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Document Revision History

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Executive Summary



Couch Perry and Wilkes have been appointed by Messrs. Peveril Securities Ltd, alongside 5plus Architects, to help steer and inform the energy credentials of the proposed Napier Court development in Reading. This Energy Statement is provided to demonstrate how the development will comply with planning policy relating to energy efficient design and generation of energy from renewable sources.

The proposals comprise a Full planning application for demolition of the existing three office buildings, and construction of new 11 storey buildings, with amenity space at roof level (part indoor and set back), to provide 576 residential dwellings consisting of 1, 2 and 3-bedroom apartments. The development will include ancillary facilities for residents, such as a residents' lounge, gym and communal workspace. The buildings will be set in landscaping to the front and between the buildings together with roof terraces. Parking is proposed for 39 cars and 6 motorbikes. Three internal storage spaces are proposed at ground floor for 289 bicycles and an additional 20 cycle spaces are provided externally for visitors. The site is 1.26 ha in size and stretches east to west along Napier Road, bound by the railway line to the south, Napier Road and Kings Meadow to the north, Thames Quarter to the west and a Network Rail site to the east. The site is located within the administrative boundary of Reading Borough Council and is very well connected to the train station, bus services and town centre facilities.

This report outlines the passive and active decarbonisation measures proposed to enhance the development's energy efficiency and reduce carbon dioxide (CO₂) emissions.

The proposals have been analysed under the current Part L 2021 assessment methodology to demonstrate compliance against the more ambitious recent update to Part L Building Regulations. Inherent to this more stringent performance criteria, the proposed residential development will be required to incorporate an average improvement in CO₂ emissions of approximately 31% when compared with the previous Part L 2013 standards. In addition, the new standards focus on primary energy use as well as reducing CO₂ emissions. This ensures better performing buildings as a whole and forces developments to focus on a fabric first approach to decarbonisation, by reducing the energy demand of the development, rather than relying on offsetting of carbon emissions.

To define the energy strategy for the development, a best practice Energy Hierarchy has been adopted, for reducing energy use and CO₂ emissions, as follows: -

- Be Lean: Use less energy and manage energy demand during operation.
- Be Clean: Exploit local energy resources and supply energy efficiently and cleanly.
- Be Green: Maximise opportunities for renewable energy by producing, storing, and using renewable energy on-site.
- Be Seen: Monitor, verify and report on energy performance.

In addition, good practice also requires energy usage associated with cooling to be minimized, by reducing overheating through effective building design and careful specification of ventilation systems.

In the first stage of the energy hierarchy, 'Be Lean', the energy demand of the development is minimized by implementation of a 'fabric first' approach and optimisation of passive design principles, providing a high-performance thermal envelope for the building. The proposed building fabric thermal envelope performance criteria are tabled below:

Element	Criteria	Notes	U-Value saving on Part L 2013 Regulations
Glazing	U = 1.2 W/m ² K	G-Value of 0.42 on North facing and 0.39 on South, East and West elevations	40%
Wall	U = 0.16 W/m ² K	Build-up TBC at later stage	47%
Roof	U = 0.1 W/m ² K	Build-up TBC at later stage	50%
Ground Floor	U = 0.1 W/m ² K	Build-up TBC at later stage	60%

This approach minimizes the energy demand through good passive design, such that the proposed buildings themselves are being used as the primary environmental modifier.

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Active energy reduction measures include, but are not limited to, heat recovery ventilation, direct electric heating (a transition away from fossil fuels), air source heat pumps for domestic hot water production, variable speed pumping and low energy LED lighting.

In the second stage of the energy hierarchy, 'Be Clean', low energy design philosophies include the utilisation of the UK electrical grid, which is ever approaching decarbonization. This is to ensure a move away from direct hydrocarbon usage for heating and hot water generation and ensure a pathway towards net zero carbon in operation whilst utilising the decarbonization trend of the electrical grid.

Mixed mode ventilation is available for occupants in the form of openable windows, providing the opportunity for natural ventilation and night-time free cooling, whilst heat recovery is achieved from whole apartment mechanical ventilation heat recovery (MVHR) systems.

In the third stage of the energy hierarchy, renewable and low carbon technologies proposed on the project include air source heat pumps (ASHP) for generation of domestic hot water in each apartment, and roof mounted solar photovoltaic (PV) panels for on-site renewable electrical energy.

In the final stage of the energy hierarchy, 'Be Seen', a Building Energy Monitoring System that allows the monitoring and reporting of landlord and tenant energy usage will be provided. This provides valuable information to enable effective operational energy management and maintenance, promoting highly efficient building operation.

The project has been designed to align with Reading planning policy and requirements of the Reading Sustainable Design and Construction Supplementary Planning Document (SPD).

The following policies are the main policies supplemented by Reading Sustainable Design and Construction SPD and the proposed design has been developed to compliment the same:

- CC2: Sustainable Design and Construction

This policy sets out the general principles of sustainability in new development that applies to both residential and non-residential uses and has been used to guide the sustainability strategy. The proposed development is meeting Home Quality Mark (HQM) credentials, to ensure holistic sustainable development in support of this policy.

- CC3: Adaptation to Climate Change

This identifies measures including building orientation, shading, heating, planting and surface water run-off to deal with the effects of climate change. This policy will ensure that development within the Borough is resilient in the face of climate change. The proposed development includes good passive design features and mitigation of overheating in respect to adaptation to climate change in line with the new Part O Building Regulations.

- CC4: Decentralised Energy

This policy requires consideration of decentralised energy infrastructure to increase the amount of decentralised energy provision in the Borough. This has been considered and there is no local decentralised energy network that may facilitate a viable connection (refer to Section 4 of this report)

- H5: Standards for New Housing

This policy outlines standards for new-build housing, including those for sustainable design and construction. The proposed development has been designed to provide considerable reduction in CO₂ emissions compared to the new Part L 2021 Building Regulations, as can be seen tabled below.

To evaluate carbon savings achieved through the measures proposed herein, the proposed development is compared against the projected Part L 2021 Target Emissions Rate utilising early design stage sample part L assessments.

