cycle storage, and connect to offsite cycle paths where applicable.
	Safe and Healthy Surroundings - Outside Space	Criterion 7	1	1	1	1	0.78%	Architect	Stage 2-3	Stage 1-2	There is an outside space providing building users with an external amenity area.
Total			**18**	**13**	**16**	**13**					

Credit Issues		Ref	Credits: 2018	Credits: Baseline	Credits: Potential	Credits: Net Zero Carbon	Credits: Weighting	Design Team Member Responsible	Target Action Stage: RIBA Stage	Target Action Stage: MIM WEP Stage	Outline Design Stage Actions/Requirements * Reference must be made to the current 2018 Technical Manual (SD5078: 3.0) for full credit requirements *
Energy											
Energy Section Weighting							**16.00%**				
Ene 01	Energy Performance	Criterion 1	9	4	6	9	4.17%	MEP	Stage 2-4	Stage 1-2	IES Modelling / Part L Compliance. **Four** credits is minimum for Excellent
	Energy Modelling and Reporting	Criteria 2-5	4	4	4	4	2.78%	MEP	Stage 2-4	Stage 1-2	Undertake additional energy modelling to generate predicted operational energy consumption figures based on TM54
Ene 02	Sub-Metering of End-Use Categories	Criteria 1-3	1	1	1	1	0.70%	MEP	Stage 3	Stage 2	Energy metering systems are installed that enable at least 90% of the estimated annual energy consumption includes lifts and provision on TM39 Metering
	Sub-Metering of High Energy Load and Tenancy Areas	Criteria 4-5	1	1	1	1	0.70%	MEP	Stage 3	Stage 2	Other types of single occupancy buildings should use the above lists of function areas as a guide to the level of sub-metering provision required to comply. The above should consider that the aim of the credit is to encourage the installation of energy sub-metering that facilitates the monitoring of in-use energy consumption (in this case by area).
Ene 3	External Lighting	Criteria 1-2	1	1	1	1	0.70%	MEP	Stage 3	Stage 2	Average initial luminous efficacy of not less than 70 luminaire lumens per circuit Watt Automatic control to prevent operation during daylight hours Presence detection in areas of intermittent pedestrian traffic.
Ene 04	Passive Design Analysis	Criteria 1-4	1	1	1	1	0.70%	Design Team	Stage 2	Stage 1	The project team carries out an analysis of the proposed building design/development to influence decisions made during Concept Design stage
	Free Cooling	Criteria 5-8	1	0	0	0	0.00%	MEP	Stage 2	Stage 1	The building uses ANY of the free cooling strategies to meet its cooling demand
	LZC Feasibility Study	Criteria 9-12	1	1	1	1	0.70%	MEP	Stage 2	Stage 1	LZC study and specification of technology
Ene 06	Energy Consumption	Criterion 1	1	1	1	1	0.70%	MEP	Stage 3	Stage 2	Lift analysis to be carried out Energy analysis completed by lift manufacturer
	Lifts	Criteria 2-4	1	1	1	1	0.70%	MEP	Stage 3	Stage 2	Manufacturer's product data
	Escalators or Moving Walks	Criterion 5	0	0	0	0	0.00%	MEP	Stage 3	Stage 2	Where only either lifts, escalators or moving walks are present, only one credit is available for the Energy efficient features credit.
Ene 08	Energy Efficient Equipment	Criteria 1-3	2	2	2	2	1.39%	MEP Client/Occupier	Stage 3	Stage 2	Identify the building's unregulated energy consuming loads and estimate their contribution to the total annual unregulated energy consumption of the building. **Identify procurement of the equipment - likely to be catering, white goods or IT equipment**
Total			**23**	**17**	**19**	**22**					
Transport											
Transport Section Weighting							**10.00%**				
Tra 01	Transport Assessment and Travel Plan	Criteria 1-5	2	2	2	2	1.67%	Client Transport Consultant	Stage 2	Stage 1	During the feasibility and design stages, develop a **travel plan** based on a site-specific travel assessment or statement.
Tra 02	Sustainable Transport Measures	Criteria 1-3	10	4	7	4	3.33%	Architect Transport Consultant	Stage 2	Stage 1	Suitable measures have been installed e.g. cycle facilities, electric parking, etc. Baseline based on (*points*): - >10% EV charging provision (1) - Car sharing group & priority spaces (1) - Cycle storage (1) - Existing amenities (1) **Potential:** **- Dedicated bus service (3) (+2.5%)?** Existing private coach system which may continue
Total			**12**	**6**	**9**	**6**					
Water											
Water Section Weighting							**7.00%**				
Wat 01	Water Performance 12.5%	Criteria 1-4	1	1	1	1	0.88%	Architect MEP Contractor	Stage 3	Stage 2	The water consumption (L/person/day) for the assessed building is compared against a baseline performance.
	Water Performance 25%		1	1	1	1	0.88%		Stage 3	Stage 2	
	Water Performance 40%		1	1	1	1	0.88%		Stage 3	Stage 2	
	Water Performance 50%		1	0	1	0	0.00%		Stage 3	Stage 2	Where a greywater and/or rainwater system is specified, its yield (L/person/day) is used to off-set non-potable water demand from components that would otherwise be supplied using potable water.
	Water Performance 55%		1	0	1	0	0.00%		Stage 3	Stage 2	
Wat 02	Water Monitoring	Mandatory Criterion 1	Pre-requisite					MEP Contractor	Stage 3	Stage 2	The specification of a water meter on the mains water supply to each building
		Criteria 2-6	1	1	1	1	0.88%		Stage 3	Stage 2	Water-consuming plant or building areas, consuming 10% or more of the building's total water demand, are either fitted with easily accessible sub-meters
Wat 03	Water Leak Detection and Prevention	Criteria 1-2	1	1	1	1	0.88%	MEP Contractor	Stage 3	Stage 2	A leak detection system is specified
		Criterion 3	1	1	1	1	0.88%		Stage 3	Stage 2	Flow control devices are specified
Total			**8**	**6**	**8**	**6**					
Materials											
Materials Section Weighting							**15.00%**				
Mat 01	Environmental Impacts from Construction Products - Building Life Cycle Assessment (LCA)	Criteria 1-5	6	4	4	6	4.29%	Architect Structural Engineer Carbon Consultant	Stage 2-4	Stage 1-2	Breakdown of materials and quantities for multiple design options Design Drawings LCA Tool Outputs
	Substructure and Hard Landscaping Options	Criteria 6-7	1	1	1	1	1.07%	Landscape Architect Carbon Consultant	Stage 2	Stage 1	
Mat 02	Environmental Impacts from Construction Products - Environmental Product Declarations (EPD)	Criteria 1-2	1	0	1	0	0.00%	Architect	Stage 3	Stage 2	Detailed description of the applicable elements Relevant clause in specification
Mat 03	Responsible Sourcing of Timber	Criterion 1	Pre-requisite					Architect Contractor	Stage 3	Stage 2	Legally harvested and traded timber
	Enabling Sustainable Procurement	Criterion 2	1	1	1	1	1.07%	Client / PM Contractor	Stage 1	Stage 1	The principal contractor sources materials for the project in accordance with a documented sustainable procurement plan
	Measuring Responsible Sourcing	Criterion 3	3	2	2	2	2.14%	Contractor	Stage 3	Stage 2	Where the applicable building materials are responsibly sourced in accordance with the BREEAM methodology
Mat 05	Designing for Durability and Resilience	Criteria 1-4	1	1	1	1	1.07%	Architect	Stage 3	Stage 2	**Protecting vulnerable parts of the building from damage** The building incorporates suitable durability and protection measures **Protecting exposed parts of the building from material degradation** The relevant building elements incorporate appropriate design and specification measures to limit material degradation due to environmental factors.
Mat 06	Material Efficiency	Criteria 1-3	1	1	1	1	1.07%	Design Team Contractor	Stages 1-5	Stages 1-3	Opportunities have been identified, and appropriate measures investigated and implemented, to optimise the use of materials in building design, procurement, construction, maintenance and end of life.
Total			**14**	**10**	**11**	**12**					
Waste											
Waste Section Weighting							**6.00%**				
Wst 01	Pre-Demolition Audit	Criteria 1-3	1	1	1	1	0.60%	Contractor	Stage 2	Stage 1	Pre-Demolition Audit completed for any existing buildings, structures or hard surfaces.
	Construction Site Waste Management	Criteria 4-5	3	2	2	2	1.20%		Stage 3	Stage 2	Resource Management Plan (RMP) has been developed * One Credit <11.1 tonnes * **Two Credits <6.5 tonnes** * Three Credits <3.2 tonnes
	Diversion from Landfill	Criteria 6-7	1	1	1	1	0.60%		Stage 3	Stage 2	Non-hazardous construction (on-site and off-site manufacture/fabrication in a dedicated facility), demolition and excavation waste generated by the project have been diverted from landfill: *Non-Demo 80% * Demolition 90%
Wst 02	Use of Recycled and Sustainably Sourced Aggregates	Criteria 1-6	1	0	0	0	0.00%	Structural Engineer	Stage 3	Stage 2	The percentage of high grade aggregate that is recycled or secondary aggregate,
Wst 03	Operational Waste	Criteria 1-9	1	1	1	1	0.60%	Architect Contractor	Stage 3	Stage 2	Dedicated space(s) is provided for the segregation and storage of operational recyclable waste volumes
Wst 05	Adaption to Climate Change	Criteria 1-3	1	1	1	1	0.60%	Structural Engineer	Stage 2	Stage 1	Conduct a climate change adaptation strategy appraisal for structural and fabric resilience
Wst 06	Design for Disassembly and Functional Adaptability - Recommendations	Criteria 1-2	1	1	1	1	0.60%	Architect Structural Engineer	Stage 2	Stage 1	Conduct a study to explore the ease of disassembly and the functional adaptation potential of different design scenarios.
	Disassembly and Functional Adaptability – Implementation	Criteria 3-5	1	1	1	1	0.60%	Design Team	Stage 4	Stage 2	Provide an update, during Technical Design, on how the recommendations or solutions proposed by Concept Design have been implemented Produce a building adaptability and disassembly guide to communicate the characteristics allowing functional adaptability and disassembly to prospective tenants.
Total			**10**	**8**	**8**	**8**	0.00%				

