



SUSTAINABILITY STATEMENT

1 DARWIN CLOSE, READING RG2 0TB

For

THE WHITE PARTNERSHIP

SEPTEMBER 2017

Sustainability Statement

Darwin Close

for

The White Partnership

N17343	Sustainability Statement, 1 Darwin Close, Reading RG2 0TB
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Appendix A – BRUKL

1.0 Executive Summary

Patrick Parsons Ltd has been appointed by The White Partnership to prepare a sustainability statement to explore the most appropriate Low and Zero Carbon technology(s) (LZC's) for the proposed new factory building known as Darwin Close in Reading. The factory/industrial building will comprise of workshops, storage areas, offices, meeting rooms etc. spread over two floors. The site is located on the corner of Darwin Close and Commercial Road in the Basingstoke Road Industrial Estate, Reading, on a plot currently accommodating a vacant factory unit, which is in a state of disrepair.

This desktop sustainability study has been undertaken with a view to exploring the most viable option(s) that would provide low and zero carbon technologies, an improvement of the building fabric, use of energy efficient technology and design features and to show compliance with Building Regulations Part L2A 2013 along with achieving BREEAM status.

It must be noted that any calculations included within this document are preliminary and subject to detail design.

The objectives of this preliminary feasibility study were to investigate;

- All technologies appropriate to the development considering site constraints and energy demand
- Reasons for excluding other technologies.

This report highlights that the use of a suitably sized Air Source Heat Pump (ASHP) within the scheme is the most viable LZC technology for the proposed site and will contribute towards achieving the minimum requirements for Part L2A Building regulation compliance. ASHP's may provide space heating and cooling in the Meeting Rooms, Reception, Office, and Conference Room.

The use of the proposed building efficiency measures and the proposed LZC technologies will result in a 1% improvement over the target emission rate (TER) required by Part L2B 2013. Should a greater margin be required, further enhanced fabric 'U' values or permeability improvements could be employed in addition to the ASHP along with a 35m² PV array. These further improvements would offer a 10% improvement in carbon reduction against the comparative notional building.

Other means of achieving compliance include the use of natural ventilation, mechanical heat recovery ventilation, efficient gas fired radiant heating, LED lighting with occupancy and daylight controls and instantaneous hot water production.

2.0 Introduction

Patrick Parsons Ltd have been appointed by The White Partnership to prepare a preliminary sustainability statement to explore the most appropriate Low and Zero Carbon technology(s) (LZC's) for the proposed Darwin Close, Reading, along with outlining other energy saving design features of the scheme.

Such a development will have significant energy requirements and thus associated CO₂ emissions. This feasibility report was commissioned to:

- Outline proposed sustainable features of the development
- Determine the most viable LZC technology for the development
- Contribute towards achieving compliance with Part L2A 2013 building regulations
- Contribute towards achieving a BREEAM rating

2.1 Development background

The site is 1 Darwin Close, Reading, RG2 0TB, in the Basingstoke Road Industrial Estate, Reading, approximately 3 miles south of Reading Railway Station. The site is currently occupied by a derelict factory unit with an approximate area of 0.28Ha with the area centred on National Grid Reference - 0.975235W 51.4277665N.

The development site is bounded by housing to the north, industrial units on all other sides. The site location within Reading can be seen in **Figure 1** below.