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Projected Part L 2021 Assessment Comparison		
Estimated Target Emissions Rate (Annual kgCO ₂ /m ²)	Projected Whole Development Emissions Rate (Annual kgCO ₂ /m ²)	Projected Percent Betterment (%)
11.20	3.22	71.2

The projected CO₂ emissions utilising the above figures are 142.21 tonnes CO₂/annum which would result in an annual excess CO₂ emissions contribution of **£255,981.02** for the development. It is expected that these figures will change as further design certainty is achieved.

In conclusion, through the implementation of a responsible and effective Energy Hierarchy throughout all stages of the design process, the proposed development will exceed current Building Regulations Part L 2021 requirements to ensure sustainable development and is expected to significantly exceed the required minimum 35% improvement over the 2013 Building Regulations Dwelling Emissions Rate.

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1.0 Introduction

Couch Perry Wilkes (CPW) have produced an Energy Statement for the proposed development at Napier Court. This is to demonstrate how the scheme will incorporate energy efficiency measures, decentralised energy sources and integrate Low and Zero Carbon (LZC) technology solutions, to reduce CO₂ emissions of the development.

To ensure responsible development, an Energy Hierarchy has been adopted for reducing CO₂ emissions, in line with best practice, as follows:

- Be Lean: Use less energy and manage demand during operation.
- Be Clean: Exploit local energy resources and supply energy efficiently and cleanly.
- Be Green: Maximise opportunities for renewable energy by producing, storing, and using renewable energy on-site.
- Be Seen: Monitor, verify and report on energy performance.

The design of the proposed development is underpinned by the desire to deliver a wide range of positive responses to climate change, the ambitions of Reading Borough Council's planning policies and the UK wide target of zero carbon.

The proposal improves biodiversity, enhances green space, reduces the impact on the local surface water drainage, significantly reduces energy use, and maximises the potential to benefit from continued decarbonisation of the electricity grid.

The Reading Borough Council's Local Plan reinforces the Council's desires to limit energy consumption and reduce CO₂ emissions through Planning Policies CC2, CC3, CC4 and H5 and the applicant team fully support these targets. These are the main policies supplemented by the Reading Sustainable Design and Construction SPD and the proposed design has been developed to compliment the same:

- Policy CC2: Sustainable Design and Construction

This policy sets out the general principles of sustainability in new development that applies to both residential and non-residential uses and has been used to guide the sustainability strategy. The proposed development is meeting Home Quality Mark (HQM) credentials, to ensure holistic sustainable development in support of this policy.

- Policy CC3: Adaptation to Climate Change

This identifies measures including building orientation, shading, heating, planting and surface water run-off to deal with the effects of climate change. This policy will ensure that development within the Borough is resilient in the face of climate change. The proposed development includes good passive design features and mitigation of overheating in respect to adaptation to climate change in line with the new Part O Building Regulations.

- Policy CC4: Decentralised Energy

This policy requires consideration of decentralised energy infrastructure to increase the amount of decentralised energy provision in the Borough. This has been considered and there is no local decentralised energy network that may facilitate a viable connection (refer to Section 4 of this report)

- Policy H5: Standards for New Housing

This policy outlines standards for new-build housing, including those for sustainable design and construction. The proposed development has been designed to provide considerable reduction in CO₂ emissions compared to the new Part L 2021 Building Regulations, as can be seen tabled below.

This report is intended to outline how the proposed development meets the targets set out in each of the requirements outlined above.

2.0 Energy Benchmarking – Estimated Energy Demands and CO₂ Emissions

In order to benchmark the proposed new development, estimated energy demands and CO₂ emissions data have been calculated based on the current design information. These estimated energy consumptions are indicative only at this stage of the design. They will, however, be used as a guideline to assess the percentage of the building's total energy consumption and CO₂ emissions that could be reduced or offset in accordance with the Energy Hierarchy.

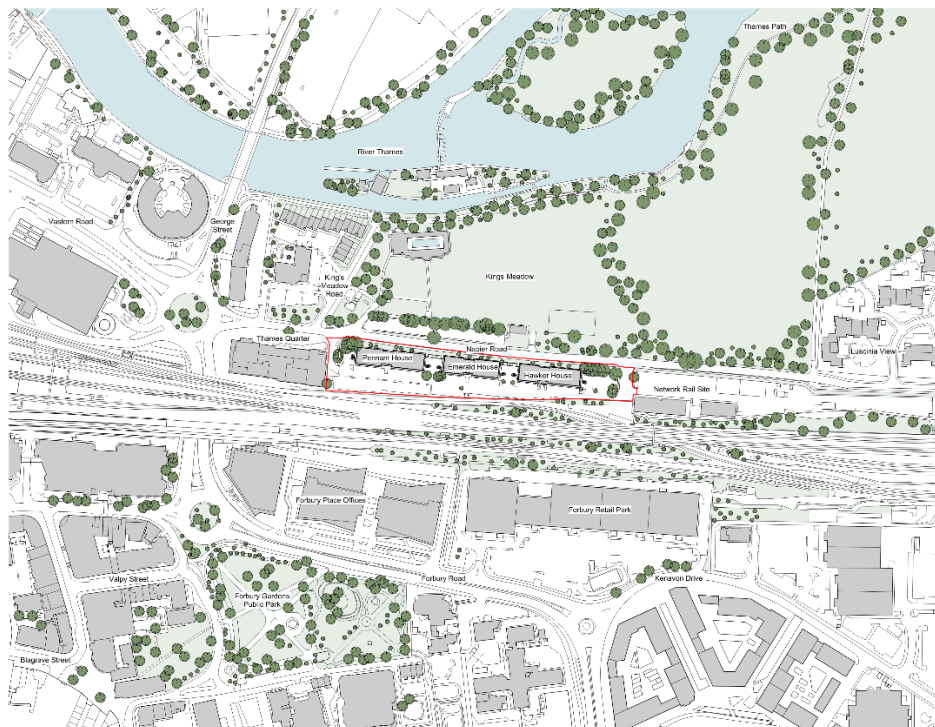
The predicted notional regulated CO₂ emissions utilising Part L 2021 emission factors and analysis methodology for the development are as follows:

Projected Part L 2021 Assessment Comparison		
Estimated Target Emissions Rate (Annual kgCO ₂ /m ²)	Projected Whole Development Emissions Rate (Annual kgCO ₂ /m ²)	Projected Percent Betterment (%)
11.20	3.22	71.2

3.0 Energy Efficiency – Be Lean

To deliver an environmentally responsible building, an exemplar approach is being proposed based on low energy design principles. In summary, this approach involves energy demand minimisation through effective building form, orientation and good passive design principles, so that the buildings themselves are being used as the primary environmental modifier.

