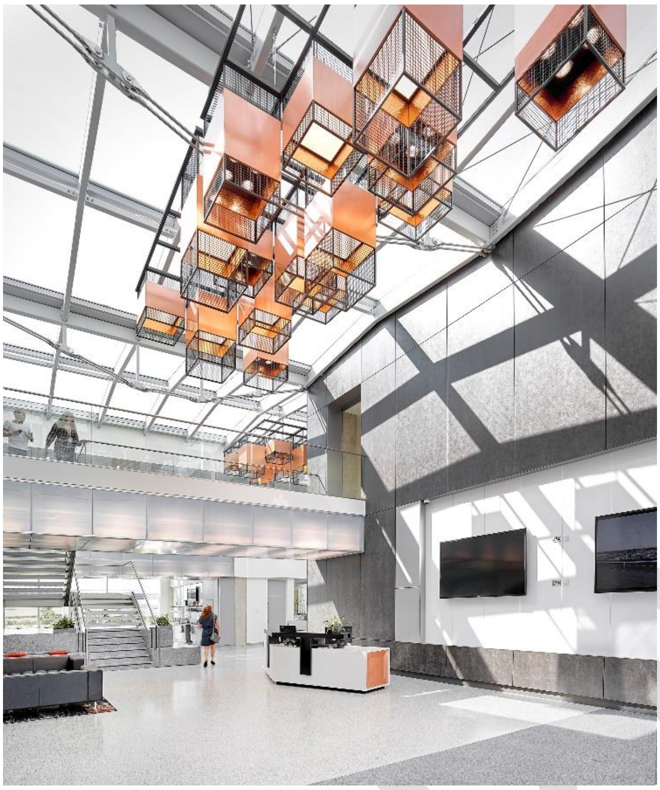
SEATON VALLEY FEDERATION SCHOOL

Net Zero Carbon in Operation – Outline Strategy





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CONTENTS

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1.0 EXECUTIVE SUMMARY

This report outlines the Net Zero Carbon in Operation and sustainability design aspiration for the proposed Seaton Valley Federation School. The proposal is for the school to meet the DfE Net Zero Carbon In Operation targets. This report shows the key design principals that the school will need in order to realise the Net Zero Carbon in Operation aspiration.

This outline report sets out the Project Energy Strategy, Sustainability & route to achieving Net Zero Carbon in Operation and provides an overview of the sustainability targets and metrics to follow that will influence the design.

The school will achieve Net Zero Carbon in operation by incorporating the following;

- ✓ Enhanced building U Values and air tightness
- ✓ Low energy MEP systems and strategies
- ✓ LED lighting throughout with energy saving automatic controls
- ✓ Building Energy Management System (BeMS)
- ✓ Electric semi-instantaneous point of use domestic hot water heating
- ✓ Hybrid Ventilation consisting of Cross ventilation (Summer Operation) and mechanical ventilation with heat recovery (Winter Operation)
- ✓ Ground Source Heat Pump Technology providing heating to the school with underfloor space heating
- ✓ Solar PV System

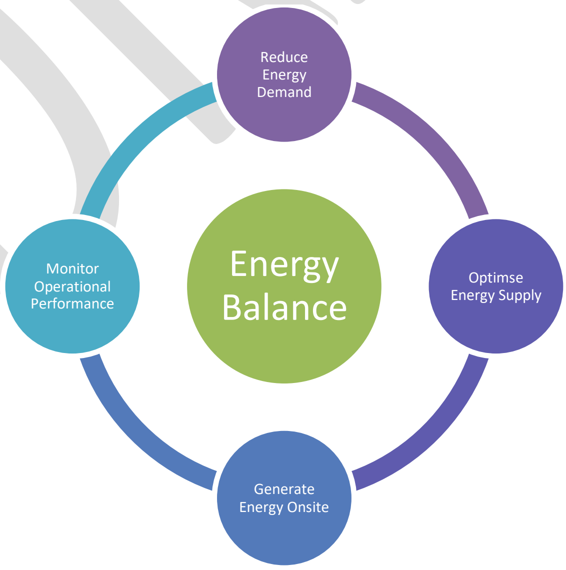

Figure 1: *Energy Balance Diagram*

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2.0 INTRODUCTION

This document sets a sustainable approach to the design, construction, production, and operation of the new Seaton Valley Federation School that achieves the following;

- Achieve Net Zero Carbon in Operation, as defined by the standards within the Net Zero Carbon Buildings: A Framework Definition UK Green Building Council (UK GBC), recognising a development of targets over a timeline:
- Create a healthy and productive whole school setting, in response to the UK's 25-year Environment Plan including biodiversity net-gain.
- Put the long-term needs of the school users (all pupils and staff) at the centre of all decisions.
- Are future-proofed against the risks of climate change as defined by UK adaptation policy i.e. higher temperatures and prolonged rainfall

The route to Net Zero Carbon consists of the following approach

- Establish the Net Zero Carbon Scope and targets
- Reduce Construction Impacts
- Reduce Operational Energy Use
- Increase Renewable Energy Supply
- On-site Offset Carbon
- Regularly monitor and report energy consumption in line with targets

The scheme proposals are subject to finalisation of the OBC (outline business case). One of the options for the scheme proposals is for the new school to be built on the existing Seaton Valley Federation Community High and Whytrig Middle School site on Elsdon Avenue, Seaton Delaval, Northumberland, NE25 0BE.

An alternative option is for a proposed new build school site. The proposed location is a greenfield site located at The Avenue, Seaton Delaval Northumberland NE25.

The proposed new build site location can be seen in Figure 2.

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Figure 2: *Site Location – New Site*

3.0 DESIGN APPROACH TO NET ZERO CARBON

As part of the Strategic Brief, a whole site approach is required to achieve Net Zero Carbon in Operation accordance with the UKGBC net zero framework and achieve the DFE target energy benchmarks. This will be achieved Focus first on energy saving and maximising onsite low carbon technologies.

3.1 Net Zero Carbon – Definition

The UKGBC net zero framework defines Net Zero Carbon in operation and construction as follows;

Net zero carbon in operational is defined as:

"When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."

Net zero carbon in construction is defined as:

"When the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy."

In order to achieve the required Net Zero carbon in construction should design the building to enable net zero carbon for operational energy, and where possible this should be achieved annually in-use. framework.

The summary table shown on Figure 4 outlines which principles recommended by the UKGBC that should be followed to demonstrate alignment with net zero carbon for construction and for operational energy. The detailed framework in the full report includes the background rationale for the principle, associated technical requirements and, where relevant, any areas for future development of the framework.