Credit Issues		Ref	Credits					Design Team Member Responsible	Target Action Stage		Outline Design Stage Actions/Requirements * Reference must be made to the current 2018 Technical Manual (SD5078: 3.0) for full credit requirements *
			2018	Baseline	Potential	Net Zero Carbon	Weighting		RIBA Stage	MIM WEP Stage	
Land Use and Ecology											
Land Use and Ecology Section Weighting							**13.00%**				
LE 01	Previously Occupied Land	Criterion 1	1	1	1	1	1.00%	Architect	Stage 2	Stage 1	Design drawings indicating area (m2) of previously developed land and location and footprint (m2) of proposed development
	Contaminated Land	Criteria 2-3	1	0	0	0	0.00%		Stage 2	Stage 1	Copy of Contamination Report Letter confirming remediation of the site
Suitably Qualified Ecologist needs to be appointed at Concept Stage to ensure early involvement in site configuration and, where necessary, influence strategic planning decisions.											
LE 02	Identifying and Understanding the Risks and Opportunities for the Project (Ecologist Route 2)	Criteria 2-5	1	1	1	1	1.00%	Ecologist	Stage 1/2	Stage 1	An appropriate individual is appointed at a project stage that ensures early involvement in site configuration and, where necessary, can influence strategic planning decisions. Prior to the completion of the preparation and brief, an appropriate level of survey and evaluation
		Criteria 6-7	1	1	1	1	1.00%	Ecologist	Stage 2-3	Stage 1-2	During Concept Design, the project team liaise and collaborate with representative stakeholders to identify and consider ecological outcome for the sites. When determining the ecological outcome for the site, this must involve the identification, appraisal and selection of specific solutions and measures sufficiently early to influence key project planning decisions.
LE 03	Managing Negative Impacts on Ecology (Ecologist Route 2)	Pre-Requisite						Contractor Ecologist	Stage 1-5	Stage 1-3	The client or contractor has confirmed that compliance is monitored against all relevant UK, and EU or International legislation relating to the ecology of the site
		Criteria 2-4	1	1	1	1	1.00%	Ecologist Landscape Architect	Stage 1	Stage 1	Roles and responsibilities have been clearly defined, allocated and implemented to support successful delivery of project outcomes at an early enough stage to influence the concept design or design brief. Site preparation and construction works have been planned for and are implemented at an early project stage to optimise benefits and outputs.
		Criteria 7-8	2	1	2	1	1.00%	Ecologist	Stage 2-3	Stage 1-2	Negative impacts from site preparation and construction works have been managed according to the hierarchy
LE 04	Liaison, Implementation and Data	Criteria 1-2	1	1	1	1	1.00%	Ecologist	Stage 2-3	Stage 1-2	The project team liaising and collaborating with representative stakeholders, taking into consideration data collated and shared, have implemented solutions and measures based on recommendations from recognised 'local' ecological expertise, specialist input and guidance to inform the adoption of locally relevant ecological solutions and measures which enhance the site.
	Enhancement of Ecology	Criteria 4-6	3	1	3	1	1.00%	Landscape Architect Contractor	Stage 3-4	Stage 1-2	Credits are awarded on a scale of 1 to 3 (Route 2), based on the calculation of the change in ecological value occurring as a result of the project.
LE 05	Planning, Liaison, Data, Monitoring and Review Management and Maintenance	Criteria 1-4	1	1	1	1	1.00%	PM Ecologist	Stage 2-3	Stage 1-2	The project team liaise and collaborate with representative stakeholders, and consider Monitoring and reporting of on the ecological outcomes for site implemented at the design and construction stage, Monitoring and reporting of outcomes and successes from the project
	Landscape and Ecology Management Plan	Criteria 5-6	1	1	1	1	1.00%	Contractor	Stage 3	Stage 2	Five Year landscape and ecology management plan required There is a requirement within the **Contractor Environmental Assessment Requirements** that the contractor should provide a Landscape and Habitat Management Plan as part of the building handover information.
Total			**13**	**9**	**12**	**9**					
Pollution											
Pollution Section Weighting							**8.00%**				
Pol 01	Impact of Refrigerants	Criteria 2-5	2	1	2	1	0.67%	Contractor	Stage 3	Stage 2	Where the systems using refrigerants have Direct Effect Life Cycle CO_2 equivalent emissions (DELC CO_2e) of≤1000 kgCO_2e/kW cooling/heating capacity.
	Refrigerant Leak Detection	Criteria 6-7	1	1	1	1	0.67%	Contractor	Stage 3	Stage 2	Where systems using refrigerants have a permanent automated refrigerant leak detection system installed
Pol 02	NOx Emissions < 27mg/kWh	Criteria 1-2	1	1	1	1	0.67%	MEP	Stage 3	Stage 2	**All Electric or District heating** Where a project is connected to a district heating system which is outside the scope of the project or the wider development (e.g. phased developments), the system does not need to be included in the assessment. This is on the basis that the design team do not have control over the specification of the system. Where the design team do have control over the specification of the system, then it must be assessed.
	NOx Emissions < 24mg/kWh	Criteria 1-2	1	1	1	1	0.67%		Stage 3	Stage 2	
Pol 03	Flood Risk **(site-specific)**	Criteria 1-4	2	2	2	2	1.33%	Civil Engineer Contractor	Stage 2-3	Stage 1-2	Flood Risk assessment
	Surface Water Run Off **(site-specific)**	Criterion 5							Stage 2-3	Stage 1-2	Consultants report
		Criteria 6-9	1	1	1	1	0.67%		Stage 3	Stage 2	Where drainage measures are specified to ensure that the peak rate of run-off from the site to the watercourses (natural or municipal) is no greater for the developed site than it was for the pre-development site.
		Criteria 10-16	1	0	1	0	0.00%		Stage 3	Stage 2	Drainage design measures are specified to ensure that the post development run-off volume, over the development lifetime, is no greater than it would have been prior to the assessed site's development for the 100-year 6-hour event, including an allowance for climate change
	Minimising Water Course Pollution	Criteria 16-24	1	0	0	0	0.00%		Stage 3	Stage 2	**Need to confirm if there is discharge from the developed site for rainfall (up to 5mm)** Where there is a high risk of contamination or spillage of substances such as petrol and oil separators are installed in surface water drainage systems.
Pol 04	Reduction of Night Time Light Pollution	Criteria 1-5	1	1	1	1	0.67%	Contractor	Stage 3	Stage 2	Lighting design in compliance with BREEAM requirements
Pol 05	Noise Attenuation	Criteria 1-5	1	1	1	1	0.67%	Contractor Acoustician	Stage 2-3	Stage 1-2	The noise level from the proposed site/building, as measured in the locality of the nearest or most exposed noise-sensitive development, is a difference no greater than +5dB during the day (07:00 to 23:00) and +3dB at night (23:00 to 07:00) compared to the background noise level.
Total			**12**	**9**	**11**	**9**					
Exemplary Scoring											
Exemplar Total Scoring							**10.00%**				
Man 03	Responsible Construction Management	Criterion 23	1	0	1	0	0.00%	Contractor			Achieve all responsible construction management items in table 4.1
Hea 01	Daylighting	Criterion 14	1	0	0	0	0.00%	Contractor			Relevant Commitment in Contractor Specification
Hea 01	Internal & External Lighting Levels, Zoning & Control	Criterion 15	1	0	0	0	0.00%	Contractor			Lighting in each zone can be manually dimmed by occupants down to 20% of maximum light output using a dimmer switch
Hea 02	Indoor Air Quality	Criterion 11	1	0	0	0	0.00%	Contractor			All seven criteria meet requirements and testing less than or equal to 0.06/0.01mg/m3
Hea 06	Security of Site and Building	Criterion 4	1	0	0	0	0.00%	Security Consultant			A compliant risk based security rating scheme has been used. The performance against the scheme has been confirmed by independent assessment and verification.
Ene 01	Beyond Zero Net Regulated Carbon	Criteria 6-8	2	0	0	2	0.00%	MEP			Zero regulated carbon or carbon negative
	Carbon Negative	Criterion 9	3	0	0	0	0.00%	MEP			
	Post-Occupancy Stage	Criteria 10-12	2	0	0	2	0.00%	MEP			Update to the TM54 Operation Energy Report based on 12-18mths actual data.
Wat 01	Water Performance 65%	Criteria 7-8	1	0	0	0	0.00%	Architect MEP			Use of Rain or Greywater systems are a must.
Mat 01	Core Building Services Options Appraisal during Concept Design	Criteria 8-9	1	0	0	0	0.00%	MEP (Sust) MEP			Carry out building LCA options appraisal of at least 3 significantly different core building services design options. Use a building LCA tool that is recognised by BREEAM (as suitable for assessing core building services during Concept Design).
	LCA and LCC Alignment (all building types)	Criteria 10-14	1	0	0	0	0.00%	MEP (Sust)			Integrate the aligned LCA and LCC options appraisal activity within the wider design decision-making process. Record this in an options appraisal summary document including the relevant cost information from the 'elemental LCC plan' and 'Component level LCC option appraisal'.
	Third Party Verification (all building types)	Criteria 15-18	1	0	1	0	0.00%	MEP (Sust)			A suitably qualified third party carries out the building LCAs or produces a report verifying the building LCAs accurately represent the designs under consideration during Concept Design and Technical Design.
Mat 03	Responsible Sourcing of Materials Exemplary Level of Compliance	Criterion 3	1	0	0	0	0.00%	Architect Contractor			
Wst 01	Construction Site Waste Management	Criteria 8-11	1	0	0	0	0.00%	Contractor			Waste Target = <1.6m3 per 100m2
Wst 02	Recycled Aggregates	Criterion 7	1	0	0	0	0.00%	Contractor			Total amount of recycled or secondary aggregate specified is greater than 35% plus within 30km
Wst 05	Responding to Climate Change	Criteria 4-5	1	0	1	0	0.00%	Design Team			Achieve if Ene 01 x 6 credits met plus Hea 04 Thermal Comfort, Ene 04 Passive Design, Wat 01 x5 credits, Mat 05 Material Degradation, Pol 03 Flood Risk and 2 x Surface Water Run-off
LE 02	Determining the Ecological Outcomes for the Site	Criteria 8-10	1	0	0	0	0.00%	Ecologist			When determining the optimal ecological outcome for the site consider, in addition to those outlined in criteria 8 to 10, the wider site sustainability-related activities and the potential for ecosystem service related benefits.
LE 04	Enhancement of Ecology	Criterion 7	1	0	0	0	0.00%	Ecologist			The change in ecological value calculated under criterion 6 above confirms significant net gain has been achieved as set out in GN36 - BREEAM, CEEQUAL and HQM Ecology Calculation Methodology – Route 2.
Total			**10**	**0**	**3**	**4**					

Appendix C

Passive Design Report

MIMWEP | Flintshire County Council

Mynydd Isa Campus, Flintshire

Annex F – Appendix C
Passive Design Stage 1 (RIBA Stage 2) Report

Stage 1 Issue | 8 March 2021

Job number 280340-00

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This report looks at key areas of energy use and examines how this can be reduced through looking at different passive design approaches for the proposed Mynydd Isa Campus building.

A range of passive design measures have been considered and incorporated into the design of the new building to reduce the overall energy demand. Optimising passive design is the most effective means, both in carbon and financial terms, of ensuring the buildings are inherently low in energy usage.

The following passive measures have been included to reduce CO_2 emissions:

- Natural daylight shall be utilised wherever practical to reduce the energy use associated with electrical lighting.
- Balanced direct solar gain to reduce the need for comfort cooling or air conditioning against beneficial gain in winter.
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2 Introduction

This Passive Design report presents the required information for the project BREEAM assessment, specifically energy credit ENE04 for the Mynydd Isa Campus building.

The report looks at how the design team have analysed the proposed building and identified opportunities to implement passive design solutions to reduce the demands on energy consuming building services.

Wherever a new development is proposed, the first priority is to reduce energy demand through passive measures, followed by improving efficiency of the building services, and only then should the application of renewable energy technologies be implemented.

Passive design has been considered and incorporated within the design brief since RIBA Stage 1 & 2.

Low emissions energy provision is a key part of building a sustainable future and specifically tackling key environmental issues of climate change, water and air pollution. The EU and UK legislation for the built environment is designed to contribute to this by setting energy saving and carbon emission targets for buildings.

This report details the passive design of the Mynydd Isa Campus, Flintshire. The building is a nursery, primary and secondary school incorporating various classrooms, specialist teaching facilities, communal spaces and sports facilities. The school will be locating adjacent to the existing Argoed High School in Flintshire, North Wales.

2.1 Sustainability Interventions Overview

This section gives an overview of some of the initial considerations to improve the sustainability through site wide interventions. This is set out in *Figure 1*.

These interventions will be needed across all aspects of the site including energy use and consumption, water use and consumption, transport strategies, owner and occupier behaviour patterns and the generation of low or zero CO_2 on the site.

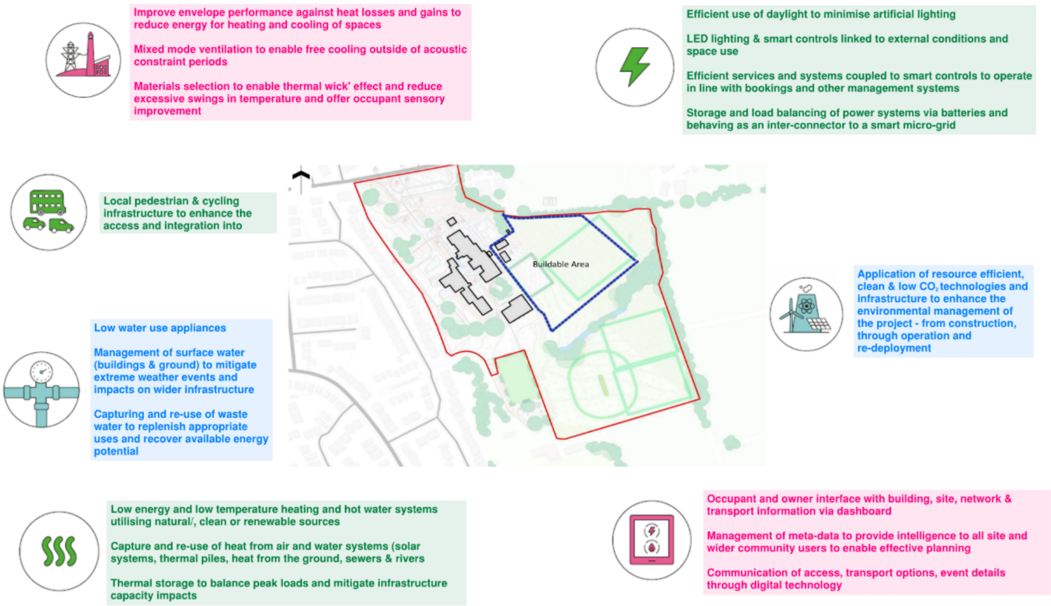

Figure 1 - Site Wide Sustainability Interventions Overview for Mynydd Isa Campus, Flintshire.