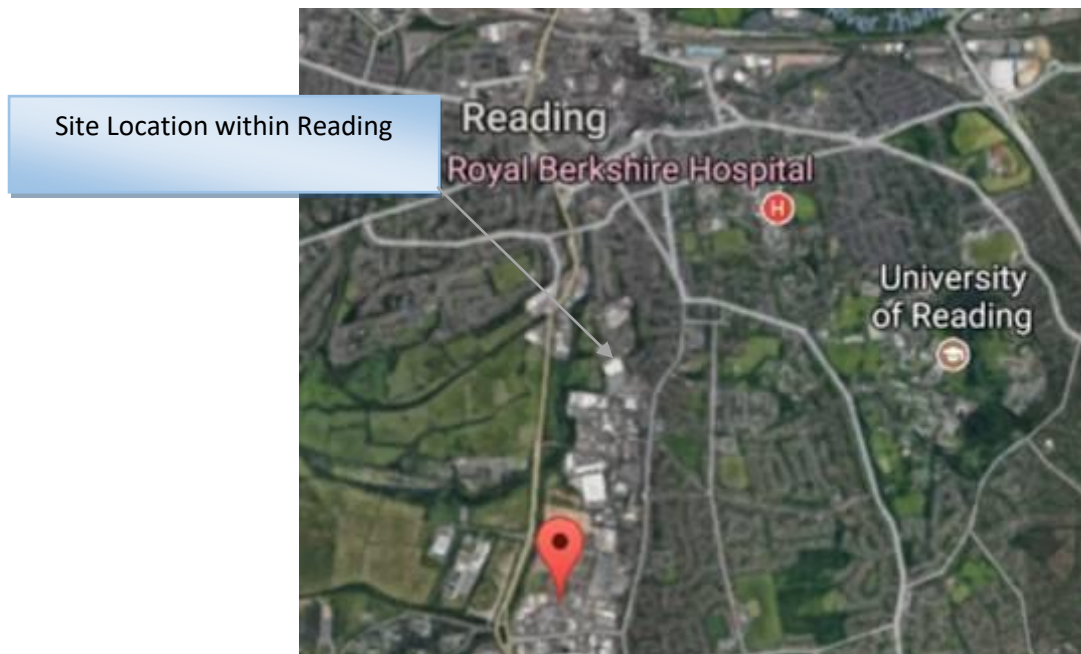


Figure 1: Site Location within Reading

The proposed factory / industrial unit known as 1 Darwin Close has been proposed as an undesignated factory unit but has had the space uses allocated, as noted in **Figure 2.** below, for the purposes of this analysis. The unit will comprise of a Reception, Workshop areas, Meeting Rooms & WC's on the ground floor with offices, storage, WC's and a Conference Room on the first floor.