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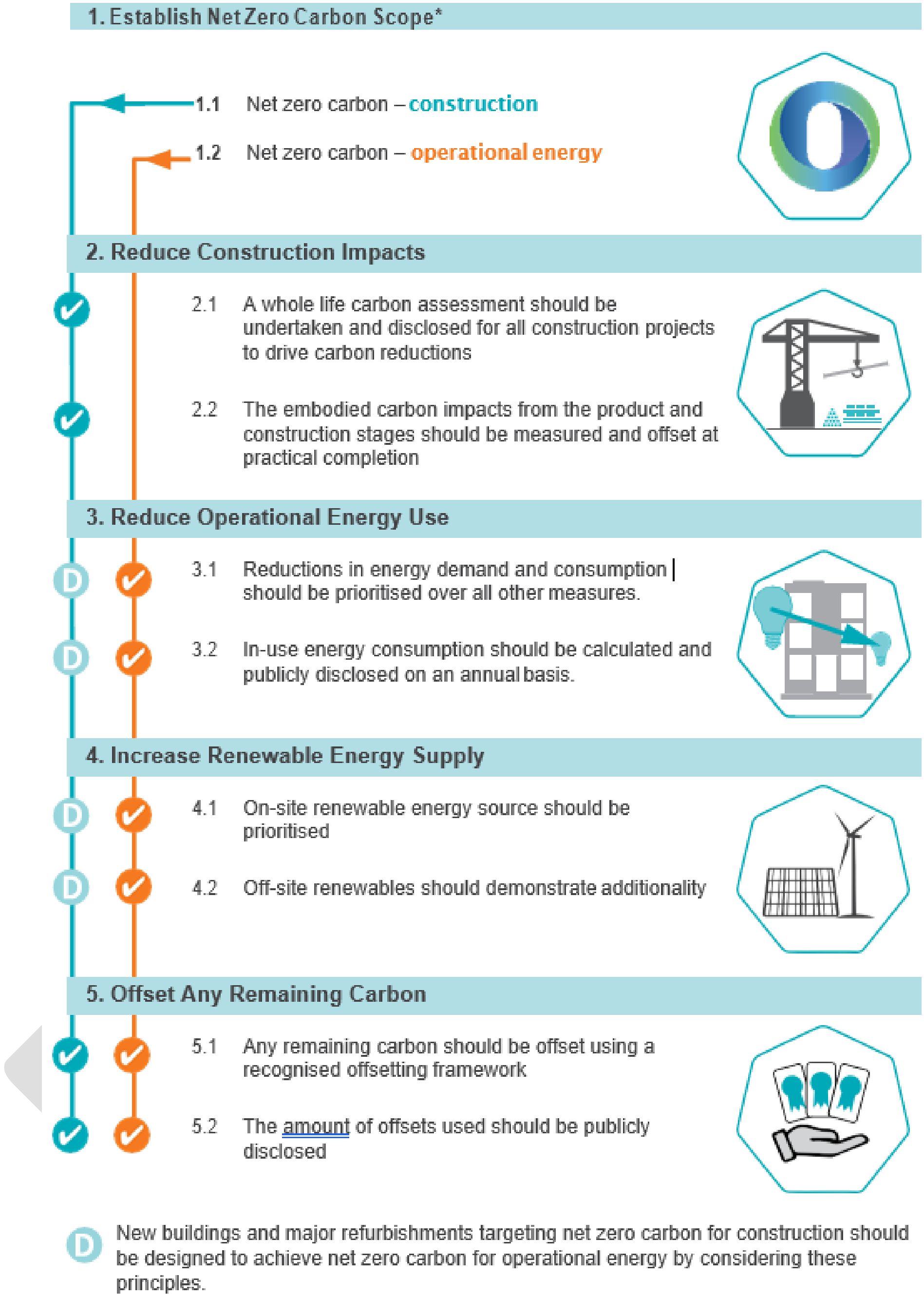


Figure 4: *Steps to Achieving a Net Zero Carbon Building*

3.2 Net Zero Carbon– DFE Requirements

The requirements over and above the current Output Specification which also forms part of the project delivery responsibilities.

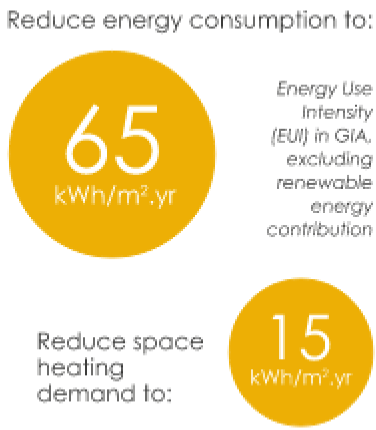
This requires the project to target and achieve the performance measures set out below;

Embodied Carbon

- An overall Embodied Carbon target of <350 to <600 $kgCO_2/m^2$
- Target between 30 - 50% of existing materials that are reused
- Target between 50 - 80% of new materials designed for reuse
- Embodied carbon including sequestration to achieve <250 $kgCO_2/m^2$

Operational Carbon

- A total energy end use of 65 kWh/m²year.
- Total Space Heating Demand - 15 kWh/m²/year
- No requirements for comfort cooling
- DEC Rating - Minimum DEC B40
- Renewable Energy Supply - Requirement for minimum % on-site RE / LZC achieved (TBC)
- Offset remaining Carbon through accredited schemes and the purchase of zero carbon electricity
- Consider running costs of gas to electrifying heat



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The RIBA 2030 Climate challenge document further identifies the expected energy and carbon targets, and targets <55kWh/m2/year and to achieve a DEC A rating.

RIBA 2030 Climate Challenge target metrics for non-domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	225 kWh/m²/y DEC D rated (CIBSE TM46 benchmark)	<170 kWh/m²/y DEC C rating	<110 kWh/m²/y DEC B rating	<0 to 55 kWh/m²/y DEC A rating	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)

To demonstrate that the school can meet the target, CIBSE Guide TM54: Evaluating Operational Energy Performance of Buildings at the Design Stage should be used to calculate what the in-use energy requirements may be.

4.0 EMBODIED CARBON

Best Practice targets for embodied carbon utilising the circular economy principle may be considered for the Seaton Valley Federation School project. This requires the building to re-used materials where possible and can be constructed in a way that disassembled so that materials and products within the building can be re-used in future buildings.

Four key areas are identified for consideration to minimise the project embodied carbon;

Materials

Reduce the use of high embodied carbon materials such as concrete but also including those that arise from extracting, transporting, manufacturing, and installing building materials on site, as well as the operational and end-of-life emissions.

The project should consider utilising natural and renewable materials that can sustainably replace carbon intensive alternatives and ensure the longevity of all materials.

Design

The building design should be simplified though design to use less materials (Tonnes of material per m²) and target the following

- Reduced weight of dead loads where possible
- Restrict long structural frame spans
- Future-proofed risers and central plant space
- Structural members should be designed for 100% utilisation rate

The MEP design teams should avoid over-provision and over sizing of MEP plant and should monitor to prevent excessive ducting, piping and wiring runs and sizes where possible.

Manufacture & Assembly

The design team should explore design for manufacture and assembly (DfMA) solutions - pre and or part fabrication undertaken offsite reducing the embodied carbon of construction.

Transportation

The use of off-site manufacturing and construction can significantly reduce carbon associated with transportation to site through the use of off-site modular construction, manufacture, consolidation centres and distribution hubs. Not only does this reduce waste removal from site, but additionally cut down the number of deliveries to site.