3.1 Site Location



The site is 1.26 Ha in size and stretches east to west along Napier Road, bound by the railway line to the south, Napier Road and Kings Meadow to the north, Thames Quarter to the west and a Network Rail site to the east. The site is located within the administrative boundary of Reading Borough Council and is very well connected to the train station, bus services and town centre facilities.

3.2 Site weather and microclimate

The local weather and any microclimate will also influence energy usage. A development on the coast may have a maritime climate, experiencing milder winters and cooler summers than those further inland, particularly on the west coast where they are subject to the jet stream influence. Inland buildings will have a continental climate, suffering more extremes in temperature and therefore more likely to require heating and cooling.

The climate in Reading is warm and temperate with annual average temperatures of approx. 14.9°C. Maximum average temperatures can reach up to 23°C in July and August, and minimum average temperatures are unlikely to drop below 2°C in the winter months. The most representative weather station near the development is in Swindon (approx. forty miles away), and this location will be used for any thermal simulations.

The site's landscape also affects the energy demand of a building. Vegetation, landform and any existing buildings can provide shade to a new development. For example, if located to the south of the building, deciduous trees can be advantageous, providing shade in the summer but allowing sunshine through in the winter when they lose their leaves. However, any tree used for energy conservation should be considered as part of a much larger landscape.

3.3 Building Orientation, layout, and form

Building layout, orientation and form can influence many key features of the development. The design should provide for an effective use of space and appealing layout, with opportunities to benefit from natural daylight balanced with achieving solar gain without overheating. In general, a higher thermal performance can be achieved by limiting the surface area to volume ratio as this minimises heat loss through the wall area.

By orientating a building so that the long sides of the building face north and south, glare arising from the low early morning and evening sun is mitigated. It should be noted that where the building footprint is extremely tight, for example in a city centre location, then the building form and orientation may have to be dictated by the available space and not by implementation of best practice measures. Invariably, planning constraints and/or the functional relationships of specific areas will result in some measure of deep planning, thus reducing the opportunity for natural ventilation.

Solar heating or solar gain is often welcome in winter months, helping to heat up the building. However, careful design and attention to building orientation is essential to avoid summertime overheating, as on a clear day in summer an unshaded window in the UK can admit 3kWhr of energy per m² of glass. Overheating is likely to be more of a problem if the windows face the southern half of the sky (east or west facing windows can also be a problem in some types of building), there are horizontal or near horizontal rooflights, the building has high internal heat gains or the building needs to be kept cooler than normal.

Planning the internal layout of buildings and rooms to maximise the benefits of solar gain and minimise the disadvantages is essential. Spaces where overheating would be critical can be placed on the north side of the building or overhangs used to protect from excessive solar gain.

The primary length of the proposed buildings at Napier Court are approximately orientated from East to West; with the largest elevations facing South and North. The rooms on the southern exposure may get more sunlight during each day for passive solar heating and have required careful thermal analysis to ensure that overheating is avoided. The Easterly facing dwellings will also benefit from passive solar pre-heating during the early day time hours.

Plant areas are located at ground floor levels. The ground floor levels also comprise communal facilities, bin stores and cycle storage space. The upper floor levels comprise residential apartments / dwellings with amenity space (part indoor and setback) and solar photovoltaic (PV) and smoke ventilation equipment at roof level.

3.4 Building Design – Energy Efficiency

The general construction design standards to be adopted must exceed the requirements of the current (2021 Edition) Part L Building Regulations.

To this end, the proposed design shall promote reduced CO₂ emissions from delivered energy consumption by minimising operational energy demand through passive and best-practice measures. The LZC technology energy options presented herein will potentially provide a further CO₂ reduction over and above the measures included as an integral part of the project design.

3.4.1 Use Less Energy

Being lean is all about utilising passive, often simple measures to help reduce the energy consumption to a sensible minimum level. We started our analysis with the thermal envelope. Using traditional construction methods, we have been able to engineer the building envelope to reduce heat loss in winter and unwanted heat gain in summer. This has been achieved by:-

- Enhanced envelope U-values - to reduce the buildings' heating requirements.
- Providing a well-sealed envelope to minimise the infiltration of cold winter air and warm air in summer - to reduce the building's heating and cooling requirement.
- Minimising thermal bridging by careful structural and architectural detailing - to reduce the buildings' heating and cooling requirement.
- Adopting a window design that prioritises daylight but controls solar gain and glare - to reduce electric lighting energy consumption while mitigating overheating.
- Providing exposed thermal mass to provide passive cooling - suppresses summertime overheating to acceptable levels without the need for high energy consuming and expensive to run and maintain mechanical cooling systems.
- Considering the layout and orientation of the buildings - To minimise summertime overheating and the need for high energy consuming and expensive to run and maintain mechanical cooling systems.

The following diagram illustrates the approach we have adopted:



The application of thermal mass to provide passive cooling is well understood and is an excellent method of suppressing the fluctuations of internal temperature without resorting to mechanical cooling systems, which are both expensive to install, consume significant amounts of energy in summer and have high maintenance costs. The thermal mass will absorb and store special heat gains during the day allowing the occupied zones to remain comfortable and compliant with the Part O criteria. Stored heat will be released at night by means of the mixed mode ventilation philosophy. This will regenerate the thermal mass' ability to absorb heat the following day.