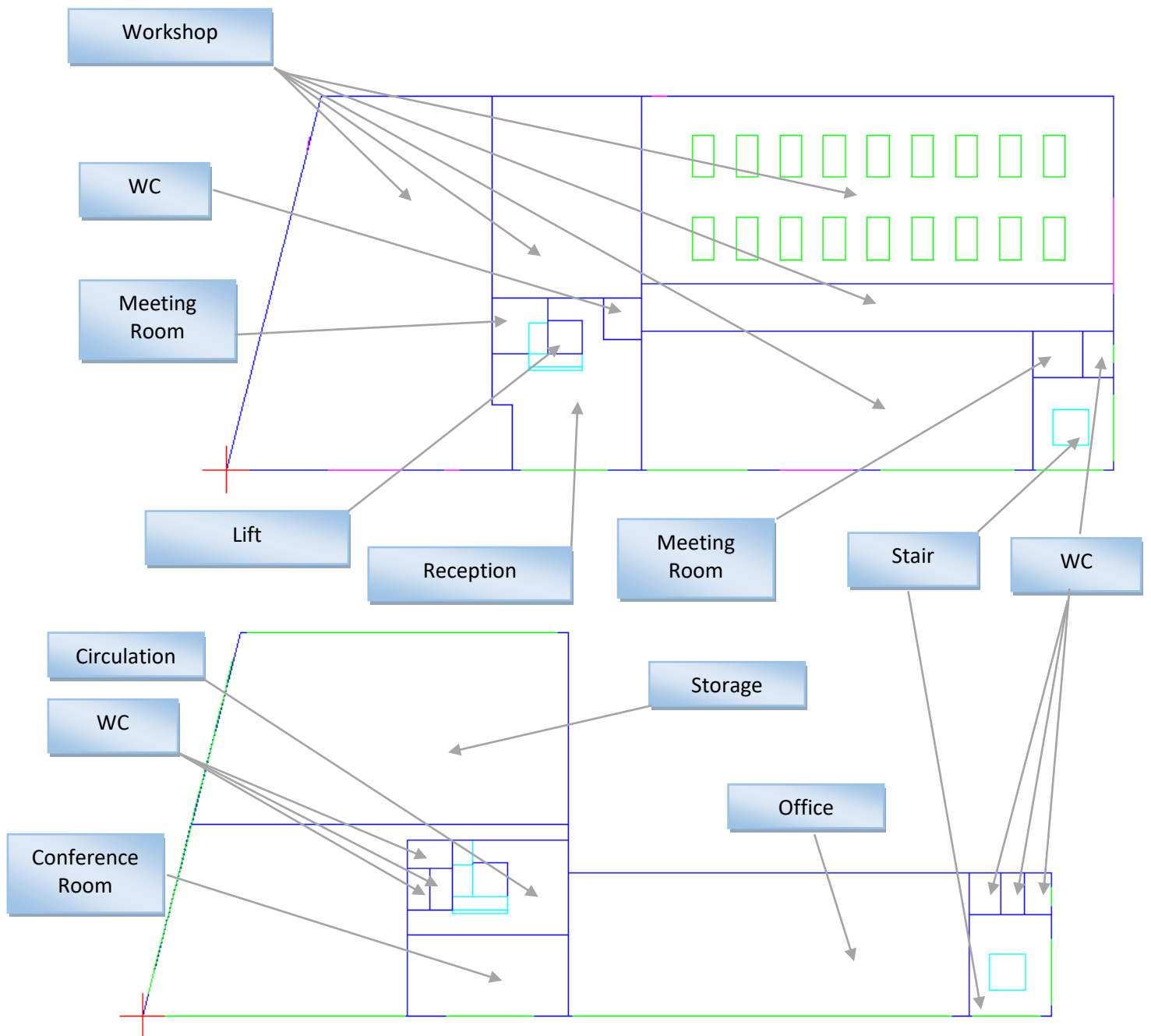


Figure 2: Room Designations

3.0 Analysis

3.1 Design Efficiency

The design teams brief shall be to make the proposed development as usable and energy efficient as possible and to comply with all applicable Buildings Regulations, whilst maximising the character and the usability of the building. Energy efficiency must always be the priority in sustainable buildings design. Low U-value construction elements and improved air permeability shall be specified to reduce heat loss from the proposed development.

High efficiency equipment shall be specified throughout the developments heating, cooling and ventilation systems where possible along with advanced buildings management controls for the proposed building.

3.2 Construction

The U-values and air tightness for this development shall be equivalent or better than that of minimum required by Part L2A 2013 building regulations.

3.3 Mechanical and Electrical Services

The building shall utilise highly efficient equipment, ideally selected from the governments approved ECA scheme. The ECA scheme is part of a government programme to manage climate change and only lists those products that perform at a suitably high efficiency and produce the lowest carbon emissions and operating costs possible, far exceeding the current regulatory requirements. The installation shall also benefit from optimisation controls to ensure systems only run, as and when required and at their optimum capacity thus reducing fuel wastage. All Equipment shall be installed and commissioned to the highest standards to ensure optimal operation.

The development shall utilise energy efficient LED luminaries and controls. Utilising the latest designs in luminaries shall allow for fewer fittings and lower wattages to be achieved for the required illumination levels. Newer fittings use significantly less energy and produce far less heat, thus also assisting in maintaining internal temperatures, without the need for extra cooling facilities.

Control strategies shall be applied throughout the building, considering each rooms usage and the amount of natural day light available. As such internal rooms (e.g. Meeting Rooms) with no natural light, could benefit from auto on/off presence detectors with a timed over run facility to minimise the chance of them being left on for no reason, while the timed over run minimises damage to switch gear and lamps from consecutive re-strikes. The Office, reception and Conference Room shall utilise daylight dimming controls as well as occupancy sensors.

External lighting if required shall be provided by compact fluorescents and/or LED which shall be both time clocked and photosensitive to ensure security of the premises, while minimizing the amount of energy required. The lights could be programmed to turn on and off at times throughout the year, and be held off should sufficient natural day light be available.

The development shall benefit from a passive design ideology and as such mechanical forms of cooling and mechanical ventilation shall be kept to a minimum using openable windows with blinds to reduce solar gains and aid natural ventilation for occupant comfort within occupied rooms. Noise and external air quality needs to be considered due to the developments urban location particularly in terms of the buildings ventilation strategy. The risk of external noise ingress shall be prevented using high efficiency mechanical supply and extract ventilation. Ventilation systems shall be fitted with attenuation to limit noise breakout. The supply and extract ventilation system shall be specified with heat recovery to limit heat loss through the system. Water usage shall be reduced as much as practically possible using low flow fittings and fixtures.