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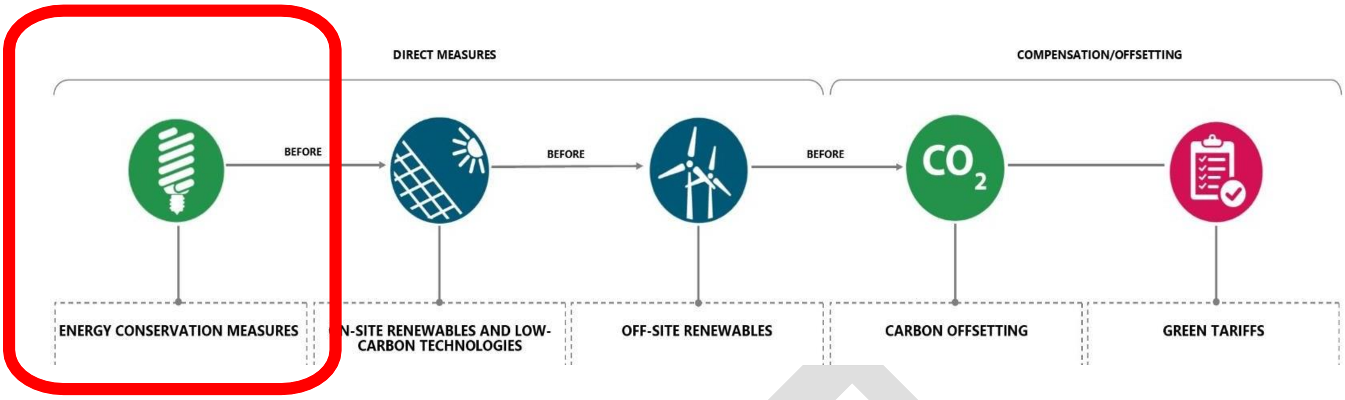
5.0 REDUCE ENERGY DEMAND



Operational energy is the energy consumed by a building associated with heating, hot water, cooling, ventilation, and lighting systems, as well as small power equipment such as computers. Reducing operational energy is key to achieving scalable zero carbon in operation.

The buildings energy demand will be reduced by designing the building around exemplar passive design standards (such as the LETI standards) which target a reduction of heat losses through high levels of insulation, low air-leakage and the following features:

Passive Building Approach - Target Net Zero

- Minimised building Form Factor - 1-3 (A building’s form factor is the ratio of its external surface area to the internal floor area).
- Minimised % Glazing targeting between 15-25% per wall (subject to meeting supplementary daylight requirements)
- Minimum Fabric U-Values ≤0.15 for walls, ≤0.12 for exposed floors), and ≤0.12 for roofs
- Minimum Window U-Values ≤1.2 including losses from frames
- Minimised Thermal bridging ≤0.04 W/m.K (y-value)
- G-Value of glass - ≤0.4 (depending on % glazing)
- Balance daylight and overheating and include external shading
- Exposed concrete thermal mass – soffit
- Semi Sealed façade – allowing limited opening windows for local occupant benefit

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School Energy Target benchmarks

Table 1 below shows an indicative benchmark to achieve a total energy end use of 65kWh/m^{2}year which is the benchmark advised to ensure that Net Zero Carbon is Operation is achievable.

	Indicative NET ZERO CARBON Benchmarks (kWh/m^2)
Heating	15
Hot Water	5
Internal Lighting	8
External Lighting	4
Fans & Pumps	6
Cooling	Zero
Lifts	1
Small Power	Up to 20
Server Rooms	Zero
Catering	6

Table 1 – Energy Target Benchmarks

5.1 Building Fabric

The target U values for the new build elements of the school are shown in Table 2.

Element	W/m^{2}K
Walls	0.13 – 0.15
Floors	0.09 – 0.12
Roof	0.10 – 0.12
Windows & Rooflights	1 (triple glazing), 1.2 (double glazing)
Doors	1.2
Air-Leakage Air Tightness	<1 (m^3/h. m^2@50Pa)
Thermal Bridging	0.04 W/m.K (y-value)

Table 2 – *Building Fabric*

We note increasing the proportion of openable windows above 1x per classroom will inevitably have a detrimental effect on airtightness. We suggest an upper-limit of <3 (m^3/h. m^2@50Pa) even with increased window opening – as long as overall kWh/m^2/year target of 45 is still met.

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5.2 Space Heating And Ventilation Strategies

Ventilation

The DFE Sustainability Brief target for this is 65kWh/m²/year. In order to achieve this a mixed mode/hybrid ventilation strategy will be needed to minimise energy use. In summer or warm days, national ventilation via openable perimeter windows and cross vent will be used. In Winter and shoulder season periods, ventilation with heat recovery will be used via a Hybrid Ventilation strategy. These strategies are outlined as follows;

Natural Ventilation

Natural ventilation will be maximised where possible. The potential for natural ventilation is dependent on room type/usage, window configuration, room dimensions and external noise considerations. Figures 7a to 7c show the potential strategies.