2.2 Expected usage

Expected usage periods for the Mynydd Isa Campus, Flintshire are detailed below in *Table 1*.

Table 1 - Table showing expected building occupancy

Infant Site	Junior Site
Infants - 9.00 a.m. to 3.00 p.m.	Juniors - 8:55 am to 3:20pm
Nursery - 9.00 a.m. to 11.30 a.m and 12.45 p.m. to 3.15 p.m.	
Breaks (full-time pupils):	Breaks (full-time pupils):
Mid-morning - 10.35 a.m. to 10.50 a.m.	Mid-morning - 10.30 a.m. to 10.45 a.m.
Lunch time - 12 noon to 1.00 p.m.	Lunch time – 11.55 to 12.50 p.m
Afternoon – no formal break time - Pupils do the Daily Mile programme	Afternoon – no formal break time - Pupils do the Daily Mile programme

The current school day (prior to Covid-19) for the Secondary School is:

Start	8.50 am
Finish	3.10 pm

Break	11.10 – 11.25 am
Lunch	12.25 – 13.10 pm

2.3 Site Constraints

The site constraints for the proposed site are summarised below with reference to *Figure 2*.

- Existing (disused) coal mines
- Narrow site access to north of site
- Existing underground main water pipe
- The existing school still operating
- Ground topology - sloping towards watercourse
- Access road to the north of the site

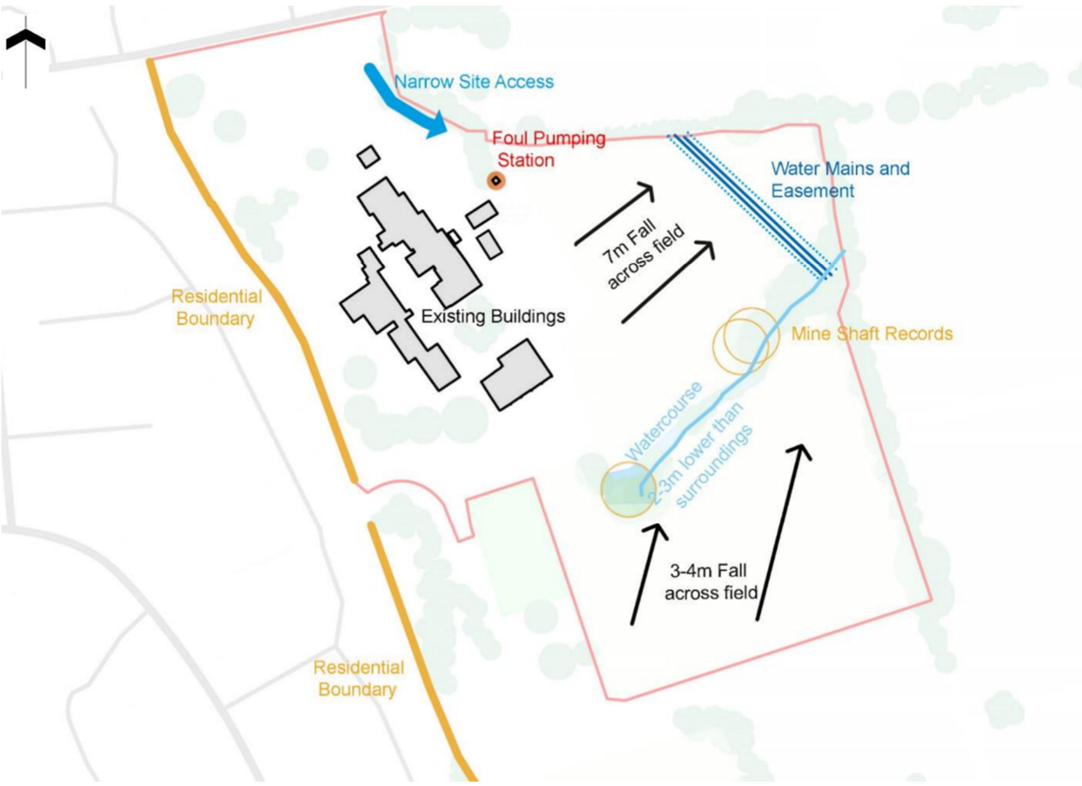

Figure 2 - Layout showing the site constraints.

3 Passive Design Approach

From brief through to concept designs, the team have been identifying opportunities for the implementation of passive design solutions that reduce demands for energy consuming building services.

A passive design analysis has been carried out on the proposed development. The energy demand of the buildings will be minimised through careful design of built form and services using ambient energy and passive solutions, making every effort to minimise the need for mechanical ventilation, heating and cooling systems. A range of passive design measures has been incorporated into the design of the new Mynydd Isa Campus, Flintshire to reduce the overall energy demand.

Optimising passive design is the most effective means, both in carbon and financial terms, of ensuring the buildings are inherently low in energy usage. These measures can be split loosely into two sections. The first representing the optimisation of the building on the site. Subsequently the following are a range of energy-efficiency measures that can be applied to the school as an integral part of the design process. The measures to be considered are:

- **Enhanced thermal envelope performance.** This reduces the heating and cooling load for the buildings. High levels of insulation have been applied to the building's thermal envelope.
- **Glazed area of facade incorporates high efficiency glazing throughout.** The glazing performance serves to reduce the solar gain and heat loss at the building perimeter that reduces the heating and cooling energy consumption.
- **Envelope air tightness to exceed that of typical facades** leading to savings in the heating and cooling energy consumption throughout the year and enhances the potential for heat recovery. The building façades are designed to have low infiltration rates.
- **Maximising Natural daylight** by optimising widow to wall ratios and building orientation.
- **Daylight dimming lighting** allows the potential to turn off the perimeter lighting automatically thereby saving lighting energy consumption.
- **Passive Solar Gain** allows solar gain to offset the perimeter heat loss in the winter. The active building controls will automatically adjust the amount of heating in each zone, and therefore energy savings in the heating system can be realised.
- **Natural Ventilation** to reduce the need for mechanical cooling.

The key passive design measures, which have been incorporated into the development, are explained in more detail below.

3.1 Site Location

The proposed site is Flintshire, North Wales. It sits adjacent to the existing Argoed primary school which will remain operation throughout the construction process of the new school.

The new school will be located on the existing sports pitches located south of Bryn Road. The sloping topography of the site will mean some level of cut and fill be required so that the building can be situated neatly on the existing site.

Figure 3 - Layout showing the site location.

3.2 Site Weather

The site weather information was taken from ASHRAE climate data with the nearest weather station to the site being Hawarden. *Table 2* shows a summary of the important weather data.

A full dynamic thermal model will be created to test thermal comfort under summer and winter conditions. This will be used to assess the passive design strategy and the temperature control strategy for the building.

Table 2 - Weather data for Hawarden, Flintshire, UK.

		Hawarden
Max temperature (0.4%)	°C (DB/WB)	25.1 / 18.2
Min temperature (99.6%)	°C (DB)	-4.7
Annual Sunshine	Hours	1249.4
Annual Rainfall	mm	862
Average wind speed	mph	4.3

3.3 Microclimate

The building is unlikely to affect the microclimate in any respect other than external wind patterns. Measures to mitigate any possible disruptive aspects from wind will be considered.

There are no surrounding buildings or natural features that would impact building shading, nor is pollution or noise likely to be a significant issue on the site.

3.4 Building Layout

The façade will be carefully designed to optimise the space planning, orientation, form and fabric of the proposed buildings to reduce energy consumption, minimise overheating and maximise natural ventilation and natural daylighting.

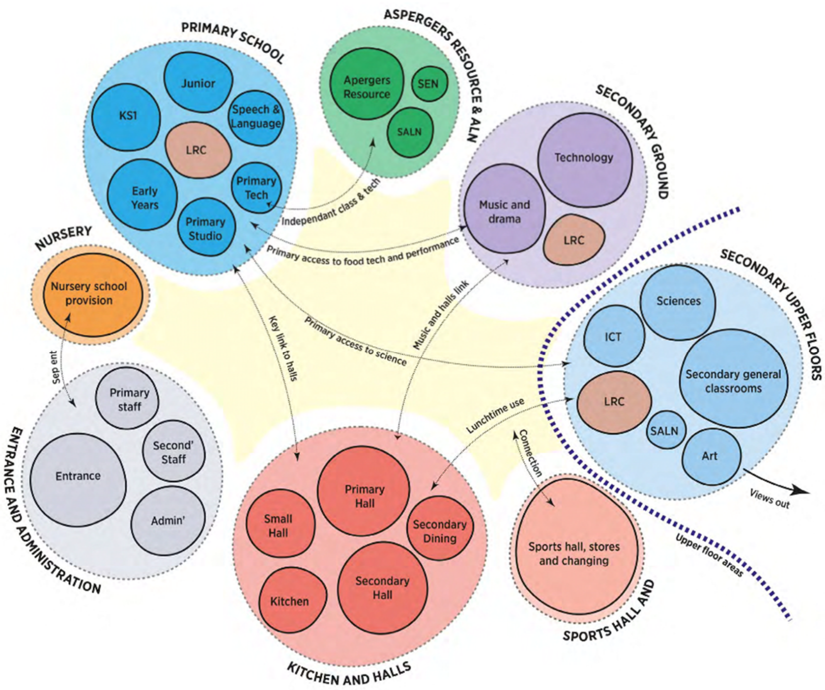

Figure 4 – Adjacency requirements for layout planning

Area adjacency is key for making a school operate effectively with key areas requiring direct access to outside and others needing to be connected to each other for ease of use. These requirements will be integrated into an optimised building layout to minimise energy use from the offset.

3.5 Building Form

The building form is generally shallow plan in nature with a central 'spine' containing non-teaching spaces and a series of building 'fingers' containing classrooms. This building form will maximise perimeter space so allow increased window area for daylighting and natural ventilation. This building form was a client preference over a deep plan 'super block' with an atrium space down the centre for both operational and energy efficiency reasons.

A ‘super block’ building would potentially perform better from a thermal energy perspective due to a consolidated form having less surface area. However this then becomes challenging from natural light and ventilation perspectives.

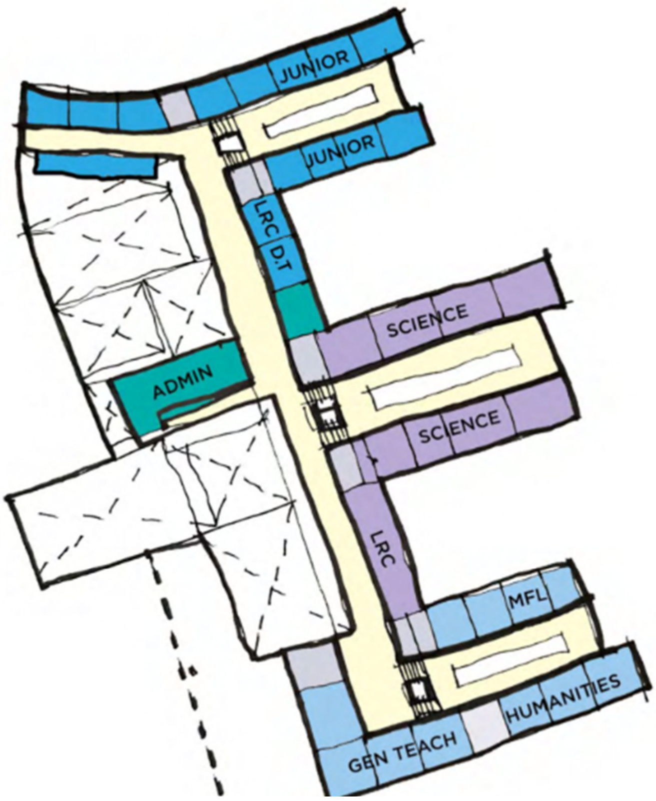

Figure 5 – Building form concept layout

The building does not perform as well thermally as a ‘super block’ due to its increased perimeter space, it is therefore more critical that the façade performance is optimised to reduce heat loss through the building fabric during winter, to maximise the benefits of solar and internal gains and to reduce losses associated with uncontrolled air permeability. The benefits of this building form are that during summer, the building is can achieve better levels of daylighting and natural ventilation. The natural daylight will be optimised to minimise solar heat gain and avoid overheating (see Hea 04 Thermal Comfort).