Additional measures shall be taken to ensure efficiency such as;

- High efficiency gas fired radiant heating
- High efficiency Air Source Heat Pumps
- Ventilation heat recovery
- Use of passive ventilation
- Instantaneous hot water production with no storage
- Inverter driven variable speed pumps and fans
- Energy metering
- Power Factor Correction
- LED Lighting, with zoned daylight dimming and occupancy sensors.

4.0 Our Approach

4.1 Total Building Energy Requirements

Energy calculations for the proposed building have been undertaken and simulation results have been produced using the accredited IES (VE) SBEM software package. A model image from the IES VE software can be seen in **Figures 3 & 4**.

High efficiency equipment shall be specified throughout the heating, cooling and ventilation systems, where possible. Several measures shall be taken to ensure efficiency from a building services point of view such as;

- Use of Natural Light where possible
- High efficiency low energy LED light fittings with intelligent control
- Photocell and time clock controlled external lighting control
- High efficiency radiant gas heating
- Ventilation heat recovery
- Inverter driven variable speed pumps and fans
- Building Management System (BMS)

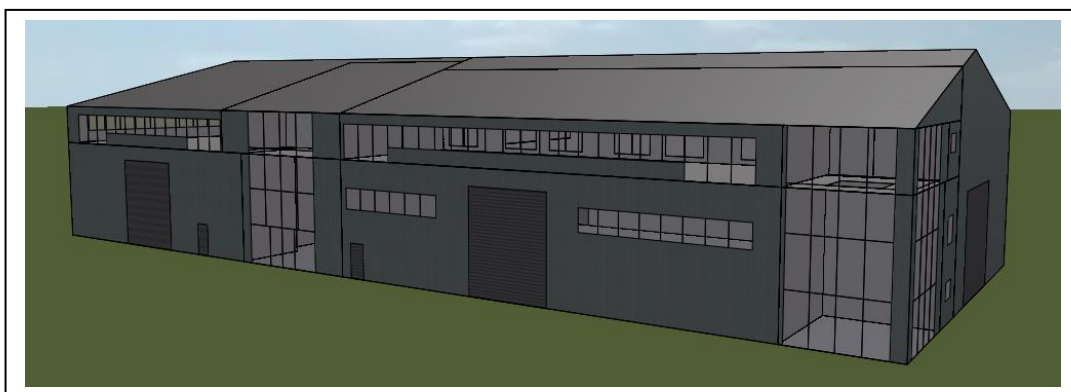


Figure 3: IES 3D Model of 1 Darwin Close, Reading – View No. 1

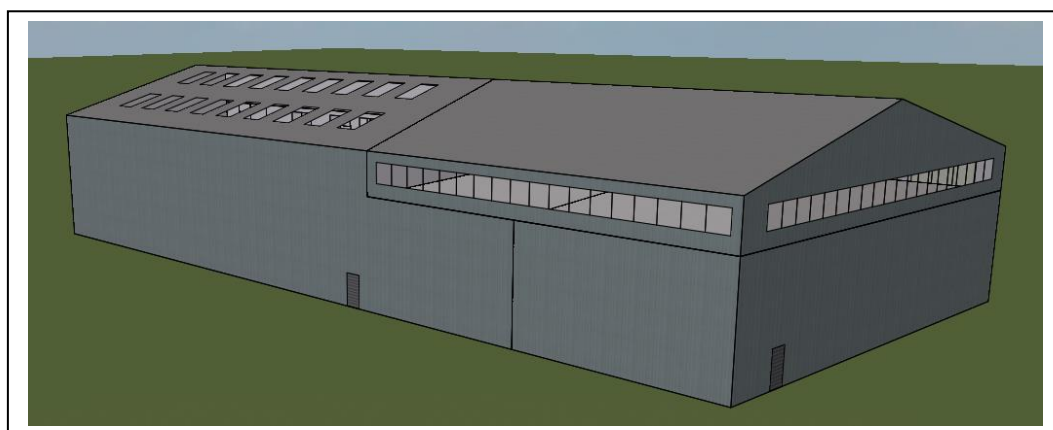


Figure 4: IES 3D model of 1 Darwin Close, Reading – View No. 2

The proposed building has a total internal area of circa 2830m².