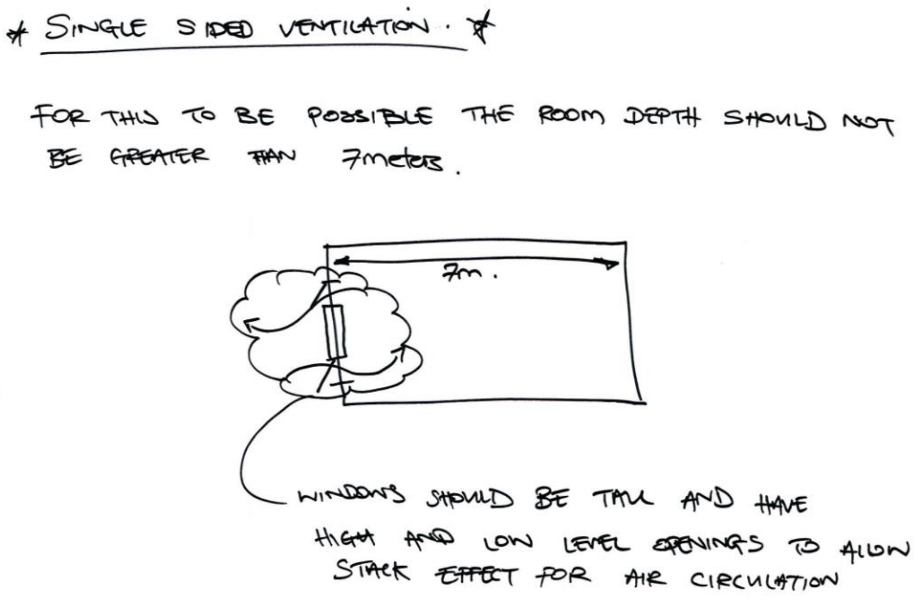

Figure 7a: *Single Sided Nat Vent Concept*

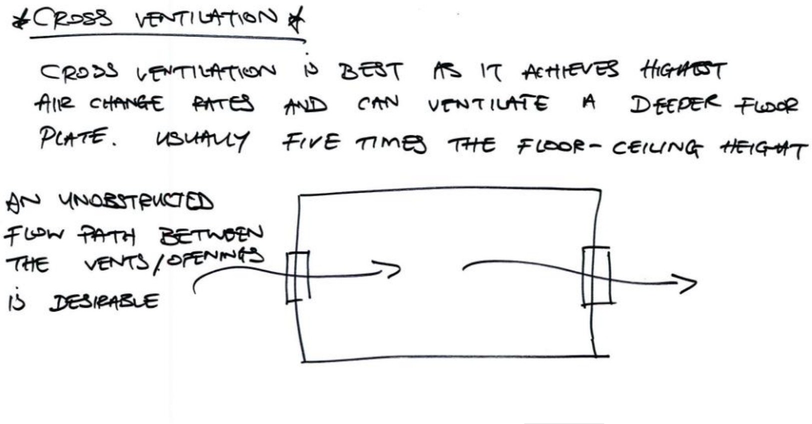

Figure 7b: *Cross Nat Vent Concept*

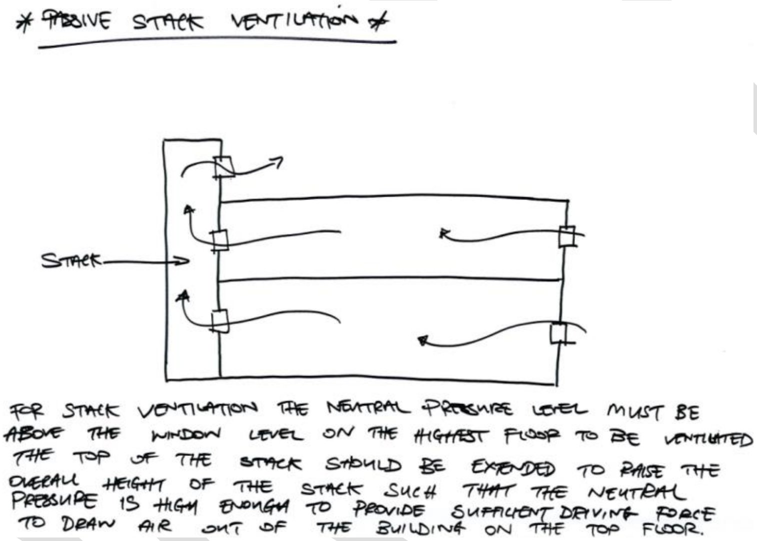

Figure 7c: *Passive Stack Nat Vent Concept*

Hybrid Vent

Within typical classrooms the principal ventilation strategy for the new school building shall be mixed mode Hybrid Ventilation (Assisted Natural Ventilation). This will be achieved using a Hybrid ventilation unit or similar. Staff/office areas shall also use this ventilation strategy where practical. Figure 8 shows the typical configuration and control strategy for the hybrid system.

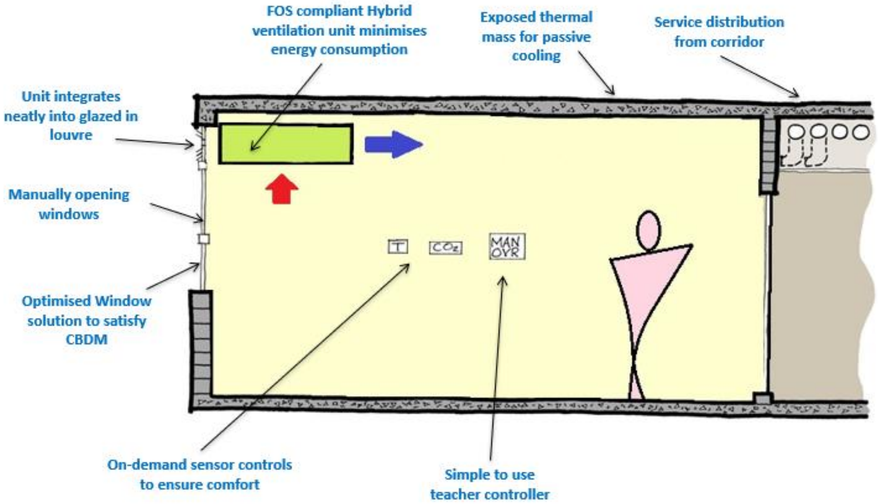

Figure 8: Hybrid Ventilation Strategy

The design of a standard classroom with Hybrid Ventilation provides the following;

- Assisted Natural Ventilation
- Extremely low energy fresh air solution
- No drafts utilising a mixing box
- Ensure ventilation without the need to open windows in inclement weather
- Exposed thermal mass to provide free cooling
- Secure night purge to pre-cool the building overnight during warm weather using cool night air. This strategy cools the building fabric utilising the thermal mass of the building which in term offsets room gain during the day
- Simple user controller

Heat Source

To meet the target of 65kWh/m²/year the school must incorporate either a Ground-Source Heat-Pump (GSHP) system or an Air Source Heat Pump (ASHP) .

Ground Source Heat Pumps (GSHP) have a higher capital cost than Air source Heat Pump (ASHP) Systems. Ground source can be either boreholes or slinky type.

Ground Source is more efficient and has better COP's than Air Source due to the reasons summarised below;

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Air Source: Air source heat pumps use heat energy from the air to ‘pump’ (using electricity) higher temperature heat into a building. The efficiency of an air source heat pump varies across the seasons and time of day. In winter because when you need heating the most, the air – its source of energy – is at its coldest, and the unit will require more electricity to operate efficiently.

Ground Source: The ground can maintain more stable temperatures than that of the air (cira 10-12°C) all year, which means the average ground temperature in winter will always be significantly warmer than the average air temperature. This means that the heat pump doesn’t need to work as hard and use as much electricity in winder when compared to air source. GSHP’s can be categorised as having closed or open loops. Closed loop can be installed in three ways: horizontally, vertically, or in an underground aquifer. The type chosen depends on the building load, available land areas and the soil and rock type at the installation site. These factors will help determine the most economical choice for installation of the ground loop.

Heat pump technology works most efficiently when use with an underfloor heating system and it is recommended that this form of space heating system is the main method of heating in the school.

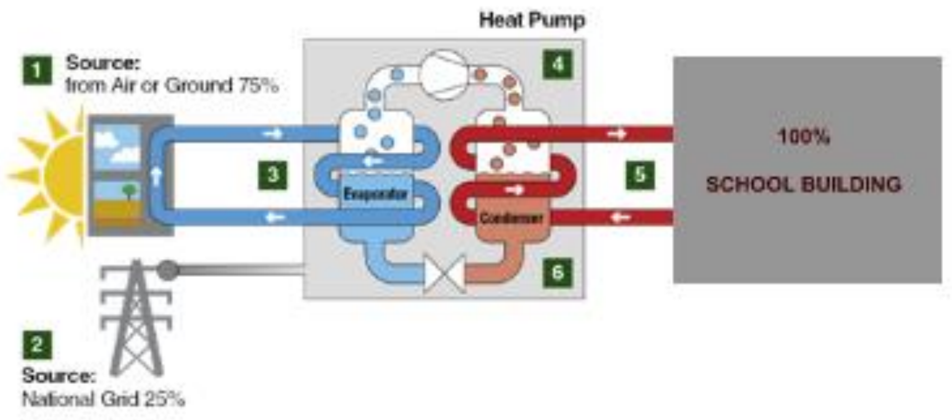

Figure 9: *Ground or Air Source Heat Pump Concept*

Domestic Hot Water Generation

The aforementioned heat-pumps will also be used for the domestic hot water with most DHW demand located close to the plantroom to minimise distribution losses. Fully insulated self- balancing thermostatic DHW recirculation valves will be used to minimise distribution losses.