3.4.2 Fabric First Energy Strategy – Thermal Envelope

Aligned with our Energy Strategy we promote a thermally efficient building fabric specification to inherently reduce the energy consumption of the buildings. This strategy optimises the building performance prior to the consideration of renewables (LZC), ensuring that all practical measure have been considered to reduce the energy use of the buildings. The table below shows the proposed building fabric thermal performance:

Element	Criteria U-Value (W/m ² K)	Notes	U-Value Improvement over Part L 2013 Building Regulations
Glazing	U = 1.2 W/m ² K	G-Value of 0.42 on North facing and 0.39 on South, East and West elevations	40%
Wall	U = 0.16 W/m ² K	Build-up TBC at later stage	47%
Roof	U = 0.1 W/m ² K	Build-up TBC at later stage	50%
Ground Floor	U = 0.1 W/m ² K	Build-up TBC at later stage	60%

3.4.3 Active Design Measures

The table below shows some of the 'Be Lean' active design measures incorporated within the design to demonstrate our approach.

System	Notes
Heat recovery ventilation	The ventilation strategy utilises heat recovery ventilation as part of a mixed-mode ventilation strategy that is deployed to maximise energy efficiency.
Direct electric heating	Heating for the buildings is provided by direct electric heating which takes advantage of the progressing decarbonization for the UK electrical grid and will result in lower and lower CO ₂ emissions as the national grid is further decarbonised and the shift to renewable electricity generation continues.
ASHP DHW generation	The DHW generation system is fed using low carbon heat pump technology which doesn't directly consume fossil fuels and will benefit from future endeavours to decarbonise the electrical grid.
Local on demand hot water generation	Landlord areas feature direct electric hot water heaters which generate domestic hot water with a limited storage volume reducing the losses from the system and preventing the unwanted heat gains inherent to traditional hot water cylinders
Lighting Efficiency	LED's have been appraised for their suitability as part of the design development and have been found to be a cost-effective measure to reduce lighting electrical energy use.

3.4.4 Solar Shading Strategy

The scheme benefits from the usage of solar performance glazing. The glazing specification is carefully selected to provide a balance between good day lighting and overheating control on all orientations by varying the g-value. In addition, all apartments contain internal blinds to limit daylight, further reducing the effective g-value. Select brise soleil is also proposed to mitigate solar heat gain and provide shade during the summer months while allowing beneficial solar gain in the heating months.

3.4.5 Heat Recovery Ventilation

All apartments will utilise trickle and boost ventilation via heat recovery units that utilise the warm exhausted air to pre-heat the incoming supply air. This helps to reduce the heat loss of the buildings where ventilation is the highest heat demand.

4.0 Decentralised Energy – Be Clean

4.1 Existing Heat Networks

Opportunities to connect the planned development to existing or future decentralised heat distribution networks, including those featuring Combined Heat and Power (CHP) plant, have been investigated.

Investigations have been carried out into the viability of connection into a local district heating network. It was found that although the University of Reading's District Heating Network is in the general vicinity of the development, with the current provisions of the existing district heating network, connection of the development was not financially feasible.

District heating networks are predominantly served by central Combined Heat & Power (CHP) plant located in a nearby heating sub-station. The CHP plant provides heating to local buildings captured from waste heat generated in the production of electricity, fed through a piped network. CHP technology can be applied in smaller scales to provide heating/hot water for single buildings.

Communal heating systems via centralized plant installations are preferred within typical planning policy compared with individual heating and hot water systems within dwellings. However, such technologies were found not suited to this development, as a favourable alternative is proposed comprising decentralised air source heat pump (ASHPs) installations for generation of hot water within each apartment. The utilization of ASHPs for hot water generation removes reliance on hydrocarbon fuels that can be associated with CHP operation.

To maximise efficiency, reduce energy losses associated with domestic hot water circulation and mitigate the inherent risk of corridor overheating that can be associated with heat networks in residential developments, the proposed design avoids use of communal circulating heating and hot water pipework distribution. This strategy will also enable straightforward metering and reporting of each dwelling's energy consumption.

4.2 Cooling and Overheating

4.2.1 The Cooling Hierarchy

Separate thermal simulation analysis has been undertaken to ensure that overheating of the dwellings is mitigated in line with the requirements of the new Building Regulations Part O. The strategy for overheating mitigation has been developed according to the following cooling hierarchy:

- Minimising Internal Heat Gains – DHW circulation and LTHW circulation pipe work have been eliminated in the communal areas of the development to minimise heat loss into the buildings.
- Reducing Solar Gains – As stated previously, glazing with low G-Values have been targeted, blinds have been implemented and select installations of brise soleil have been included on the facades of the development to control solar heat gains.
- Thermal Mass – Thermal mass is being incorporated through the floor slabs, external walls and roof.
- Ventilation – A mixed mode ventilation strategy is proposed that utilises mechanical ventilation for primary / background ventilation, supplemented with natural ventilation via opening opaque fenestration panels.

Mechanical ventilation systems will be specified with heat recovery and variable speed operation to reduce energy demand to a minimum while in operation. Where external noise levels are high, or where additional ventilation has been determined necessary for control of overheating, then additional mechanical ventilation will be provided.

5.0 Appraisal of Renewable and Low Carbon Technology Energy Options – Be Green

The technical feasibility and economic viability of installing each LZC technology at the development has been assessed to discount any unsuitable generation options at an early stage.

A summary of the feasibility process is tabulated below and an overview of each viable technology is given subsequently.

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for Site?
Solar Photovoltaic	Solar photovoltaic panels convert solar radiation into electrical energy through semiconductor cells. They are not to be confused with solar panels which use the sun's energy to heat water (or air) for water and space heating.	- Low maintenance/no moving parts - Easily integrated into building design	- Any overshadowing reduces panel performance - Panels ideally inclined at 30° to the horizontal facing a southerly direction	Yes, but limited to the unshaded roof space available
Solar Thermal	Solar thermal energy can be used to contribute towards space heating and hot water requirements. The two most common forms of collector are panel and evacuated tube.	- Low maintenance - Little/no ongoing costs	- Must be sized for the building hot water requirements - Panels ideally inclined at 30° to the horizontal facing a southerly direction	No, not suitable on this site
Ground Source Heat Pump (GSHP)	GSHP systems tap into the earth's considerable energy store to provide both heating and cooling to buildings. A number of installation methods are possible including horizontal trench, vertical boreholes, piled foundations (energy piles) or plates/pipe work submerged in a large body of water. The design, installation and operation of GSHPs is well established.	- Minimal maintenance - Unobtrusive technology - Flexible installation options to meet available site footprint	- Large area required for horizontal pipes - Full ground survey required to determine geology - More beneficial to the development if cooling is required - Integration with piled foundations must be done at an early stage	No, not suitable on this site and cost prohibitive