3.5.1 Building Orientation

3.5.1.1 Sun Path

Natural daylight is a key requirement for the learning environment and when linked with daylight dimmable lighting it can reduce the requirement for artificial lighting. Daylight should therefore be maximised where possible but controlled to limit the risk of overheating during the summer months due to solar gain.

The building ‘fingers’ have been aligned to avoid having facades facing multiple angles at the same time as this would make it difficult to optimise the orientation for each. Generally speaking, south facing glazing can be treated using solar shading devices to deal with peak mid-day sun while east and west facades are difficult to shade effectively. Large areas of East and West facing facades have therefore been limited where possible.

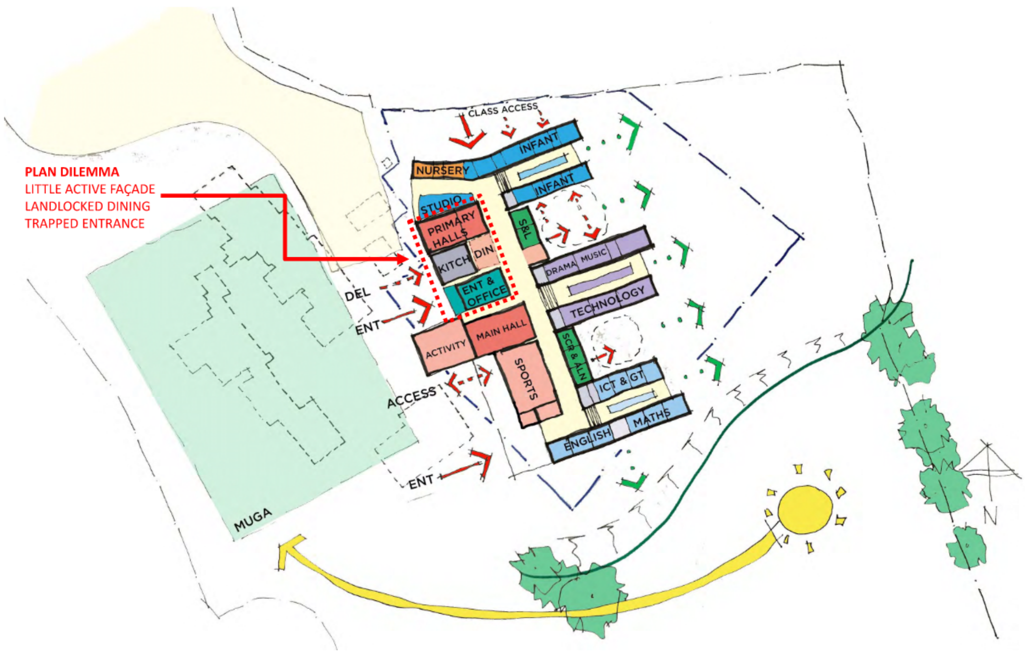

Figure 6 - Sunpath of the proposed development.

Solar shading devices will be used to fine tune the facades where needed during the next design stage.

3.5.1.2 Wind Direction

The Wind Rose diagram for the Argoed site (*Figure 7*) shows the wind speed and wind direction a period of time, here being from 01/Jan to 31/Dec. The wind direction is important when looking at natural ventilation in buildings and ensuring external wind patterns do not affect the microclimate.

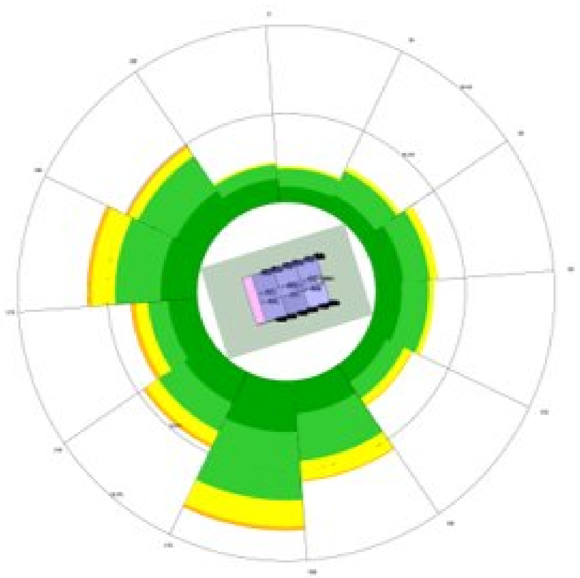

Figure 7 - Wind Rose diagram for proposed Mynydd Isa Campus.

3.6 Building Fabric

Thermal transmittance, also known as U-value, is the rate of transfer of heat (in watts) through one square metre of a structure divided by the difference in temperature across the structure. Well-insulated parts of a building have a low thermal transmittance whereas poorly insulated parts of a building have a high thermal transmittance. Reducing the thermal transmittance of the building envelope by adding insulation can help reduce annual heating demand and result in lower heating energy consumption. To achieve net zero carbon, the building fabric will be pushed to a maximum into order to reduce the overall building heating load and annual energy consumption.

Another critical element of the building fabric is its infiltration rate, this is a measure of how much outside air can enter the building through air leakage alone and is usually measured during an air leakage test prior to building handover. To achieve a good air leakage, the building must be designed with simplified junction and façade details from the offset. The construction details must then be monitored and checked throughout the installation process as it can be very difficult to rectify the problem once the building construction is complete.

3.7 Thermal Mass or Building Fabric

Thermal mass is a property that enables building materials to absorb, store, and later release heat. Concrete, for example, is a material which is high in thermal mass, allowing it to absorb heat and release it slowly throughout the day.

Thermal mass can add significant thermal comfort benefits with a naturally ventilated building, particularly if night-time purge ventilation is utilised to remove excess heat during the cooler night-time hours. The trade-off with utilising thermal mass is the increase in embodied carbon associated with the use of concrete and other heavy building materials.

3.8 Building Occupancy Type

The expected building occupancy is **1,400**, split of learning ages as *Table 3*.

Table 3 - Maximum occupancy of Mynydd Isa Campus.

Learning Age	**Number of Pupils**
Nursery	**43**
Primary School	**600**
Secondary School	**700**
SRPs	**50**

3.9 Daylighting Strategy

Passive design of daylighting has been prioritised initially to reduce the requirement for artificial lighting and reduce energy consumption. This has been a result of climate-based daylight modelling (CBDM), using the Useful Daylight Index (UDI) metric. Design utilising CBDM ensures that optimum levels of daylight are achieved.

An early assessment of the building has indicated that the overall building form and split fingers approach is yielding spaces that are likely to comply with the UDI limits prescribed for the project. The daylighting scheme will be developed continually as the design progresses, and significantly checked against the energy consumption (as a balance may have to be struck between providing additional daylight vs introducing another element of heat loss).

Figure 8 - Daylighting - Preliminary Assessment

3.10 Ventilation Strategy

Natural ventilation is the most energy efficient mode of ventilating a building as it does not rely on energy driven fans etc. As stated in section 3.3, the site is generally greenfield with minimal pollution of noise issues which means there are almost no constraints that would prevent natural ventilation being used.

However, in contrast natural ventilation provision is much more challenging in winter where provision of fresh air may cause cold draughts and poorer thermal comfort. Therefore, options to utilise mechanical ventilation with heat recovery shall be examined to develop the ventilation strategy as the design progresses.

The current proposal is to utilise natural ventilation in all classrooms using single sided ventilation supplemented with mechanical ventilation with heat recovery. The option of using natural ventilation combining single sided ventilation with centralised voids to induce cross flow ventilation was examined and was found to work extremely well during summer but did not perform well during winter.

Full details of the proposed ventilation at this stage can be found in the MEP Stage 2 report.

3.11 Contribution of Passive Design Measures

The following measures shall be included to reduce CO_2 emissions:

- Natural daylight shall be utilised wherever practical to reduce the energy use associated with electrical lighting.
- Balanced direct solar gain to reduce the need for comfort cooling or air conditioning against beneficial gain in winter.
- Implement stringent targets for façade air tightness and include high performance façade insulation.
- Incorporate a medium level of thermal mass to store and release energy where possible (although this has more influence over the thermal comfort than energy consumption).
- Mechanical ventilation heat recovery systems for classrooms to benefit from natural ventilation while reducing heating loads during winter.
- Daylight shall be balanced against solar gain to give the best combination of glazing and external shading.
- High efficiency lighting system (LED) shall be provided with manual on and automatic off absence detection controls.
- High efficiency lighting system (LED) shall be provided with daylight dimming controls.

The contribution these passive design measures will drive down the primary energy demand of the building from the onset.

4 Adaption to Climate Change

Developing the building utilising passive design elements needs to consider the impact of future climate change and subsequently building adaptability as we should seek to maximise opportunities to avoid unnecessary carbon emissions or water consumption.

4.1 Background

The 2014 report from the Intergovernmental Panel on Climate Change (IPCC), concluded that, “The global mean surface temperature changes for the period 2016–2035 relative to 1986–2005 is similar for the four RCPs, and will likely be in the range 0.3 ˚C to 0.7 ˚C”. RCP stands for representative concentration pathway, a series of trajectories for future climate warming.

The MET Office and UK Government have published an update to their previous modelling (UKCP09) with the current UKCP18 reporting on how climate change may affect the UK. By extensive computational simulations, they are able to advise on the impacts on temperatures and rainfall across the four RCP scenarios for 25km² regions of the UK.

The analysis is split into 20-year blocks of time, ranging from 2020 to 2099. For the purpose of analysing Mynydd Isa, the following timescales shall be discussed:

- 2020s (2020-2039)
- 2040s (2040-2059)
- 2060s (2060-2079)