This assessment was completed using the noted IES Virtual Environment Software in accordance with the published National Calculation Methodology (NCM) Modelling Guide 2013 Edition. In order to perform the calculation a virtual model of the building was constructed within the IES software. The model was constructed using the architectural plans and elevations and fabric build up to suit current building regulations. Once this model was complete, details such as occupancy and equipment gains were added by applying default activity templates from the National Calculation Method (NCM) data base to each room. These NCM templates effectively define the energy use patterns within each space. Additional templates describing primary fuel sources and building services system efficiencies are then added.

The software then uses the model to construct an equivalent notional model which in turn is used to calculate the initial emission target for comparison with the actual. If the Buildings' Carbon Emission Rate (BER) which is calculated, is less than the Target Emission Rate (TER), then the building is deemed to have passed Criterion 1 of Part L 2A requirements.

For the most part, data used for the calculation is taken from the NCM templates however a few minor adjustments had to be made to reflect the proposed design of the building.

The following systems have been simulated in the buildings' IES energy model;

Heating System 1: Air Source Heat Pumps providing heating and cooling via ceiling mounted cassettes with Mechanical Heat Recovery Ventilation.

(Reception, Conference Room, Office, Meeting room)

Heating System 2: Gas Fired radiant heating with natural ventilation.

(Workshop & Storage areas)

Heating System 3: Electric Heaters with Natural Ventilation

(Circulation Areas)

Heating System 4: Electric Heaters with Mechanical Extract

(WC's)

Domestic Hot Water System: Local Instantaneous Hot water heaters.

The building will have the following annual energy consumption requirements based on simulation results from the Part L IES energy model produced, refer to **Figures 5 & 6** and **Table 1**.

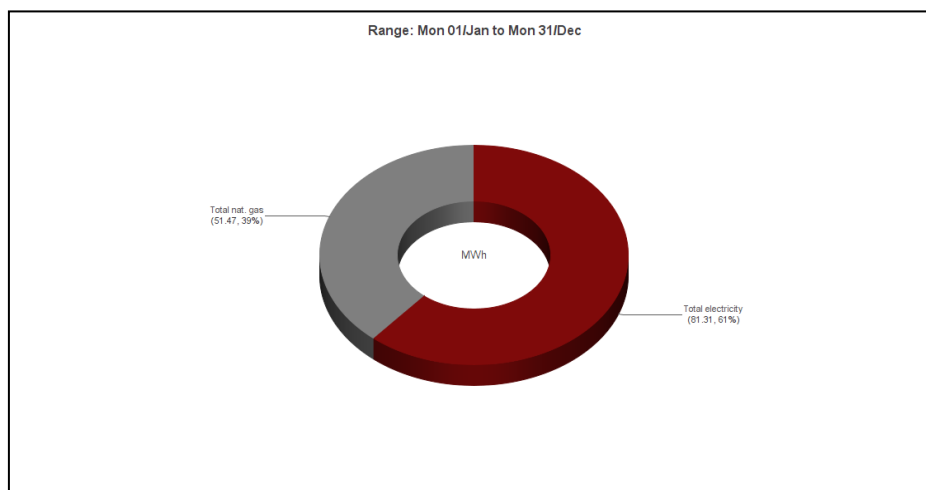


Figure 5: Annual Predicted Gas Energy & Electrical Energy Usage (MWh)

Energy Type	Energy MWh/annum	CO2 (kg annum)
Thermal (Gas)	51.47	11117
Electrical	81.31	41145
Total	132.78	52262