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for Site?
Air Source Heat Pump	Electric or gas driven air source heat pumps extract thermal energy from the surrounding air and transfer it to the working fluid (air or water).	• Efficient use of fuel • Relatively low capital costs	• Specialist maintenance • More beneficial to the development if cooling is required • Requires defrost cycle in extreme conditions • Some additional plant space required	Yes
Wind Turbine (Stand-alone column mounted)	Wind generation equipment operates on the basis of wind turning a propeller, which is used to drive an alternator to generate electricity. Small scale (1kW – 15kW) wind turbines can be pole or roof mounted.	• Low maintenance/ongoing costs • Minimum wind speed available • Excess electricity can be exported to the grid	• Planning issues • Aesthetic impact and background noise • Space limitations on site • Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site
Wind Turbine (Roof Mounted)	As above	• Low maintenance/ongoing costs • Minimum wind speed available • Excess electricity can be exported to the grid	• Planning issues • Aesthetic impact and background noise • Structural/vibration impact on building to be assessed • Proximity of other buildings raises issues with downstream turbulence • Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site
Bio-Renewable Energy Sources (Automated feed – wood-fuel boiler plant)	Modern wood-fuel boilers are highly efficient, clean and almost carbon neutral (the tree growing process effectively absorbs the CO ₂ that is emitted during combustion). Automated systems require mechanical fuel handling and a large storage silo.	• Stable long-term running costs • Potential good CO₂ saving	• Large area needed for fuel delivery and storage • Reliable fuel supply chain required • Regular maintenance required • Significant plant space required	No, not suitable on this site

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for Site?
Fuel Cells and Fuel Cell Combined Heat and Power	Fuel cells convert the energy of a controlled chemical reaction, typically involving hydrogen and oxygen, into electricity, heat and water vapour. Fuel cell stacks operate in the temperature range 65°C – 800°C providing co-generation opportunities in the form of Combined Heat and Power (CHP) solutions.	• Zero CO₂ emissions if fired on pure hydrogen and low CO₂ emissions if fired on other hydrocarbon fuels • Virtually silent operation since no moving parts • High electrical efficiency • Excess electricity can be exported back to the grid • Benefits from being part of an energy centre/district heating scheme	• Expensive • Pure hydrogen fuel supply and distribution infrastructure limited in the UK • Sufficient base thermal and electrical demand required • Some additional plant space required • Reforming process, used to extract hydrogen from alternative fuels, requires energy, lowering overall system efficiency	No, emerging technology and cost prohibitive

5.1 Heat Pump Technologies

Electric driven air source heat pumps extract thermal energy from the surrounding air and transfer it to the working fluid (air or water). They can provide both heating and cooling to buildings and have an associated Coefficient of Performance (COP). This is typically around 3 to 4 for heat pumps driven by compressors powered by electric motors and incorporating Variable Refrigerant Flow (VRF) technology. With VRF technology, there is an opportunity to heat and cool separate spaces and recover the heat between them.



Care should be taken when mounting the units to avoid any acoustic problems associated with operating the fans. The outdoor units normally operate with sound levels typically in the range 55 - 60dB(A).

A downside of electric driven air source heat pumps is that they require a defrost cycle in extreme conditions which impacts on the system efficiency. Heating capacity also falls off as the ambient temperature drops below 5°C but still maintains 80% capacity at -5°C.

Air source heat pump systems are scalable to meet the specific demands of the development and have the potential to offer good CO₂ reduction as the grid electricity supply is decarbonised.

To achieve compliance with the environmental requirements stated earlier air source heat pump systems have been adopted to provide:

- Space heating
- Domestic hot water

5.2 Solar Photovoltaic (PV) Panels

Solar photovoltaic panels convert solar radiation into electrical energy through semiconductor cells. They are not to be confused with solar panels which use the sun's energy to heat water (or air) for water and space heating.



Photovoltaic panels are available in a number of forms including mono-crystalline, polycrystalline, amorphous silicon (thin film) or hybrid panels (discussed later). They are fixed or integrated into a building's un-shaded south facing façade or pitched roof ideally at an incline of 30° to the horizontal for maximum energy yield.

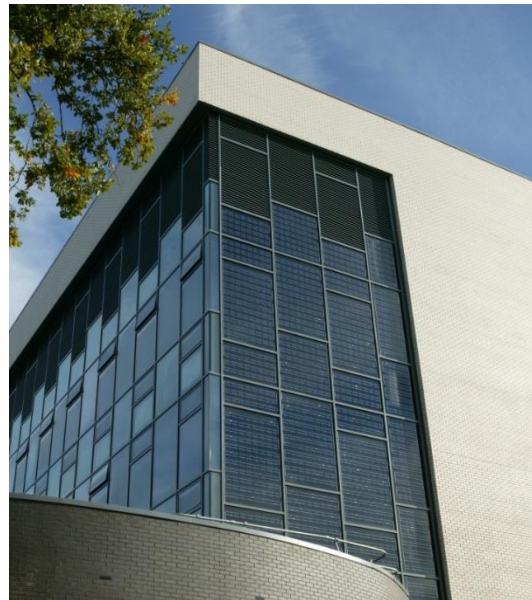


It is essential that the panels remain un-shaded, as even a small shadow can significantly reduce output. The individual modules are connected to an inverter to convert their direct current (DC) into alternating current (AC) which is usable in buildings.

Although sloping rooftops provide an ideal site for fixing PV panels using traditional mounting frames, there are a number of alternative solutions whereby PV panels can be incorporated into the actual building fabric of the development.

Solar louvres use PV panels to provide solar shading on the south façade of buildings as part of the brise soleil (see above), and this can be a highly effective way of controlling overheating and help reduce glare.