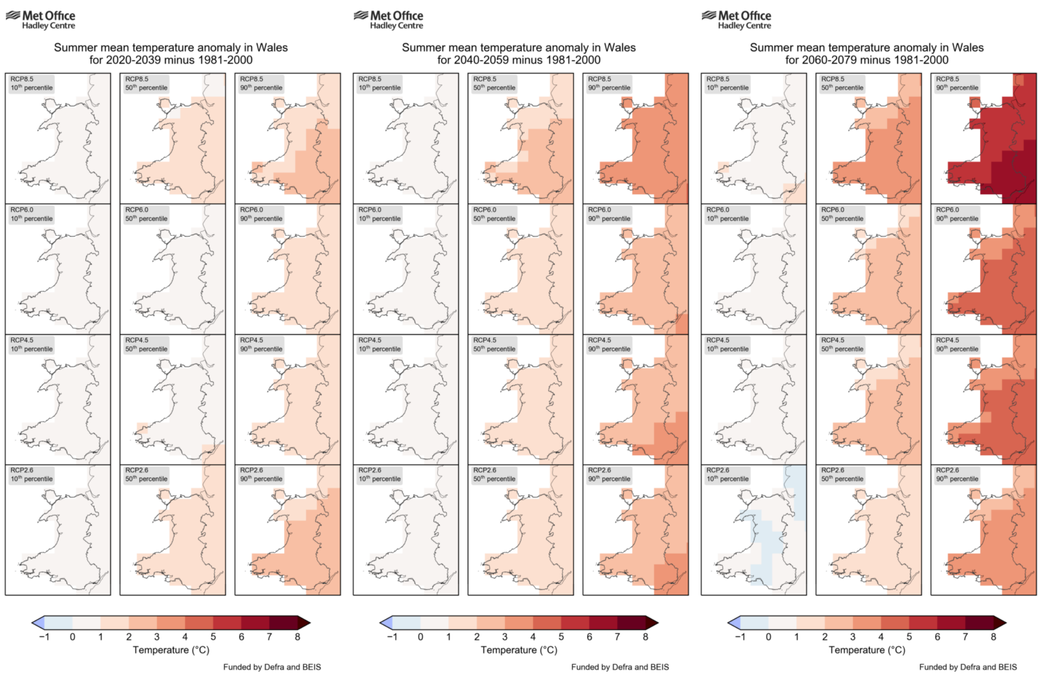

Figure 9 - Summer Mean Temperature Increases - Wales

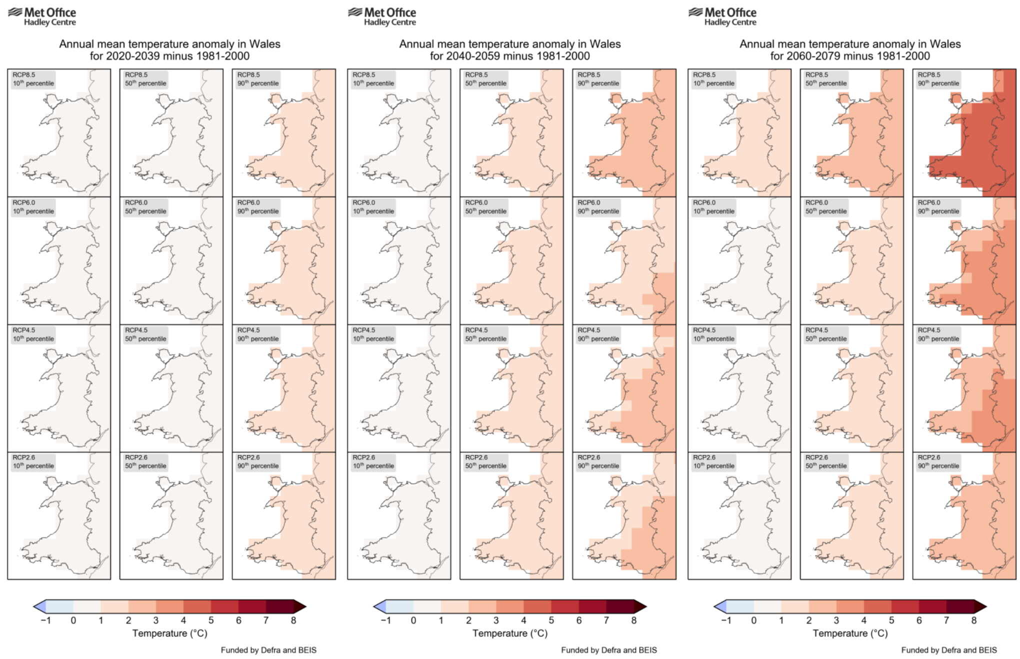

Figure 10 - Annual Mean Temperature Increases - Wales

Figure 9 and Figure 10 broadly show increasing temperatures for the various RCP scenarios as an example.

4.2 Project Aim for Climate Change

The Mynydd Isa Campus should have a high level of resilience to the impacts of climate change and be appropriate not only to the current climate but also to the future climate throughout the expected design life of each element.

The recommended approach to climate change includes adaption measures to deal with key site-specific impacts; changes in temperature; changes in rainfall; and changes in the level of solar radiation.

The key aspects for the built environment are the ability to deal with warmer and dryer summers, through provision of comfort control, and ability to cope with water scarcity.

4.2.1 Irrigation

Wales is fortunate in that projections for rainfall show a limited reduction of around 10% in precipitation over the course of the 21st century.

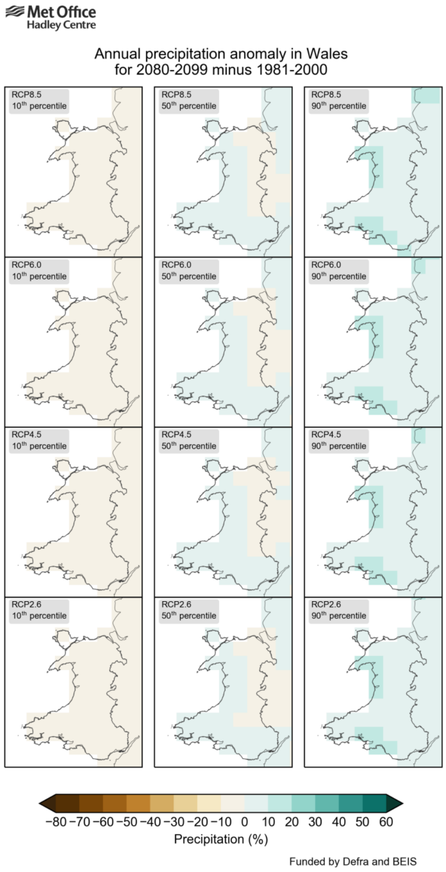

Figure 11 - Precipitation Change Projections - Wales

However, the broader climate trends are likely to make making summers dryer and winters wetter, increasing irrigation requirements during hot months.

The strategy at Mynydd Isa will be to follow a hierarchical approach to define a storm water drainage strategy in compliance with 'Statutory standards for sustainable drainage systems - designing, constructing, operating and maintaining surface water drainage systems 2018'.

4.2.2 Cooling & Shading

Cooling and thermal comfort requirements in the future are likely to be more onerous than those currently experienced.

At Mynydd Isa mechanical cooling is to be largely eliminated from the scheme with a reliance on natural ventilation as the primary cooling strategy. Furthermore, facades will be optimised to balance thermal loads and daylighting (as demonstrated in Figure 12).

In compliance with BREEAM and the ACR's the natural ventilation analysis will go beyond current BB101 guidelines for thermal comfort. This will involve performing an assessment of the building to the more challenging 'CIBSE TM52 – Avoiding Overheating in European Buildings', plus testing against the 2050 Design Summer Year (DSY) weather files available for the site.

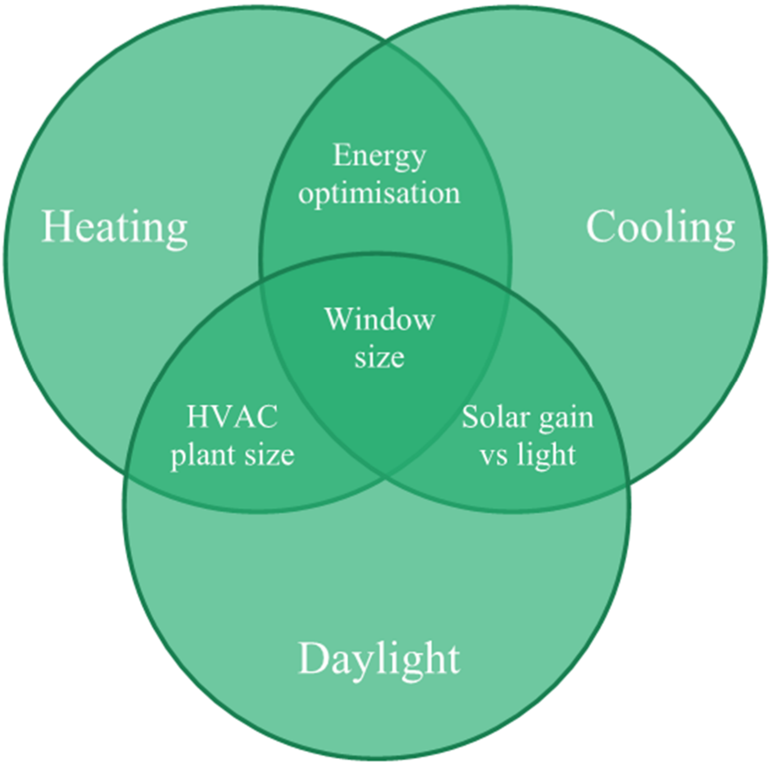

Figure 12 - Window Sizing Venn Diagram

5 Low Carbon Technologies

A separate Low and Zero Carbon Technologies (LZC) report has been undertaken for Mynydd Isa Campus.

Arup considered the use of a number of LZC technologies. The feasibility has been assessed in terms of energy produced, cost, payback period, carbon savings and logistics. A brief summary of the findings is presented below.

Minimising energy consumption for the new building has been accommodated by driving down energy demand through passive building design and operation techniques prior to focusing on energy efficient plant and controls, in doing so challenging existing conditions and solutions by adopting a design audit to achieve a low carbon building.

PV panels on the roof are recommended to provide a significant percentage of the developments electrical power and are expected to have a payback time of 9 years.

Air source heat pumps (ASHP) were identified as being a feasible LZC technology in the study. This is an efficient and reliable technology. Although they do not pay back financially following the removal of the renewable heat incentive, they do have a large CO_2 saving potential and are a more suitable solution for the site compared to the GSHP alternative.

Battery Storage was also identified as technologies considered suitable for the school and will be investigated further.

No suitable heat networks (current or future) were identified in the area for the proposed school.

Appendix C

Passive Design Report

MIMWEP | Flintshire County Council

Mynydd Isa Campus, Flintshire

Annex F – Appendix C
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Stage 1 Issue | 8 March 2021

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The report looks at how the design team have analysed the proposed building and identified opportunities to implement passive design solutions to reduce the demands on energy consuming building services.

Wherever a new development is proposed, the first priority is to reduce energy demand through passive measures, followed by improving efficiency of the building services, and only then should the application of renewable energy technologies be implemented.

Passive design has been considered and incorporated within the design brief since RIBA Stage 1 & 2.

Low emissions energy provision is a key part of building a sustainable future and specifically tackling key environmental issues of climate change, water and air pollution. The EU and UK legislation for the built environment is designed to contribute to this by setting energy saving and carbon emission targets for buildings.

This report details the passive design of the Mynydd Isa Campus, Flintshire. The building is a nursery, primary and secondary school incorporating various classrooms, specialist teaching facilities, communal spaces and sports facilities. The school will be locating adjacent to the existing Argoed High School in Flintshire, North Wales.

2.1 Sustainability Interventions Overview

This section gives an overview of some of the initial considerations to improve the sustainability through site wide interventions. This is set out in *Figure 1*.

These interventions will be needed across all aspects of the site including energy use and consumption, water use and consumption, transport strategies, owner and occupier behaviour patterns and the generation of low or zero CO_2 on the site.

Figure 1 - Site Wide Sustainability Interventions Overview for Mynydd Isa Campus, Flintshire.

2.2 Expected usage

Expected usage periods for the Mynydd Isa Campus, Flintshire are detailed below in *Table 1*.

Table 1 - Table showing expected building occupancy

Infant Site	Junior Site
Infants - 9.00 a.m. to 3.00 p.m.	Juniors - 8:55 am to 3:20pm
Nursery - 9.00 a.m. to 11.30 a.m and 12.45 p.m. to 3.15 p.m.	
Breaks (full-time pupils):	Breaks (full-time pupils):
Mid-morning - 10.35 a.m. to 10.50 a.m.	Mid-morning - 10.30 a.m. to 10.45 a.m.
Lunch time - 12 noon to 1.00 p.m.	Lunch time – 11.55 to 12.50 p.m
Afternoon – no formal break time - Pupils do the Daily Mile programme	Afternoon – no formal break time - Pupils do the Daily Mile programme

The current school day (prior to Covid-19) for the Secondary School is:

Start	8.50 am
Finish	3.10 pm

Break	11.10 – 11.25 am
Lunch	12.25 – 13.10 pm

2.3 Site Constraints

The site constraints for the proposed site are summarised below with reference to *Figure 2*.