Table 1: Annual Energy Consumption and Carbon Emissions per Energy Type

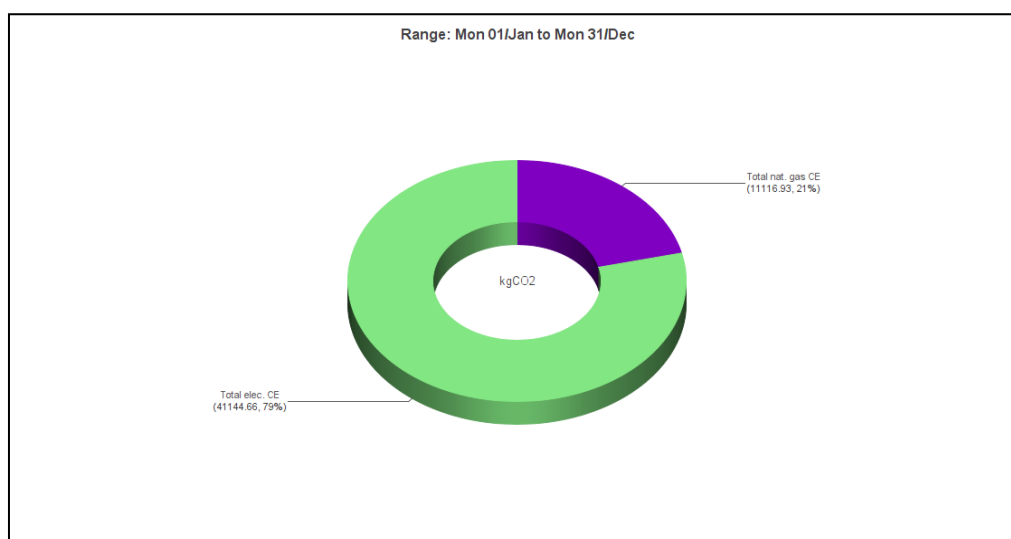


Figure 6: Annual Gas & Electrical Carbon Emissions (Kg CO2)

4.2 Technical Analysis

The section examines the LZC options considered for the proposed Darwin Close Building. Technical analysis for each technology has been compiled using extracts from the Energy Saving Trust and the Low or Zero Carbon Energy Sources: Strategic Guide (Interim Publication), The Office of the Deputy Prime Minister, © Crown Copyright 2005.

4.2.1 Gas Fired Combined Heat and Power (CHP)

Technology Overview

Combined heat and power (CHP) systems are now available for individual houses, group residential units and small nondomestic premises. CHP at the large commercial size is now common in premises which have a simultaneous demand for heating and electricity for long periods, such as hospitals, recreational centres, hotels and multi-residential buildings. Compared with using centrally generated electricity supplied via the grid, CHP offers a more efficient and economic method of supplying energy demand, due to the utilisation of the heat which is normally rejected to the atmosphere from central generating stations, and by reducing network distribution losses due to local generation and use, see **Figure 7**. It is not a renewable energy technology, but installed in the appropriate manner there is potential for overall energy savings.

Most systems replace (or run in parallel to) the domestic sized boiler and will be linked directly into the building electricity distribution system. Heat generated will be used for space and water heating, and additional heat storage may be used to lengthen use periods, to assist in warm-up and to improve overall energy efficiency.

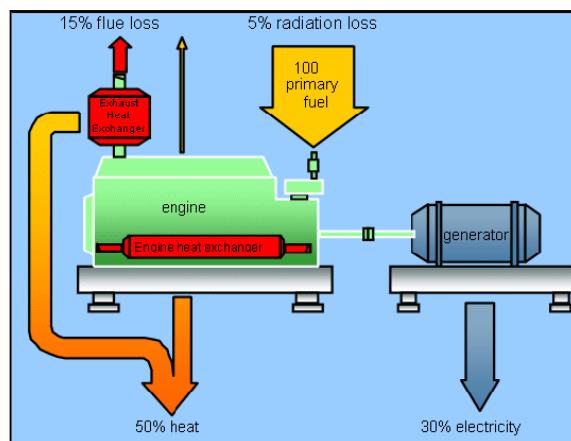


Figure 7: Schematic diagram of CHP system

For overall energy efficiency, as with all CHP, usage must be heat demand lead, thus a sophisticated control system is required and users should be made aware of efficient operating practices.

There are currently two types of mechanical engines available:

- Internal combustion engines
- Stirling engines.

Internal combustion engine systems normally supply an electrical output of upwards of 5kW, with a heat output of upwards of 10kW. They are normally suitable for groups of flats, grouped residential buildings such as nursing homes, and some small commercial premises, depending on the heat demand. The units will normally be in a dedicated boiler house and will need to run for more than 10 hours a day to be economic.