Solar glazing uses a combination of solar PV and glass, where the PV cells are laminated between two panes of specialised glazing (see above). The resulting glass laminate serves the dual function of creating energy and shade at the same time, reducing the risk of overheating.



Solar glazing can be used wherever conventional glass would be specified, especially in atria. Bespoke designs allow for varying light penetration by changing the spacing between individual cells. Typically, a combination of 50% PV and 50% translucent glazing is used.

Vertical solar facades can be used to directly replace conventional rain screen cladding materials providing a smooth, flat facade surface for the building. Where circumstances allow, the PV panels can be tilted towards the sun to maximize the energy yield.

As mentioned earlier, there are a number of types of PV cell:

Mono-crystalline Silicon Cells: These are made using cells saw-cut from a single cylindrical crystal of silicon. The principle advantage of mono-crystalline cells is their high efficiency, typically around 15 – 20%, although the manufacturing process required to produce mono-crystalline silicon is complicated, resulting in slightly higher costs than other competing technologies.

Polycrystalline Silicon Cells: These are made from cells cut from an ingot of melted and re-crystallised silicon. In the manufacturing process, molten silicon is cast into ingots of polycrystalline silicon. The ingots are then saw-cut into very thin wafers and assembled into complete cells giving a granular textured finish. Polycrystalline cells are cheaper to produce than mono-crystalline types, due to the simpler manufacturing process but tend to be slightly less efficient, with average efficiencies of circa 12 – 15%.

Thick-Film Silicon: This is another polycrystalline technology where the silicon is deposited in a continuous process onto a base material giving a fine grained, sparkling appearance. Like all crystalline PV, this is encapsulated in a transparent insulating polymer with a tempered glass cover and usually bound into a strong aluminium frame.

Thin-Film Amorphous Silicon: Amorphous silicon cells are composed of silicon atoms in a thin homogenous layer rather than a crystalline structure. Amorphous silicon absorbs light more effectively than crystalline silicon, so the cells can be thinner. For this reason, amorphous silicon is also known as a 'thin film' PV technology. Amorphous silicon can be deposited on a wide range of substrates, both rigid and flexible, which makes it ideal for curved surfaces and 'fold-away' modules. Amorphous cells are, however, less efficient than crystalline based cells, with typical efficiencies of around 6%, but they are easier and, therefore, cheaper to produce.

Other Thin Films: A number of other promising materials such as cadmium telluride (CdTe) and copper indium diselenide (CIS) are now being used for PV modules. The attraction of these technologies is that they can be manufactured by relatively inexpensive industrial processes, certainly in comparison to crystalline silicon

technologies, yet they typically offer higher module efficiencies than amorphous silicon. New technologies based on the photosynthesis process are at early stages of commercialisation.

Photovoltaic technology is considered feasible on this project.

5.3 Solar Thermal

Solar thermal energy can be used to contribute towards space heating and hot water requirements. In the UK, most applications focus on hot water installation as the solar availability during the space heating season is limited.



The use of solar water heating installations is widespread throughout Europe. The systems use a heat collector, generally located at roof level on support frames, orientated in a southerly direction to maximise solar heat absorption.



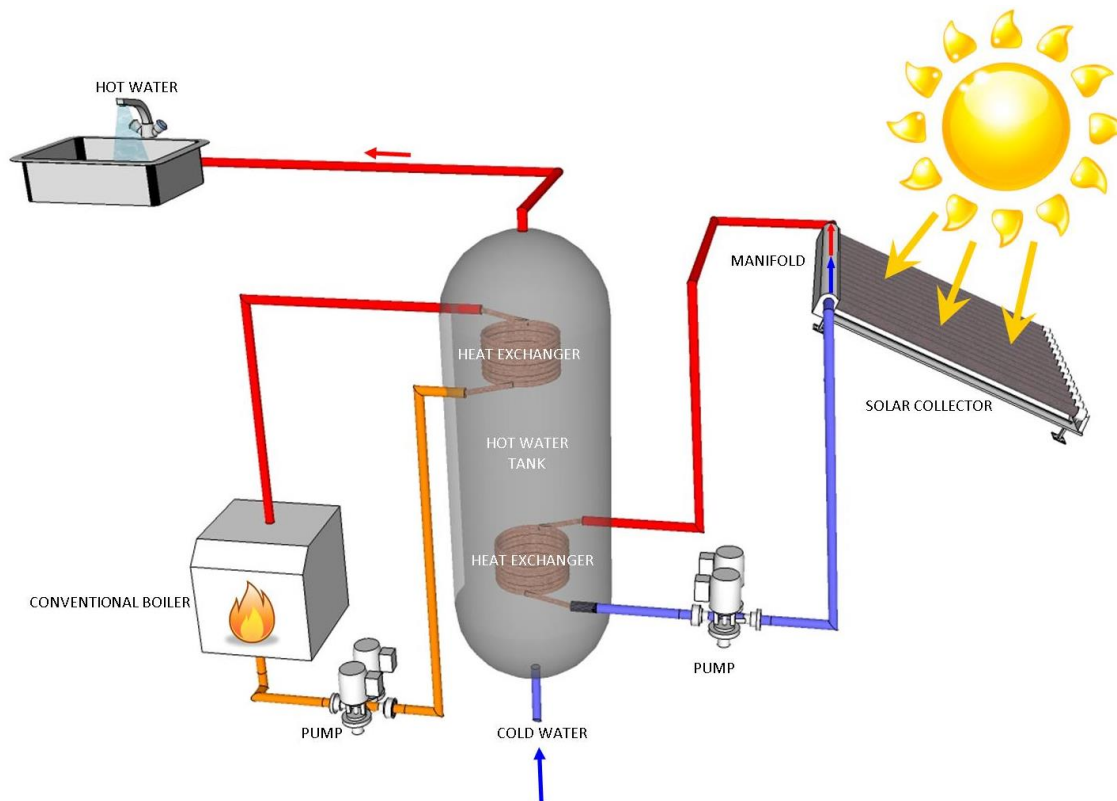
A working fluid is used to heat water that is stored in either a separate hot water cylinder or more commonly a twin coil hot water cylinder with the second coil providing top-up heating from a conventional boiler.