- Existing (disused) coal mines
- Narrow site access to north of site
- Existing underground main water pipe
- The existing school still operating
- Ground topology - sloping towards watercourse
- Access road to the north of the site

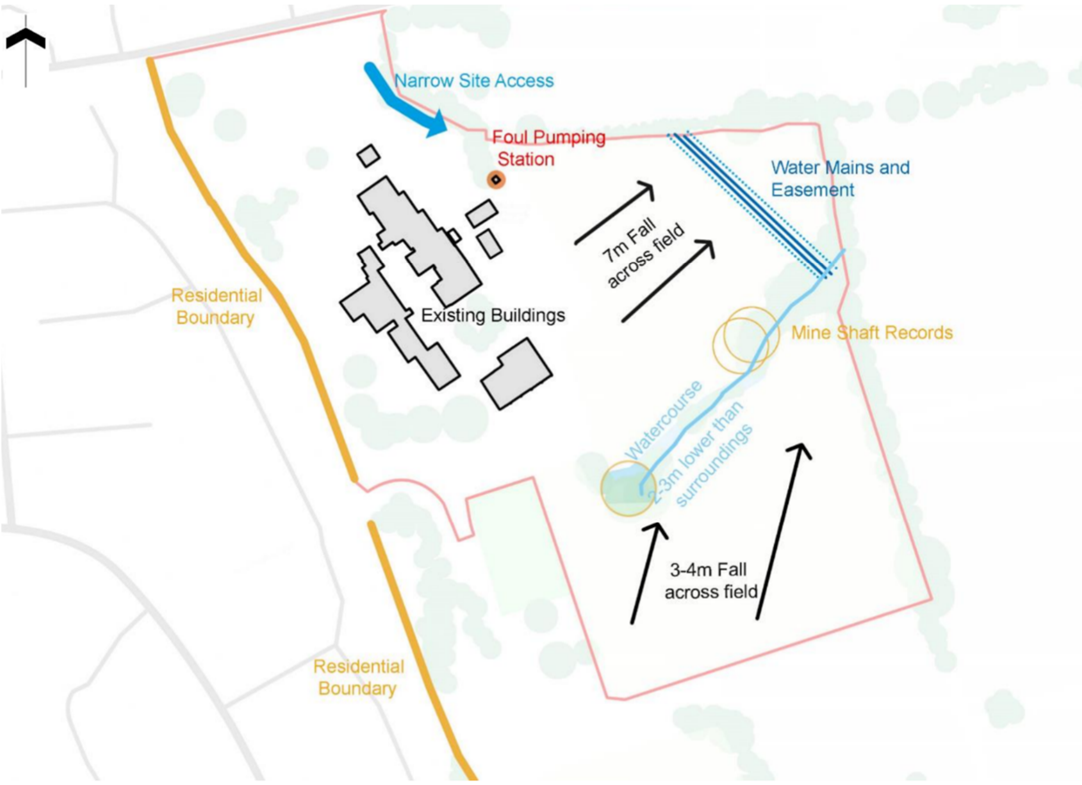

Figure 2 - Layout showing the site constraints.

3 Passive Design Approach

From brief through to concept designs, the team have been identifying opportunities for the implementation of passive design solutions that reduce demands for energy consuming building services.

A passive design analysis has been carried out on the proposed development. The energy demand of the buildings will be minimised through careful design of built form and services using ambient energy and passive solutions, making every effort to minimise the need for mechanical ventilation, heating and cooling systems. A range of passive design measures has been incorporated into the design of the new Mynydd Isa Campus, Flintshire to reduce the overall energy demand.

Optimising passive design is the most effective means, both in carbon and financial terms, of ensuring the buildings are inherently low in energy usage. These measures can be split loosely into two sections. The first representing the optimisation of the building on the site. Subsequently the following are a range of energy-efficiency measures that can be applied to the school as an integral part of the design process. The measures to be considered are:

- **Enhanced thermal envelope performance.** This reduces the heating and cooling load for the buildings. High levels of insulation have been applied to the building's thermal envelope.
- **Glazed area of facade incorporates high efficiency glazing throughout.** The glazing performance serves to reduce the solar gain and heat loss at the building perimeter that reduces the heating and cooling energy consumption.
- **Envelope air tightness to exceed that of typical facades** leading to savings in the heating and cooling energy consumption throughout the year and enhances the potential for heat recovery. The building façades are designed to have low infiltration rates.
- **Maximising Natural daylight** by optimising widow to wall ratios and building orientation.
- **Daylight dimming lighting** allows the potential to turn off the perimeter lighting automatically thereby saving lighting energy consumption.
- **Passive Solar Gain** allows solar gain to offset the perimeter heat loss in the winter. The active building controls will automatically adjust the amount of heating in each zone, and therefore energy savings in the heating system can be realised.
- **Natural Ventilation** to reduce the need for mechanical cooling.

The key passive design measures, which have been incorporated into the development, are explained in more detail below.

3.1 Site Location

The proposed site is Flintshire, North Wales. It sits adjacent to the existing Argoed primary school which will remain operation throughout the construction process of the new school.

The new school will be located on the existing sports pitches located south of Bryn Road. The sloping topography of the site will mean some level of cut and fill be required so that the building can be situated neatly on the existing site.

Figure 3 - Layout showing the site location.

3.2 Site Weather

The site weather information was taken from ASHRAE climate data with the nearest weather station to the site being Hawarden. *Table 2* shows a summary of the important weather data.

A full dynamic thermal model will be created to test thermal comfort under summer and winter conditions. This will be used to assess the passive design strategy and the temperature control strategy for the building.

Table 2 - Weather data for Hawarden, Flintshire, UK.

		Hawarden
Max temperature (0.4%)	°C (DB/WB)	25.1 / 18.2
Min temperature (99.6%)	°C (DB)	-4.7
Annual Sunshine	Hours	1249.4
Annual Rainfall	mm	862
Average wind speed	mph	4.3

3.3 Microclimate

The building is unlikely to affect the microclimate in any respect other than external wind patterns. Measures to mitigate any possible disruptive aspects from wind will be considered.

There are no surrounding buildings or natural features that would impact building shading, nor is pollution or noise likely to be a significant issue on the site.

3.4 Building Layout

The façade will be carefully designed to optimise the space planning, orientation, form and fabric of the proposed buildings to reduce energy consumption, minimise overheating and maximise natural ventilation and natural daylighting.

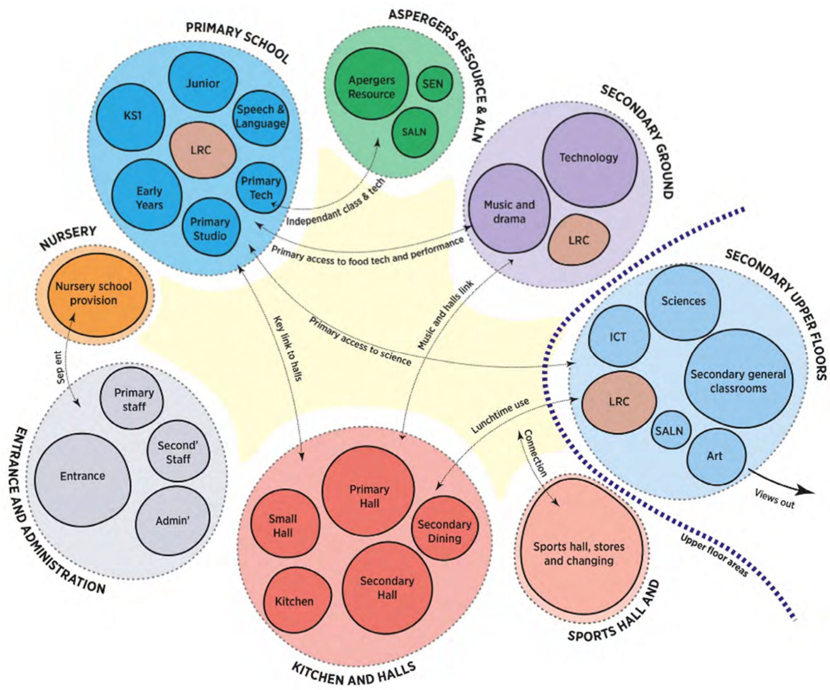

Figure 4 – Adjacency requirements for layout planning

Area adjacency is key for making a school operate effectively with key areas requiring direct access to outside and others needing to be connected to each other for ease of use. These requirements will be integrated into an optimised building layout to minimise energy use from the offset.

3.5 Building Form

The building form is generally shallow plan in nature with a central 'spine' containing non-teaching spaces and a series of building 'fingers' containing classrooms. This building form will maximise perimeter space so allow increased window area for daylighting and natural ventilation. This building form was a client preference over a deep plan 'super block' with an atrium space down the centre for both operational and energy efficiency reasons.

A 'super block' building would potentially perform better from a thermal energy perspective due to a consolidated form having less surface area. However this then becomes challenging from natural light and ventilation perspectives.

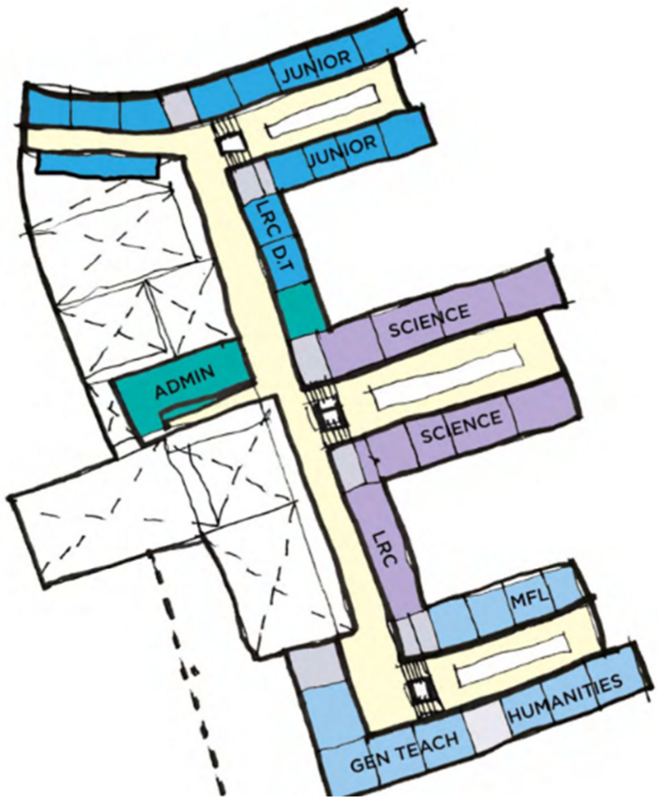

Figure 5 – Building form concept layout

The building does not perform as well thermally as a 'super block' due to its increased perimeter space, it is therefore more critical that the façade performance is optimised to reduce heat loss through the building fabric during winter, to maximise the benefits of solar and internal gains and to reduce losses associated with uncontrolled air permeability. The benefits of this building form are that during summer, the building is can achieve better levels of daylighting and natural ventilation. The natural daylight will be optimised to minimise solar heat gain and avoid overheating (see Hea 04 Thermal Comfort).

3.5.1 Building Orientation

3.5.1.1 Sun Path

Natural daylight is a key requirement for the learning environment and when linked with daylight dimmable lighting it can reduce the requirement for artificial lighting. Daylight should therefore be maximised where possible but controlled to limit the risk of overheating during the summer months due to solar gain.

The building 'fingers' have been aligned to avoid having facades facing multiple angles at the same time as this would make it difficult to optimise the orientation for each. Generally speaking, south facing glazing can be treated using solar shading devices to deal with peak mid-day sun while east and west facades are difficult to shade effectively. Large areas of East and West facing facades have therefore been limited where possible.