Stirling engine systems use a 'heat engine' as the motive force for the generator and these units are available with an electricity output of around 1kW upwards. With a power to heat ratio of between 6:1 and 3:1, these systems are most suitable for larger new houses, older houses with high heat demand and some small commercial premises. Stirling engine systems cannot be modulated rapidly and take several minutes to start up and close down. Thus, they cannot be used in quite the same way as traditional domestic boilers, which are normally sized for maximum start-up loads and cycle on/off to maintain required temperatures. Stirling engine systems are used differently and their control strategy is designed to deliver the same heating performance, whilst maximising the length of time for which the generator produces electricity and thus maximising the carbon emission savings.

Since the electricity supplier is likely to buy out electricity for less than the supply price, coupled import-export meters need to be installed in order to indicate the electricity flow in both directions.

Applicability to the Darwin Close, Reading Development

Since the proposed building in question is an industrial workshop / factory unit, a CHP unit will not be suitable due to the low domestic hot water load associated with a building of this type, and seasonal heating load.

The use of CHP in some applications can be beneficial as it can act as a feed into a district network and can be housed in a central plant area or energy centre on the site and serve all areas of the development. No district network is currently available in close proximity to the site.

As indicated in the technical analysis, a CHP unit will need to run for more than 10 hours a day to be economically viable. There needs to be a constant heat and hot water demand for most of the year. A constant thermal base load will lead to the optimal operation of the CHP unit if sized correctly. These criteria are not envisaged to be met at this stage.

A CHP installation may be eligible for Climate Change Levy (CCL) exemption if certified by CHPQA as Good Quality CHP, CCL Exemption may be applied on fuel input and electricity output used on site (direct supply).

4.2.2 Solar Thermal

Technical Overview

Solar thermal or active solar water heating is a well-established renewable energy system in many countries outside the UK. It can be one of the most cost effective renewable energy systems available.

Technology	Characteristics	Functionality	Cost effectiveness	Reliability	Maintenance requirement	CO ₂ saving	Overall rating
Solar water heating	Solar energy used to heat water, usually for domestic hot water purposes	Medium. Proven technology with a range of collectors for different operational requirements	Medium	Medium – high. Circulation pump and valves are relatively reliable	Low	Medium. Circulating pumps can be PV powered	****

Source: BSRIA; The Illustrated Guide to Renewable Technologies, 2008

Solar hot water can be applied in several non-domestic building types, such as hospitals, nursing homes and leisure facilities, which have high demands for hot water.

Solar hot water systems are rarely installed in commercial buildings, where the demand for hot water is lower.

Considerable technical and market research has been undertaken in UK, the main conclusions of which are that most systems are technically proven and will provide a significant contribution to hot water demand if correctly installed. Fears of poor quality installations have been largely overcome by installer training and accreditation supported by the DTI.

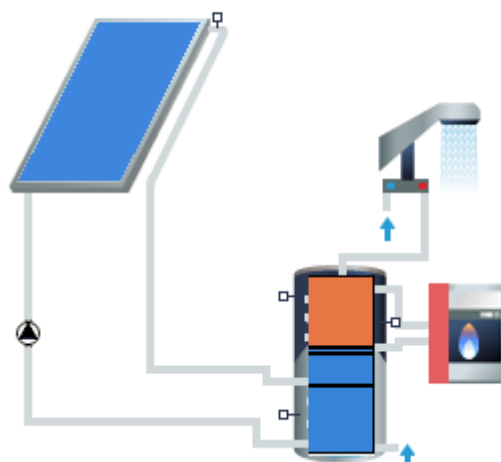


Figure 8: Typical Solar Thermal System

Solar thermal systems in the UK normally operate with a back-up source of heat, such as gas or electricity. The solar system preheats the water through a heat exchanger up to the maximum hot water supply temperature. If there is not enough solar power available to fully heat the water it is heated up to the desired temperature by the back-up heat source.

There are four main types of solar collector, which can be used in solar water systems. These are:

- Evacuated tubes
- Selective surfaced flat plate
- Non-selective surfaced flat plate
- Unglazed plastic collectors (mostly use for swimming pool heating)

Solar water heating systems are usually fitted with standard boilers which operate using hot water cylinders. However, there are several manufacturers that make combination boilers specifically designed to take preheated water from solar water systems.

Applicability to the Darwin Close, Reading Development

The suitability of this technology for the site depends on space availability for panel mounting and access for maintenance. For this building, the only area available area for mounting STHW panels is the roof. The optimum orientation for mounting the panels is due south. The roof of the building has the potential for Solar Thermal Panel mounting as depicted in Figure 9. The height of the building compared to the surrounding buildings would need to be considered so no shadowing from adjacent structures occurs.