Instantaneous electric domestic hot water systems are increasingly viable with falling grid carbon factors, but we note GSHP electricity is likely to be consumed when grid CO2 emissions are lower, and point-of-use heating tends to consume electricity when electricity CO2 emissions are is higher.

Space Cooling

The DFE Sustainability Brief target for this is 0kWh/m²/year. In these proposals we aim to design passive cooling for the IT room (usually the only room in the school with air- conditioning)

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5.3 Artificial and Natural Lighting

The DFE Sustainability Brief target for lighting energy use in schools equates to 8kWh/m²/year. In these proposals the aim is to better this and target an energy use figure of 6.2 kWh/m²/year. This is to be achieved using the following methods:

Daylighting

A great emphasis will be placed upon providing an effective daylighting strategy, which delivers the following benefits;

- Provides good visual comfort: High levels of uniform daylight are provided to learning spaces which ensures good visual comfort is achieved
- Minimises the need for artificial light, thus minimising running costs

Daylight will be provided to the various spaces as indicated in the following table:

Type of Space	Daylight Solution
L1 - Basic Teaching Spaces / Admin Offices	Façade glazing with windows as high as possible, providing an even spread of daylight across the depth of the spaces.
L2 - Main Hall / Dining / LRC	Double height vertical glazing allows good levels of daylight in to the space.
L2 - Sports Hall	Bands of clerestory glazing possibly on all 4 sides of the sports hall, to allow significant levels of daylight into the space.
L3 – Group Rooms / Study Rooms / Staff Areas	Façade glazing with windows as high as possible, providing an even spread of daylight across the depth of the spaces.
L4 – Circulation / Prep Areas / Changing	Subject to layout. Borrowed or Rooflights
L5 – Storage / WCs / Kitchen / Plant Areas	*No daylight Requirement*
L6 – Drama Studios / Dark Room / Control Rooms	*No daylight Requirement*

Table 3 *– Daylighting Solutions*

Interior Lighting

The lighting design shall be part of the whole architectural scheme and sufficient care shall be taken to provide visual variety and stimulation. Notwithstanding this, the lighting installation and luminaires shall be designed and selected to ensure energy efficiency is at the forefront of the design. High quality LED sources shall be specified to maximise the efficacy of luminaires.

The lighting design shall ensure the circuit luminous efficacy for fixed lighting installations exceeds current guidance with the following figures targeted:

- Lighting throughout has a minimum efficacy of 110-120 luminaire-lumens/circuit-Watt.
- Display lighting has a minimum efficacy of 90-100 luminaire-lumens/circuit-Watt.

Lighting Control

Lighting Controls shall be incorporated to suit the operational requirements of the School, energy efficiency requirements, available daylight levels and occupancy detection with systems designed to suit the intended day to day building operation patterns and to take account of the available daylight.

An energy efficient and simple to operate lighting control system will be installed to implement the lighting control strategies identified.

It is proposed to have localised intelligent lighting controls located in ceiling voids and at high level where applicable. The lighting control strategy shall meet Building Regulations Part L to minimise energy consumption of the lighting installation.

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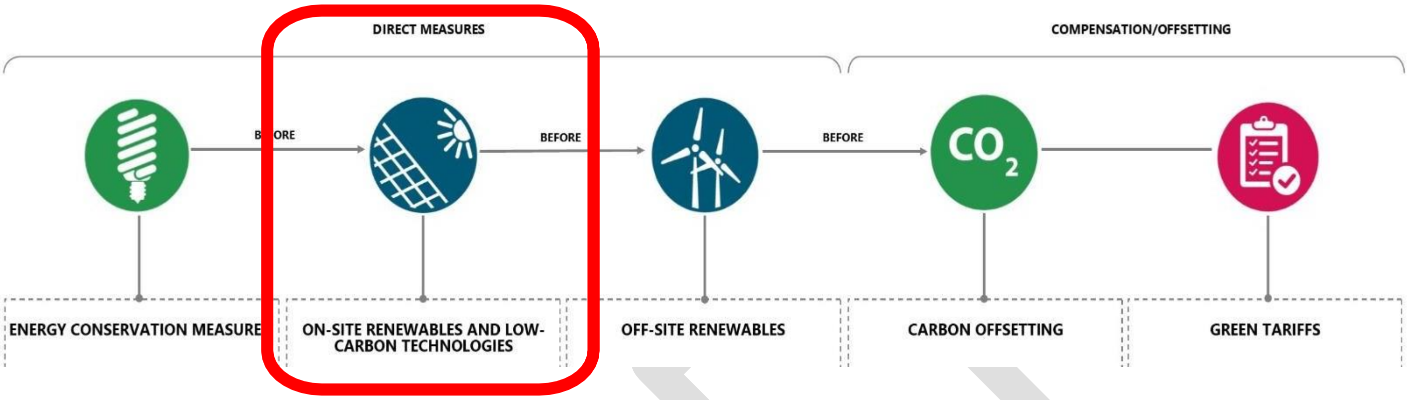
6.0 RENEWABLES

The adopted approach focusses first on energy saving and maximising onsite low carbon technologies. If further carbon reductions are required than can be achieved on site then these can be captured through considering offsite renewables and finally using carbon offsetting.



A renewables options appraisals matrix has been undertaken, which is included in Appendix A of this report. This initial appraisal has identified the following technologies as being the most appropriate for the site and the required Net Zero Carbon in Operation Strategy.

- Air Source or Ground Source Heat Pumps
- Solar PV.

Maximise use of renewables to generate the annual energy requirement including the use of heat pumps

Ensure heating and hot water generation is fossil fuel free. The building will benefit from fossil free heating and hot water, essential for maintaining achieving the Zero Carbon target. The building will likely utilise heat pumps for both of these areas, therefore the design will put in place measures where the demand for electricity can be reduced, particularly for those parts of the day where the demand on the electricity grid is likely to be highest.

The use of PV, to offset some of the demand on the electrical grid and contribute towards offsetting the electrical consumption of the heat pump system.