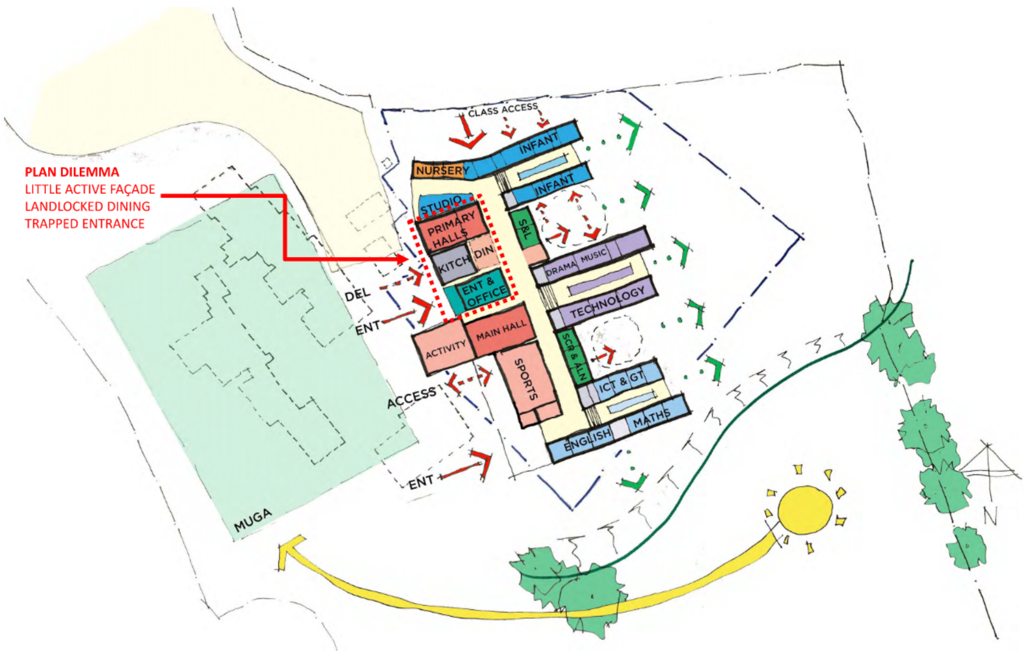

Figure 6 - Sunpath of the proposed development.

Solar shading devices will be used to fine tune the facades where needed during the next design stage.

3.5.1.2 Wind Direction

The Wind Rose diagram for the Argoed site (*Figure 7*) shows the wind speed and wind direction a period of time, here being from 01/Jan to 31/Dec. The wind direction is important when looking at natural ventilation in buildings and ensuring external wind patterns do not affect the microclimate.

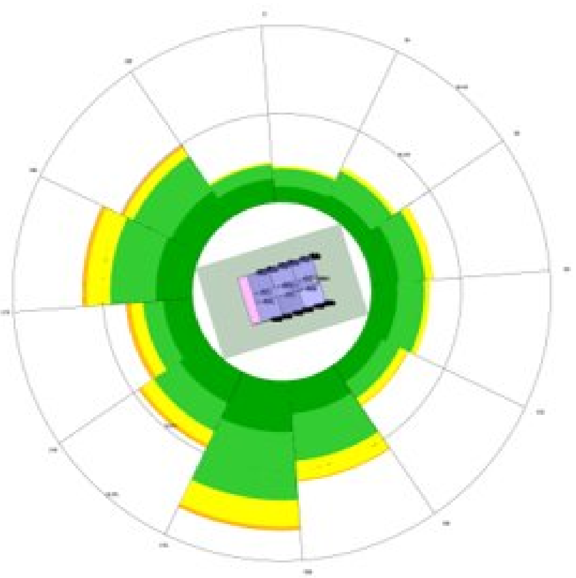

Figure 7 - Wind Rose diagram for proposed Mynydd Isa Campus.

3.6 Building Fabric

Thermal transmittance, also known as U-value, is the rate of transfer of heat (in watts) through one square metre of a structure divided by the difference in temperature across the structure. Well-insulated parts of a building have a low thermal transmittance whereas poorly insulated parts of a building have a high thermal transmittance. Reducing the thermal transmittance of the building envelope by adding insulation can help reduce annual heating demand and result in lower heating energy consumption. To achieve net zero carbon, the building fabric will be pushed to a maximum into order to reduce the overall building heating load and annual energy consumption.

Another critical element of the building fabric is its infiltration rate, this is a measure of how much outside air can enter the building through air leakage alone and is usually measured during an air leakage test prior to building handover. To achieve a good air leakage, the building must be designed with simplified junction and façade details from the offset. The construction details must then be monitored and checked throughout the installation process as it can be very difficult to rectify the problem once the building construction is complete.

3.7 Thermal Mass or Building Fabric

Thermal mass is a property that enables building materials to absorb, store, and later release heat. Concrete, for example, is a material which is high in thermal mass, allowing it to absorb heat and release it slowly throughout the day.

Thermal mass can add significant thermal comfort benefits with a naturally ventilated building, particularly if night-time purge ventilation is utilised to remove excess heat during the cooler night-time hours. The trade-off with utilising thermal mass is the increase in embodied carbon associated with the use of concrete and other heavy building materials.

3.8 Building Occupancy Type

The expected building occupancy is **1,400**, split of learning ages as *Table 3*.

Table 3 - Maximum occupancy of Mynydd Isa Campus.

Learning Age	**Number of Pupils**
Nursery	**43**
Primary School	**600**
Secondary School	**700**
SRPs	**50**

3.9 Daylighting Strategy

Passive design of daylighting has been prioritised initially to reduce the requirement for artificial lighting and reduce energy consumption. This has been a result of climate-based daylight modelling (CBDM), using the Useful Daylight Index (UDI) metric. Design utilising CBDM ensures that optimum levels of daylight are achieved.

An early assessment of the building has indicated that the overall building form and split fingers approach is yielding spaces that are likely to comply with the UDI limits prescribed for the project. The daylighting scheme will be developed continually as the design progresses, and significantly checked against the energy consumption (as a balance may have to be struck between providing additional daylight vs introducing another element of heat loss).

Figure 8 - Daylighting - Preliminary Assessment

3.10 Ventilation Strategy

Natural ventilation is the most energy efficient mode of ventilating a building as it does not rely on energy driven fans etc. As stated in section 3.3, the site is generally greenfield with minimal pollution of noise issues which means there are almost no constraints that would prevent natural ventilation being used.

However, in contrast natural ventilation provision is much more challenging in winter where provision of fresh air may cause cold draughts and poorer thermal comfort. Therefore, options to utilise mechanical ventilation with heat recovery shall be examined to develop the ventilation strategy as the design progresses.

The current proposal is to utilise natural ventilation in all classrooms using single sided ventilation supplemented with mechanical ventilation with heat recovery. The option of using natural ventilation combining single sided ventilation with centralised voids to induce cross flow ventilation was examined and was found to work extremely well during summer but did not perform well during winter.

Full details of the proposed ventilation at this stage can be found in the MEP Stage 2 report.

3.11 Contribution of Passive Design Measures

The following measures shall be included to reduce CO_2 emissions:

- Natural daylight shall be utilised wherever practical to reduce the energy use associated with electrical lighting.
- Balanced direct solar gain to reduce the need for comfort cooling or air conditioning against beneficial gain in winter.
- Implement stringent targets for façade air tightness and include high performance façade insulation.
- Incorporate a medium level of thermal mass to store and release energy where possible (although this has more influence over the thermal comfort than energy consumption).
- Mechanical ventilation heat recovery systems for classrooms to benefit from natural ventilation while reducing heating loads during winter.
- Daylight shall be balanced against solar gain to give the best combination of glazing and external shading.
- High efficiency lighting system (LED) shall be provided with manual on and automatic off absence detection controls.
- High efficiency lighting system (LED) shall be provided with daylight dimming controls.

The contribution these passive design measures will drive down the primary energy demand of the building from the onset.

4 Adaption to Climate Change

Developing the building utilising passive design elements needs to consider the impact of future climate change and subsequently building adaptability as we should seek to maximise opportunities to avoid unnecessary carbon emissions or water consumption.

4.1 Background

The 2014 report from the Intergovernmental Panel on Climate Change (IPCC), concluded that, “The global mean surface temperature changes for the period 2016–2035 relative to 1986–2005 is similar for the four RCPs, and will likely be in the range 0.3 ˚C to 0.7 ˚C”. RCP stands for representative concentration pathway, a series of trajectories for future climate warming.

The MET Office and UK Government have published an update to their previous modelling (UKCP09) with the current UKCP18 reporting on how climate change may affect the UK. By extensive computational simulations, they are able to advise on the impacts on temperatures and rainfall across the four RCP scenarios for 25km² regions of the UK.

The analysis is split into 20-year blocks of time, ranging from 2020 to 2099. For the purpose of analysing Mynydd Isa, the following timescales shall be discussed:

- 2020s (2020-2039)
- 2040s (2040-2059)
- 2060s (2060-2079)

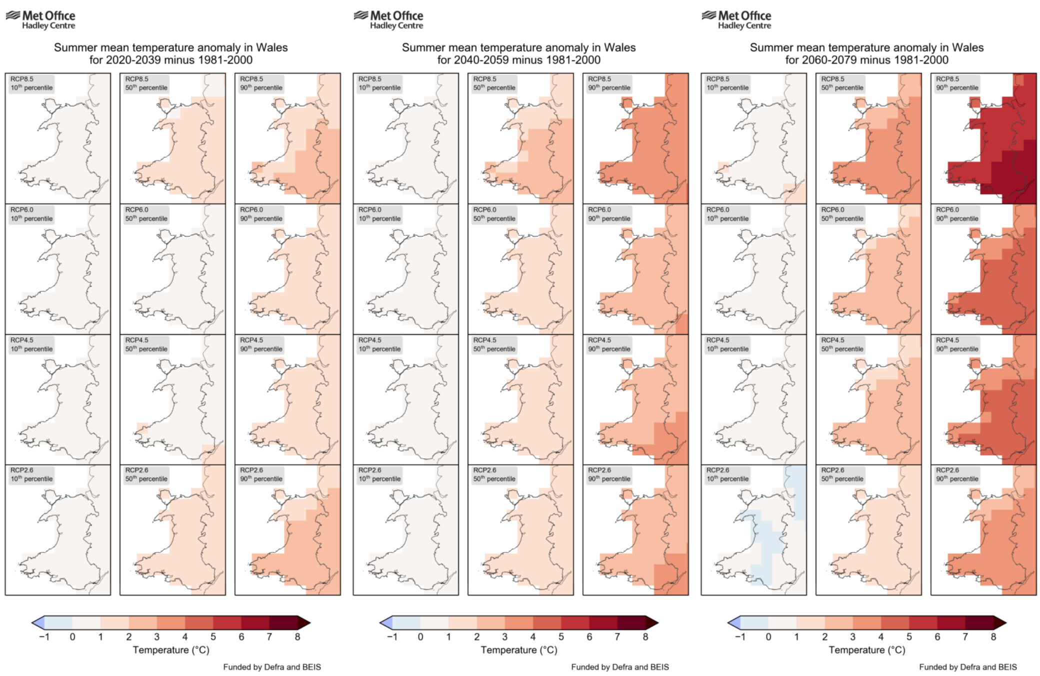

Figure 9 - Summer Mean Temperature Increases - Wales

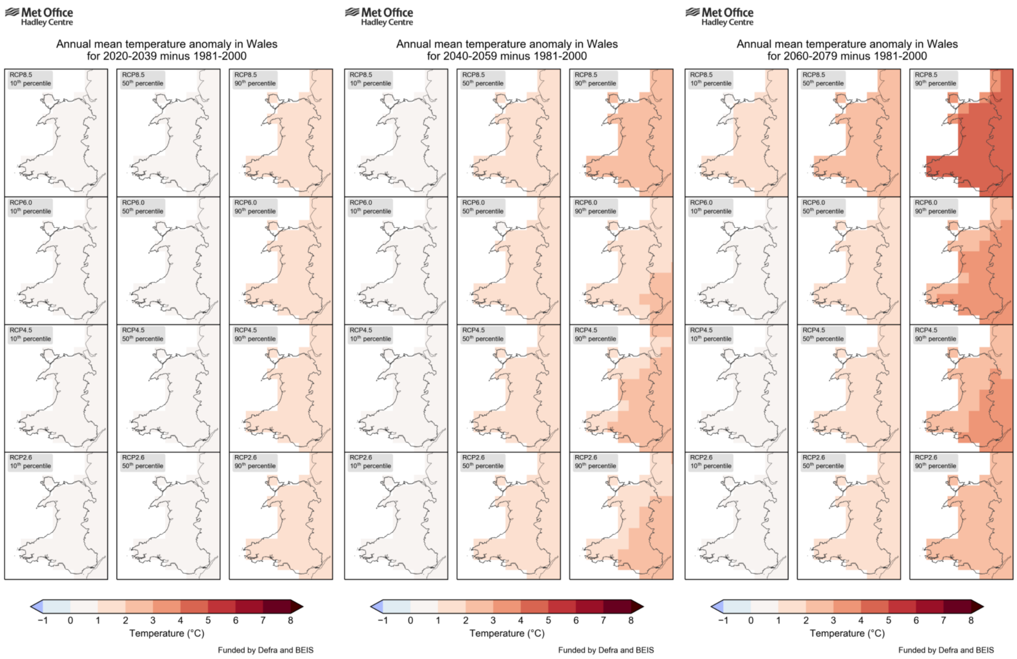

Figure 10 - Annual Mean Temperature Increases - Wales

Figure 9 and Figure 10 broadly show increasing temperatures for the various RCP scenarios as an example.