The two most common forms of collector are panel and evacuated tube.

The panel type collectors are generally more robust and reliable while manufacturers claim that the evacuated tube versions offer better winter all-round performance.

The design of the flat plate panels is relatively straightforward; consisting of water tubes arranged behind solar glass and an absorber plate. The absorber plate absorbs the sun's rays and transfers energy to the water flowing through the tubes. In contrast, the evacuated tube type collectors are more complicated consisting of double wall glass tubes with a space in the centre containing a heat pipe and a liquid.

Coatings on the inner glass ensure that around 93% of the absorbed heat is retained within the system and the vacuum prevents loss of heat through conduction and convection. The circular design helps maximise the potential to collect solar energy all year round when the sun is at different angles.



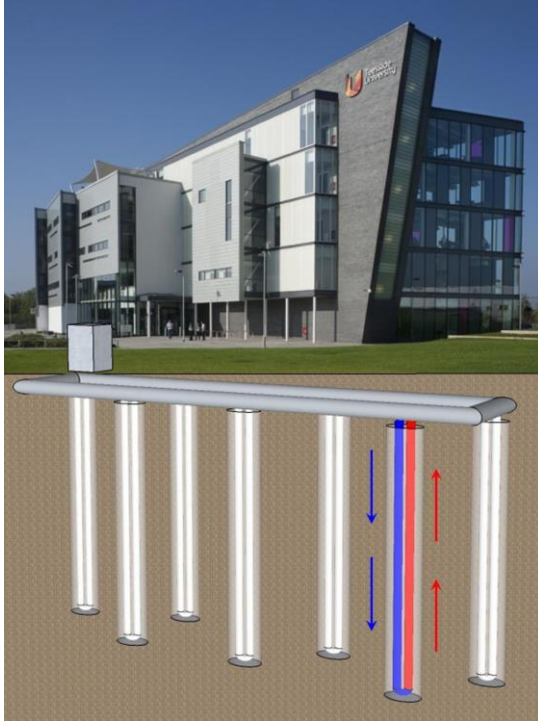
The heat pipes are connected to a manifold containing circulating water (see above). The liquid in the heat pipe is evaporated by the sun's energy and rises to a heat exchanger within the manifold where it condenses and gives up its latent heat energy to the water. This heated water is then pumped to a coil in the hot water cylinder sized to meet the demand of the installation. Evacuated tube systems deliver higher temperature water than flat plate types, with little decrease in efficiency, making them more effective with thermal storage solutions.

As a general rule, the evacuated tube collectors can deliver around $700\text{kWh/m}^2/\text{yr}$ when in optimum orientation (inclined at 30° to the horizontal facing a southerly direction). This compares to around $580\text{kWh/m}^2/\text{yr}$ for the flat plate collectors under similar conditions.

Solar thermal installations can be designed to fit the available roof space and/or building façade. Each evacuated tube is approximately 2m in length with an external diameter of 58mm. They weigh around 2kg each and can be spaced from 10mm to 500mm apart in an array. A typical panel array, $2.1\text{m} \times 1.0\text{m}$, will provide around 1.33m^2 of absorber area and weigh approximately 45kg. Bespoke mounting frames can be fashioned to provide the ideal inclination of 30° to the horizontal facing a southerly direction. Access to the roof mounted solar collectors will be necessary for occasional cleaning of the active tubes.

Solar thermal technology on a large scale is often difficult to support where there is a limited domestic hot water demand. As will have minimal communal hot water demand and are looking to minimise pumping and heat losses into the communal areas a solar thermal installation will not be considered further on this project.

5.3.1 Ground Source Heating and Cooling



The design, installation and operation of Ground Source Heat Pumps (GSHPs) is well established. These geothermal systems tap into the earth's considerable energy store to provide both heating and cooling to buildings. They take advantage of the fact that at a depth of a few metres, the temperature of the ground remains at a constant 12°C throughout the year.

In heating mode, GSHPs absorb energy from the earth and transfer it into the building using highly efficient heat pumps. The effectiveness of heat pumps is measured by the ratio of the heating capacity to the power input, referred to as the Coefficient of Performance (COP). Typically, manufacturers state that for every 1 unit of electrical energy used to drive the pump, around 4 to 5 units of thermal energy can be produced. When operating in cooling mode, during the summer months, the system reverses its cycle and heat is extracted from the building and dissipated into the earth.

The ground loops can be installed either vertically in boreholes (typically 50m – 100m deep), or horizontally in trenches at a depth of 1.5m – 2.0m. Either method is dependent upon local geology conditions and space available. The system also benefits from the fact that most of the components are hidden below ground or in plant room enclosures.

Costs for drilling vary according to the location and ground conditions. A preliminary site investigation, by means of a desktop study, can usually determine the viability of a ground source heating and cooling system. Fine tuning of the design may be required once actual site ground conditions are established.

It should be noted that GSHPs generally deliver water at a temperature approaching 50°C (which would be ideal for under floor heating). Additional heat sources would be needed to satisfy the requirements for domestic hot water to raise the temperature well above 60°C.

The design intention is not to employ under floor heating on the scheme. This, coupled with the fact that there is no available space on site for sinking of boreholes and/or trenching for pipe work, means that a GSHP system cannot be considered further on this project.

5.3.2 Wind Turbines

Wind generation equipment operates on the basis of wind turning a propeller, which is used to drive an alternator to generate electricity. Small scale wind turbines are typically in the range of 1kW – 15kW, with rotor diameters of 2.5m – 9.0m respectively. These systems can be stand-alone or, in some cases, building mounted.

The efficiency and effectiveness of wind turbines depends on many factors, not least the average wind speed and wind pattern of the proposed site. Exposed sites, free from obstacles such as buildings and greenery, are more



viable than sheltered sites. Column mounted (stand-alone) wind turbines installed at a suitable height above the building line are more effective than wind turbines located at roof level. There are often some planning difficulties associated with the use of wind turbines. Background noise and a phenomenon known as shadow flicker are also potential issues.