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7.0 ENERGY CONSUMPTION

Reduced energy consumption will be achieved by;

- Reduce regulated energy consumption from controlled, fixed building services
- Reduce unregulated energy consumption through occupant's incentive schemes
- Lighting design should be implemented to effectively light the spaces
- Use LENI calculation method to understand true lighting system consumption (W/m2/100lux)

8.0 WATER CONSUMPTION

Potable Water Use < 10-13 l/p/day

9.0 METERING AND MONITORING STRATERGY

The school will be provided with an automated metering system capable of half hourly data logging Metering to provide a breakdown of major energy uses in line with Soft Landings requirements to provide accurate, useful information and should be designed in collaboration with building operators

The school shall implement a metering management scheme to ensure that meters are and remain calibrated throughout the operational life of the building. In addition to this a sustainability and efficiency energy management plan will be implemented in line with ISO 50001 that includes provisions for carrying out a DEC assessment, reporting on the DEC assessment outcome on an annual basis and incentivise incremental performance improvement.

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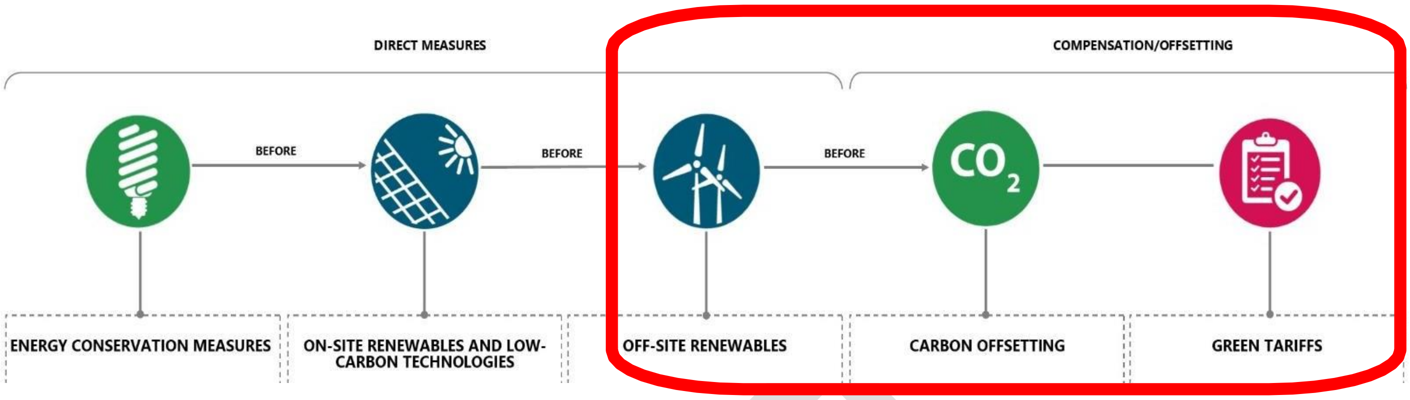
10.0 INCOMING ENERGY AND CARBON OFFSETTING



Carbon offsetting could be considered in order to achieve Net Zero Carbon in operation. This may be achieved by ensuring that energy imported to the site is from renewable energy sources via a 'green tariff' or equivalent.

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APPENDIX A

Net Zero Carbon Strategies Appraisals Matrix

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The following table summarises some of the currently available sustainable techniques for the Seaton Valley Federation School project. The list is by no means exhaustive, but includes most methods which may be currently available for the scheme.

The table also highlights techniques which will contribute towards the Net Zero Carbon requirements

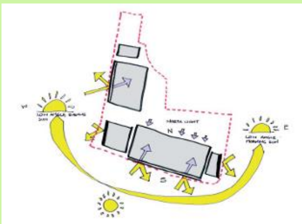
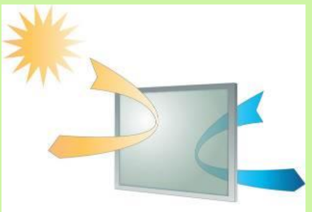
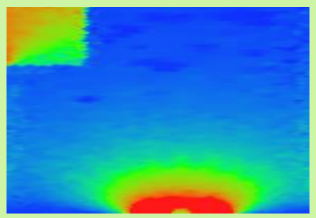
The table indicates the general advantages and disadvantages of each option and its likely relevance / application to the scheme. It should be noted that the details are not based on any form of project specific modelling, calculation, consumption estimates, utilisation profile, payback analysis, etc. at this stage.

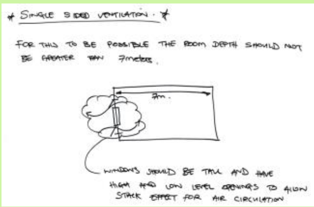
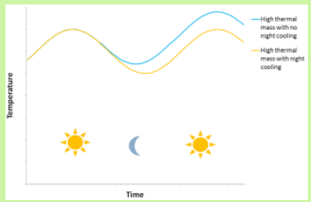
The table is intended to give an overall appreciation of the potential techniques

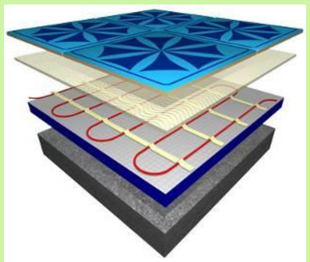
The most appropriate and viable techniques and technologies for the scheme have been highlighted in the matrix below.

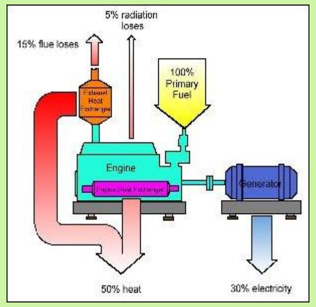
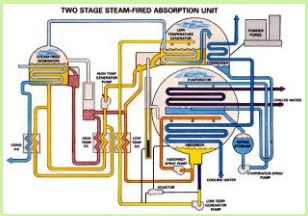
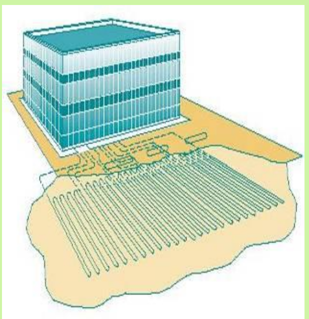
Site Feasibility Key

(Green)	Potentially applicable to the site. Will be further evaluated during the design development.
(Yellow)	Could be feasible for the site, although potential site / design / cost constraints have been identified. Further investigation required as the design progresses.
(Red)	Unlikely to be feasible on site due to site / design / cost constraints.