4.2 Project Aim for Climate Change

The Mynydd Isa Campus should have a high level of resilience to the impacts of climate change and be appropriate not only to the current climate but also to the future climate throughout the expected design life of each element.

The recommended approach to climate change includes adaption measures to deal with key site-specific impacts; changes in temperature; changes in rainfall; and changes in the level of solar radiation.

The key aspects for the built environment are the ability to deal with warmer and dryer summers, through provision of comfort control, and ability to cope with water scarcity.

4.2.1 Irrigation

Wales is fortunate in that projections for rainfall show a limited reduction of around 10% in precipitation over the course of the 21st century.

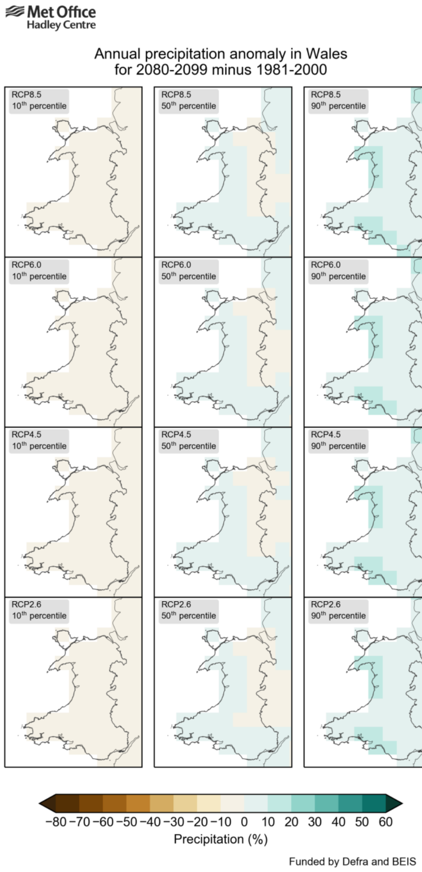

Figure 11 - Precipitation Change Projections - Wales

However, the broader climate trends are likely to make making summers dryer and winters wetter, increasing irrigation requirements during hot months.

The strategy at Mynydd Isa will be to follow a hierarchical approach to define a storm water drainage strategy in compliance with 'Statutory standards for sustainable drainage systems - designing, constructing, operating and maintaining surface water drainage systems 2018'.

4.2.2 Cooling & Shading

Cooling and thermal comfort requirements in the future are likely to be more onerous than those currently experienced.

At Mynydd Isa mechanical cooling is to be largely eliminated from the scheme with a reliance on natural ventilation as the primary cooling strategy. Furthermore, facades will be optimised to balance thermal loads and daylighting (as demonstrated in Figure 12).

In compliance with BREEAM and the ACR's the natural ventilation analysis will go beyond current BB101 guidelines for thermal comfort. This will involve performing an assessment of the building to the more challenging 'CIBSE TM52 – Avoiding Overheating in European Buildings', plus testing against the 2050 Design Summer Year (DSY) weather files available for the site.

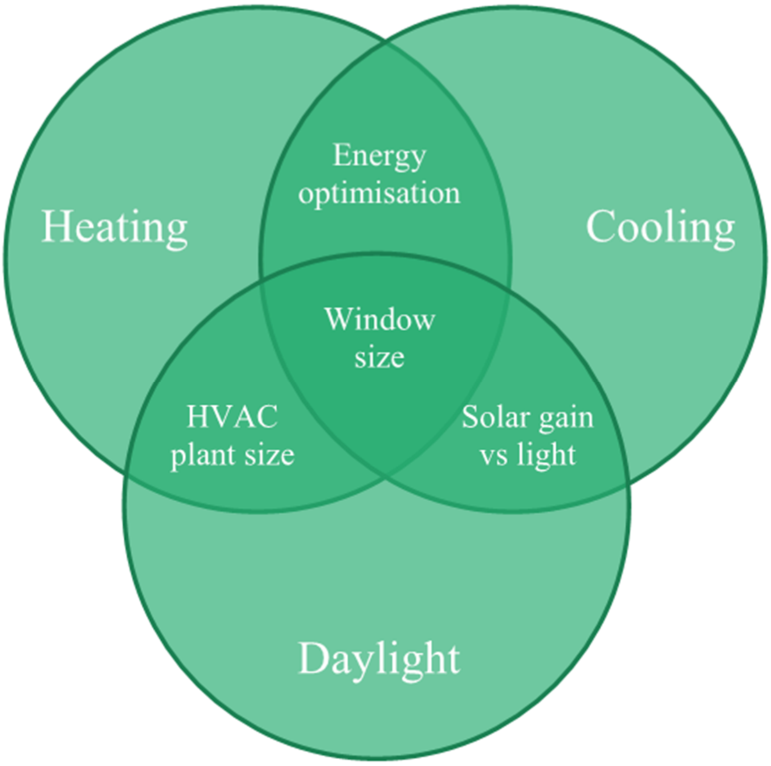

Figure 12 - Window Sizing Venn Diagram

5 Low Carbon Technologies

A separate Low and Zero Carbon Technologies (LZC) report has been undertaken for Mynydd Isa Campus.

Arup considered the use of a number of LZC technologies. The feasibility has been assessed in terms of energy produced, cost, payback period, carbon savings and logistics. A brief summary of the findings is presented below.

Minimising energy consumption for the new building has been accommodated by driving down energy demand through passive building design and operation techniques prior to focusing on energy efficient plant and controls, in doing so challenging existing conditions and solutions by adopting a design audit to achieve a low carbon building.

PV panels on the roof are recommended to provide a significant percentage of the developments electrical power and are expected to have a payback time of 9 years.

Air source heat pumps (ASHP) were identified as being a feasible LZC technology in the study. This is an efficient and reliable technology. Although they do not pay back financially following the removal of the renewable heat incentive, they do have a large CO_2 saving potential and are a more suitable solution for the site compared to the GSHP alternative.

Battery Storage was also identified as technologies considered suitable for the school and will be investigated further.

No suitable heat networks (current or future) were identified in the area for the proposed school.

Appendix D

Daylight Analysis

CEM 05 Development - Ground Floor Plan
1 : 250

A1

DO NOT SCALE FROM THIS DRAWING
The contractor shall check and verify all dimensions on site and report any discrepancies in writing to Sheppard Robson before proceeding work

FOR ELECTRONIC DATA ISSUE
Electronic Data / drawings are issued as "read only" and should not be interrogated for measurement. All dimensions and levels should read, only from those values stated in text on the drawing.

REV.	DATE	AMENDMENT
P01	19/02/2021	Sketch Issue to design team

KEYPLAN

CLIENT
Flintshire County Council

SHEPPARD ROBSON

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PROJECT
Mynydd Isa Campus

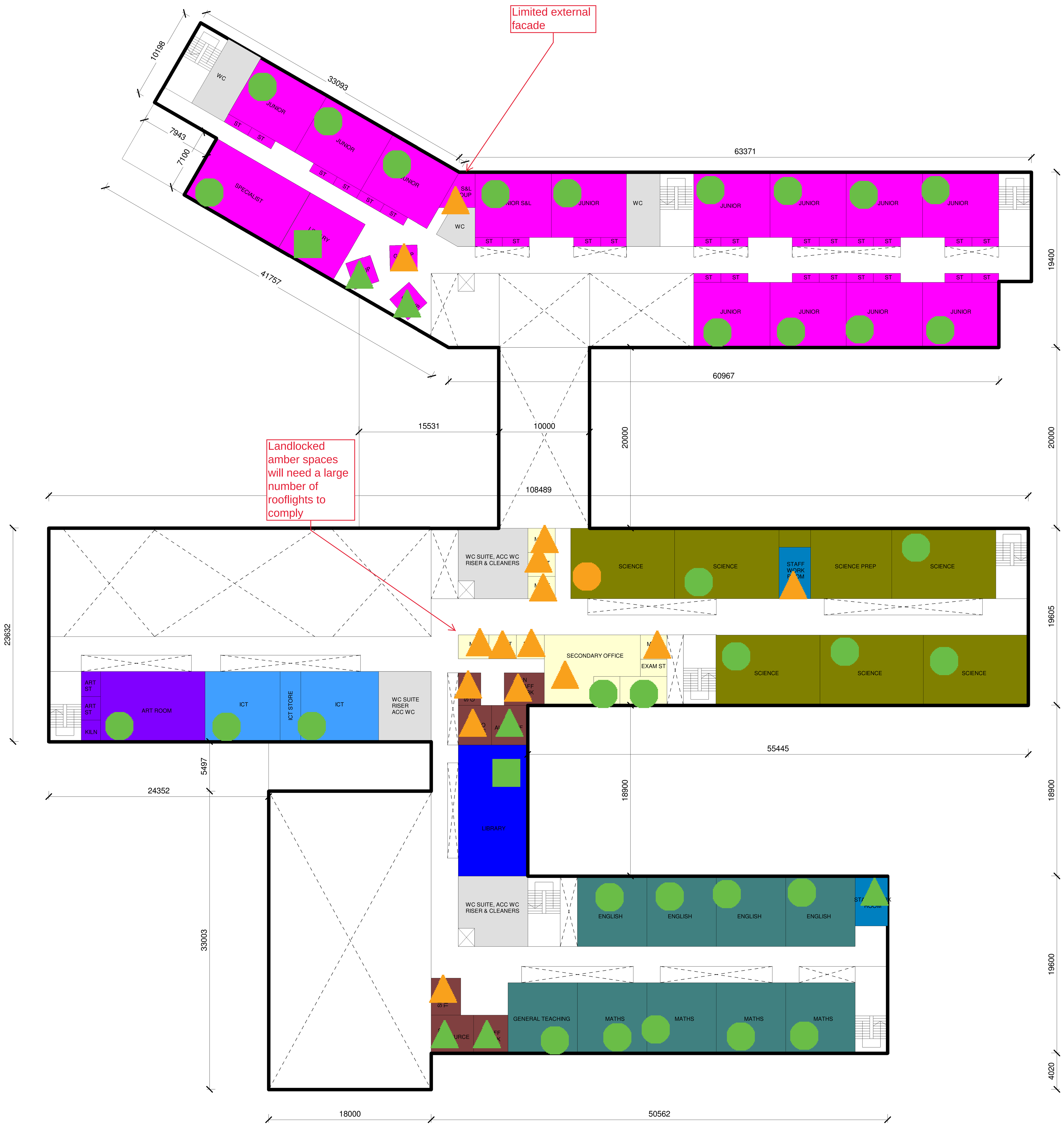
SCALE@A1	DATE	ORIGINATOR	CHECKED	AUTHORISED
1 : 250	19/02/2021	SD	JJ	JJ

CEM 05 - Ground Floor Plan Development

WEPCO Stage 1/ RIBA 2

STATUS	PURPOSE FOR ISSUE	SR NO.
S2	For Information	6636

DRAWING NO.	REV.
FCMI · SRA · XX · 00 · DR · A · SK010	P01



Key

- Expected to pass (green circle)
- Possible pass (orange circle)
- Expected to fail (red circle)
- L1 - 80% to pass (circle)
- L2 - 75% to pass (square)
- L3 - 60% to pass (triangle)

CEM 05 Development - First Floor Plan
1 : 250

A1

REV.	DATE	AMENDMENT
P01	19/02/2021	Sketch Issue to design team

KEYPLAN

CLIENT

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PROJECT
Mynydd Isa Campus

SCALE@A1	DATE	ORIGINATOR	CHECKED	AUTHORISED
1 : 250	19/02/2021	SD	JJ	JJ

CEM 05 - First Floor Plan Development

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STATUS	PURPOSE FOR ISSUE	SR NO.
S2	For Information	6636

DRAWING NO.	REV.
FCMI · SRA · XX · 01 · DR · A · SK011	P01