Typical noise levels measured 20m from the base of an operating 5kW wind turbine (both upstream and downstream) in the range 4m/s to 8m/s are 48 – 50dB(A). At 100m, the predicted noise level would be below 35dB(A).

The use of wind turbines is often seen as an obvious statement of a development's dedication to the use of sustainable technologies.

The proposed development does not lend itself to small-scale stand-alone or roof mounted wind turbines due to the proposed height of the buildings, obstacles and greenery causing problems with downstream turbulence. It is considered that the local environs are unsuitable for a large stand-alone column mounted wind turbine given the nearby existing residents and heritage buildings. For these reasons, the installation of wind turbines on the site is not practical and will not be considered further.

5.3.3 Bio-fuel CHP

Consideration has been given to the possibility of utilising a bio-gas, bio-diesel or dual fuel CHP engine.

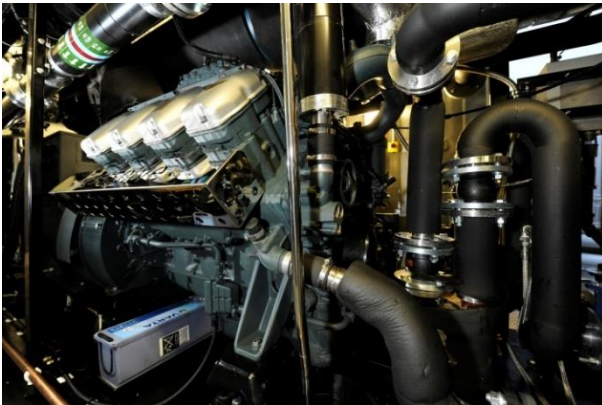


A dual fuel engine (normally based on field-proven diesel engine technology) can run on oil alone, or a mixture of gas and oil.

It should be noted that the engine cannot run on gas alone because it doesn't have a spark ignition system.

Schnell (Germany) supply a range of dual fuel 6-cylinder Scania turbo CHP engines that can be driven on diesel oil, vegetable oil or a mixture of biogas and oil.

ENER-G supply a series of 6 to 20-cylinder turbo charged reciprocating CHP engines for biogas applications. As an option, natural gas can be connected into the system, albeit via a separate unit, to provide back-up electrical and heat energy, if required. Dual fuel engine options (biogas and natural gas) are available, but this requires a special upgrade on the engine management system.



An initial evaluation indicates that the space available on site is too restricting to install a biofuel CHP system.

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

Bio-renewable energy sources are considered to be those which are grown, harvested and replaced by new stock. Modern wood-fuel boilers are highly efficient, clean and smokeless. Wood-fuel is almost carbon neutral as an energy source (the tree growing process effectively absorbs the CO₂ that is emitted during combustion).



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

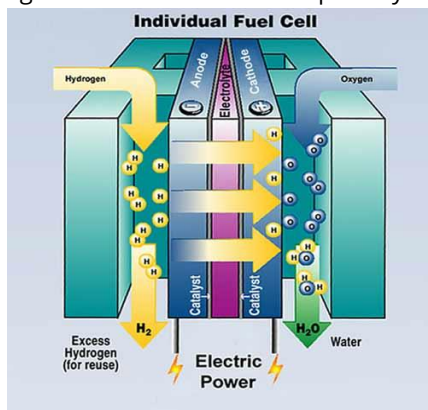
These requirements create the need for a substantial amount of external plant space (typically 150m²). A large area would have to be sacrificed to accommodate the wood-fuel facilities. An underground fuel bunker 5m x 5m x 3m deep would be needed for a boiler of 500kW capacity. Furthermore, the logistics of fuel deliveries and ongoing maintenance costs could be a potential issue.

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

5.3.5 Fuel Cells and Fuel Cell Combined Heat and Power

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

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



Pure hydrogen fuel cells have zero CO₂ emissions but the hydrogen supply and distribution infrastructure is somewhat limited in the UK. As a result, commercially viable systems use alternative fuels in the form of natural gas, LPG and bio-fuels from which hydrogen is derived through a process called reforming. Extracting hydrogen in this manner, comes at the expense of system efficiency and an increase in emissions due to the presence of impurities in the fuel.

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

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

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

5.4 Combined Heat and Power (CHP)

A CHP installation is effectively an on-site mini power plant providing both electrical power and thermal heat. CHP is strictly an energy efficiency measure rather than a renewable energy technology. A CHP system operates by burning a primary fuel (normally natural gas) by use of either a reciprocating engine or turbine, which in turn drive an alternator to generate electrical power. The heat emitted by the engine and exhaust gases is recovered and used to heat the building or to provide hot water.



The viability of CHP is dependent upon the building base load requirements for both heat and power. 24 hour buildings with high heat demands and constant power demands lend themselves to CHP.

The noise levels associated with a CHP installation should not be overlooked. Typically, acoustic enclosures and upgraded low noise attenuators are employed to ensure noise levels don't exceed 65dBA when 1m from the unit. On confined sites, the plant room structure can be enhanced, and attenuators fitted to the mechanical ventilation to prevent any noise issues.

Noise emissions are of the order of 52dBA – 56dBA. Additional CHP plant can be easily (1 day) retrofitted and connected to the existing buffer store if capacity dictates, and plant room space allows.

The scale of the scheme is considered too small to generate a base load which would provide a benefit from installing a CHP system, hence this has been considered not viable for this scheme.

5.5 Energy production from Low and Zero Carbon (LZC) Technologies

As described above the adopted LZC's within this scheme are:

Air source heat pumps and photo voltaic panels.

The energy produced by these heat pumps serves the domestic hot water for the proposed buildings. The air source heat pumps are estimated to be able to provide an average COP of 2.4 over the course of the year and approximately 58% of the energy generated is assumed to be renewable energy.

The development will benefit from a roof mounted PV installation on each block furthering the developments efforts to reduce operational carbon emissions.

5.6 Feasibility of Exporting Heat

The cooling requirements of the site are relatively low and, in most cases, free cooling via heat exchangers and fresh air ventilation are expected to maintain the internal environment. Additionally, there are no major heat producers in the buildings other than the residential kitchens. Hence, based on the above, the site does not have a considerable potential to export any type of heat generated within the buildings.