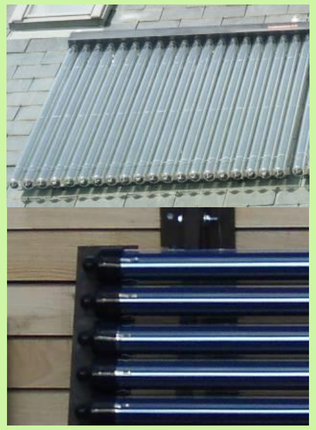
Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further
Passive Energy					
1.1		**Orientation** Optimising orientation to make best use of passive design measures, the solar interaction with the building and wind direction in order to enhance the potential for natural ventilation and avoiding overheating in summer.	• Low cost method of reducing energy consumption significantly. • Makes solar control and daylighting easier to optimise.	• May conflict with architectural vision (although this can be overcome). • May conflict with functionality (although this can be overcome).	Preliminary modelling has already been conducted to identify the correct orientation. This should be verified as the design detail progresses. The POA and firing ranges have no glazing and so their orientation is of little / no significance.
1.2		**Solar Control** Solar gains and daylighting should be balanced through measures such as: • Recessed windows • Overhangs • Solar control glass • Active shading.	• Improves thermal comfort. • Controls glare. • Reduces cooling energy consumption. • Can be integrated into the architecture.	• Additional capital cost. • May conflict with architectural vision (although this can be overcome).	This is applicable to all buildings with glazing and so is good design practise. Daylight calculations can be undertaken iteratively to optimise the glazing strategy. Our research on the Target Zero Project has identified that this measure can save 1% of the building's CO_2 emissions. The POA and firing ranges have no glazing and so their solar control is of little / no significance.
1.3		**Daylighting** Careful sizing and positioning of glazing to ensure that daylight penetrates the building to reduce use of electric light without causing glare.	• Reduces the lighting energy consumption. • Provide high quality natural light for building occupants. • Creates a link between social and habitable spaces.	• May conflict with architectural vision (although this can be overcome).	This is applicable to all buildings with glazing and so is good design practise. Daylight and thermal calculations can be undertaken iteratively to optimise the glazing strategy.

Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further
1.4		**Building Envelope** Optimising levels of insulation and air tightness to achieve thermal efficiency cost effectively.	• Reduces the heating energy consumption. • Improves the thermal comfort for the occupants.	• Very high level of air tightness may lead to the requirement for mechanical ventilation. • Cooling loads or risk of overheating can be increased. • Excessive insulation and air tightness may raise the risk of overheating in summer.	This is applicable to all buildings and so is good design practise. Dynamic thermal modelling can be undertaken to optimise the envelope performance parameters.
1.5		**Natural Ventilation** Sustaining indoor air quality and thermal comfort through the natural movement of air. Movement may be wind or buoyancy driven or both.	• Low running cost and low energy ventilation strategy. • No mechanical ventilation equipment to maintain and clean. • Full user control of the environment. • Low capital cost.	• Noise and pollution from adjacent roads may prohibit this option. • Can be difficult to manage thermal comfort, and may be potential for overheating at certain times of the year. • Air quality issues must be carefully managed (CO_2, NOx, dust, etc). • Open windows may present a security risk in some instances. • Care must be taken to prevent draughts. • Potentially increased heating demand. However all of these can be overcome through careful façade design.	The choice of ventilation strategy will be highly dependent on the client's requirements for air quality and thermal comfort. The design approach will seek to use natural ventilation wherever possible. Where this cannot be achieved, the ventilation strategy will be selected on the basis of the following order of preference: • Natural Ventilation • Mixed Mode Ventilation • Mechanical Ventilation • Cooling.
1.6		**Thermal Mass** Using the thermal inertia of materials such as concrete to keep the building cool during peak summer temperatures by stabilising and reducing peak internal temperatures.	• Reduces extremes in internal temperatures. • Helps maintaining an average moderate internal temperature year round. • Can reduce heating and cooling energy requirements. • Can improve thermal comfort in location with hot summers.	• Night operation of the building will impede the ability to provide night cooling. • Hard internal surfaces may hamper acoustic performance of rooms. • Higher embodied carbon in structure.	Thermal mass is only of benefit when carefully integrated into the building concept. Analyses should be undertaken in order to establish whether its use is appropriate in the case of each building and area.
Active Energy Efficiency					
2.1		**Plant Efficiency** Specifying efficient plant to provide heating, cooling, and ventilation with minimal losses. This should include elements such as heat recovery devices such as thermal wheels and consideration of heating systems which can efficiency utilise low grade heat from sources such as heat pumps.	• Reduction in operation energy cost. • Efficient plant is often of a higher quality and so requires less maintenance. • Reduced energy consumption and carbon emissions. • Often low capital cost.	• May require large air handling units and ceiling voids. • More expensive plant equipment.	The specification of efficient plant is good practise; however care should be taken to ensure that the performance specification pays careful attention to cost / benefit analyses / life cycle costing.

Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further
2.3		**Lighting Efficiency** Specifying efficiency light bulbs and fittings which spread light effectively.	• Substantially reduced energy running cost especially for areas which operate 24 / 7. • May reduce the number of fitting to achieve the required LUX level. • More efficient lamps generally have a longer operational life. • Lower maintenance cost / replacement rate.	• May conflict with architectural vision (although this can be overcome). • High capital cost.	The specification of efficient lighting is good practise; however care should be taken to ensure that the performance specification takes account of cost benefit analyses. Furthermore specialist lighting design advice should be sought to ensure that light quality is maintained.
2.4		**Lighting Controls** Daylight sensing and occupancy sensing controls which automatically provide electric light only when needed as well as well positioned switch controls to make it easy for users to only use the lights they require.	• Reduces the lighting energy consumption. • Reduces carbon emissions and running costs. • Avoids over illuminating spaces. • Low capital cost. • Reduces risk of overheating in summer.	• Poor commissioning could result in worse control, (this can be easily overcome).	The inclusion of automatic lighting controls is becoming standard practise on a wide range of projects. This measure has only a small capital cost implication. However careful design is required to ensure control is appropriate to suit user requirements.
2.5		**Seasonal Commissioning** Commissioning plant for winter, summer, and mid season operation to ensure efficient operation throughout the year.	• Ensures correct and efficient operation throughout the year. • Reduced risk of failures. • Ensures correct installation. • Will reduce energy consumption, running cost and carbon emissions.	• Increasing commissioning. • Might cause disruption to building operation (although this can be overcome through careful planning – please refer to the soft landings document).	Seasonal commissioning should be carried out on all projects. The marginal cost increase is generally recouped through energy savings. Seasonal commissioning will ensure optimal performance under real operational conditions.
2.6		**Thermal Zoning** Ensuring that heating and cooling can be easily controlled in well sized zones so that comfort is maintained without using energy unnecessarily.	• Reduce energy consumption, carbon emissions and running cost. • User customisable internal conditions for higher thermal comfort.	• Slightly higher system complexity. • Slightly higher capital cost.	Discussions with the client will be necessary in order to establish the size and geometry of appropriate thermal control zones. The building layouts are taking account of predicted hours of operation to facilitate efficient thermal zoning.
2.7		**Underfloor Heating** With an underfloor heating system, the floor itself becomes the heat emitter. This way the room is, effectively heated from the floor upward.	• Reduces energy consumption as the water used is at a lower temperature (typically 50°C rather than 60°C plus). • Higher thermal comfort for the occupants. • Heat is distributed more efficiently. • No need for wall mounted emitters with increasing of useful floor area. • Less 'dust traps' so the rooms are easier to keep dust free. • In wet areas, (bath, shower rooms, kitchen etc.) the floors will dry quicker.	• May have slower response time depending on the floor thermal mass (not a problem as the building has a 24 / 7 operation). • Delayed response to heating system may challenge building control strategy. • Higher installation costs.	This technology is more expensive than conventional radiators, but provides a clean internal appearance and improves the functionality of each room. The low flow temperature required by this technology is suitable for all types of heat pump.

Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further	Site Feasibility
3.1		**Combined Heat and Power (CHP)** A small on-site generator which burns fuel (gas, biodiesel, or biomass etc.) to provide heat and electricity.	• Potential for large reduction in carbon emissions. • Provides on-site generated electricity. • Could double up as emergency generator.	• Higher capital cost. • Higher system complexity. • Requirement for a buffer vessel (hot water tank). • Larger space requirement. • Higher maintenance cost.	This technology will benefit from the extended running hours of the sites however the base load in summer is not expected to be great. Additional space will be required for a larger hot water tank. The economics of CHP should be analysed carefully to ensure that financial savings are made. Not suitable for the schemes Net Zero Carbon strategy.	
3.2		**Combined Cooling, Heat and Power (CCHP)** CHP Providing Space heating and DHW combined with an absorption chiller to provide space cooling from high grade waste heat.	• Potential for large reduction in carbon emissions. • Provides on-site generated electricity. • Could double up as emergency generator.	• Higher capital cost. • Higher system complexity. • Requirement for a buffer vessel (hot water tank). • Larger space requirement. • Higher maintenance cost.	This technology will benefit from the extended running hours of the sites and the cooling load in summer will help to provide a larger base-load to increase plant operating hours. Additional space will be required for a larger hot water tank. The economics of CCHP should be analysed carefully to ensure that financial savings are made. The key issue with this technology is the high maintenance cost. Deemed not suitable for the schemes Net Zero Carbon strategy.	
3.3		**Ground Source Heat Pumps (GSHP)** A refrigeration cycle which draws heat from the ground into the building in winter and returns the heat from the building to the ground in summer.	• Technology that reduces the site carbon emissions. • Versatile technology that can provide low carbon heating and cooling.	• Very high capital cost. • Higher system complexity. • Less efficient when providing hot water for taps and showers than when providing space heating. • Performance is highly dependent on ground conditions which are currently unknown and expensive to investigate.	The ground conditions would need to be investigated by drilling trial bore holes before a final decision is taken to include a GSHP. There is no guarantee that ground conditions will be suitable for this technology. GSHP technology is best utilised when combined with low temperature heating and cooling systems such as underfloor heating, LST radiators.	
3.4		**Air Source Heat Pumps (ASHP)** A refrigeration cycle which draws heat from the surrounding air into the building in winter and returns the heat from the building to the ground in summer.	• Technology that reduces the site carbon emission. • Versatile technology that can provide low carbon heating and cooling. • Typically around 105 of the cost of a GSHP.	• Less efficient when providing hot water for taps and showers than when providing space heating. • Higher noise output than conventional plant although near busy roads this may not be a problem.	This technology can be installed on most sites. The plant emits more noise than conventional plant and is best utilised when combined with low temperature heating and cooling systems such as underfloor heating, LST radiators or chilled beams.	

Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further	Site Feasibility
3.6		**Hydrogen Fuel Cell** Converts hydrogen in to electricity and heat. Hydrogen can be produced by either reforming mains gas (which produces CO_2) or by electrolysing water with renewable electricity.	• Innovative technology for flagship site. • Potential to make the site zero carbon when combined with large wind turbines and / or photovoltaics (see below). • Potential to make site run independently from the national grid. • On-site energy storage. • Potential to provide fuel to hydrogen-powered vehicles.	• Very high capital cost. • Very high maintenance costs. • Emerging technology. • Large energy centre space requirement.	Fuel cells have a very high capital and maintenance cost associated with them at the moment although prices will fall in future. The technology has only recently become market ready. Fuel cell should be fuelled by hydrogen from electrolysis of water with the energy from wind turbines or PV to be a true renewable.	
3.7		**Biomass Boilers** A boiler which burns wood chips or pellets to provide space heating and hot water to the building.	• Reduces the building carbon emission related to heating and hot water for taps and showers. • Small increase in capital cost for large carbon savings.	• Requirement for a buffer vessel (hot water tank). • Larger space requirement for boiler. • Space also required for fuel storage. • Higher maintenance cost. • Regular site access required by large vehicles for fuel delivery. • Fuel supply chain reliability. • Higher NOx emissions. • Requires planning approval for smoke free areas. • High flue is likely to be required.	Local fuel supplies should be identified in order to ensure the sustainability of this technology. Fuel delivery vehicle movements should be planned. Fuel storage space must be identified. The running cost of this technology is likely to be similar to that of conventional gas boilers. Deemed not suitable for the schemes Net Zero Carbon strategy.	
4.1		**Wind Turbines** Wind energy is harnessed to generate zero carbon electricity.	• Eligible for the feed in tariff. • Provides a renewable zero carbon source of electricity. • Reduces building carbon emissions, energy use and running cost. • Iconic visual statement of sustainability.	• Needs careful assessment of the wind resource. • May be difficult to get planning permission in some areas. • Requires annual maintenance. • Possible annoyance from shadow flicker and background noise.	A wind resource analysis should be undertaken as well as consulting with a planning consultant. This technology is unlikely to be appropriate on urban sites. Ideally wind speed monitoring should be undertaken onsite. Care should also be taken to ensure that turbines do not interfere with helicopter movements.	

Ref	Image	Description	Advantages	Disadvantages	Suitability / Likelihood of Taking Further	Site Feasibility
4.2		**Photovoltaics** Solar panels which generate zero carbon electricity.	• Eligible for the feed in tariff. • Easy to install. • Low maintenance as there are no moving parts. • Silent operation. • Reduces building carbon emissions, energy consumption and running cost. • Iconic visual statement of sustainability. • Can be integrated into standing seam roof panels.	• Requires a well oriented and un-shaded installation area. • The PV array must be cleaned periodically. • Increased capital cost. • The solar collector should be cleaned annually.	If photovoltaics are to be included then they should be integrated into the architecture by providing a suitable location for their installation in terms of orientation and elevation without shading. Orientation and elevation are crucial. Panels must not experience significant amounts of shading in order to maintain performance. The introduction of the feed in tariff has shortened the payback period to within 15 years. Deemed suitable for the schemes Net Zero Carbon strategy. Could be mounted on buildings flat roof.	
4.3		**Solar Thermal Water Heating** Solar panels which heat water for use at taps, showers, etc.	• Reduces building carbon emissions, energy consumption and running cost. • Low maintenance. • Silent operation. • Visual statement of sustainability.	• Increases the complexity of the hot water system. • Requirement for a buffer vessel (hot water tank). • Requires a well oriented and un-shaded installation area. • The solar collector should be cleaned annually.	If solar thermal panels are to be included then they should be integrated into the architecture by providing a suitable location for their installation in terms of orientation and elevation without shading. Orientation and elevation are crucial. Panels must not experience significant amounts of shading in order to maintain performance. The size of the annual hot water requirement should also be identified when establishing the viability of this technology. The location of the panels should also be close to the plant room in order to minimise pipe-work heat loss.	