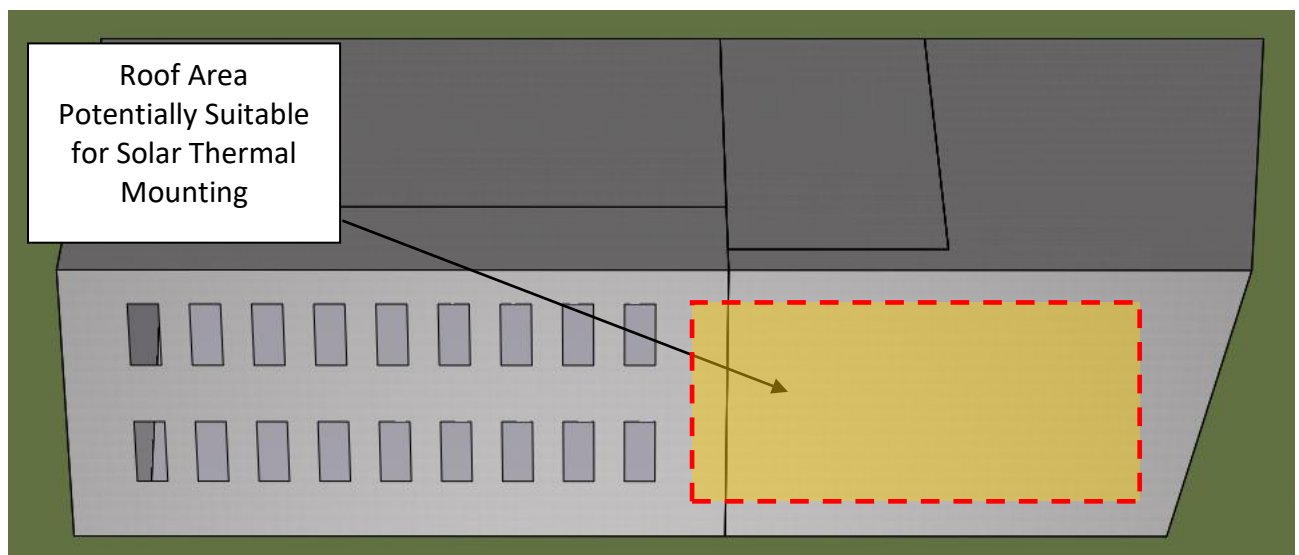


Figure 9: Proposed Roof Plan

Since this building is an industrial workshop / factory unit, it will have a low hot water demand.

For the reasons detailed above, STHW technology may not be considered as a potential LZC option for the proposed development.

4.2.3 Photovoltaic's

Technical Overview

Photovoltaic modules convert sunlight into DC electricity and can be integrated into buildings. PV is distinct from other renewable energy technologies since it has no moving parts to be maintained and is silent. PV systems can be incorporated into buildings in various ways; on sloped roofs and flat roofs, in facades, atria and as shading devices.

Technology	Characteristics	Functionality	Cost effectiveness	Reliability	Maintenance requirement	CO ₂ saving	Overall rating
Photovoltaics	Converts sunlight directly to DC electrical power. Requires inverter to convert to AC	Medium. Requires careful positioning for optimum performance. Wide range of installation options	Low. However, costs are predicted to improve	Medium. Associated inverters can cause problems	Low, but specialist	Low. Relative to high cost	3.5.5

Source: BSRIA; The Illustrated Guide to Renewable Technologies, 2008

Deployment in the UK has started with several building integrated field trial schemes and a major demonstration programme. While single crystal silicon remains the most efficient flat plate technology (15-16% conversion efficiency); it also has the least potential for cost reduction. PV cells made from multicrystalline silicon have become popular as they are less expensive to produce, although they have a slightly lower efficiency.

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials on a low cost backing such as glass, stainless steel or plastic. Much less semiconductor material is required than for crystalline silicon cells, material costs are potentially much lower. Efficiencies are much lower, around 4-5%, although this can be boosted to 8-40% by depositing 2 or 3 layers of thin film material.

Since PV's generate DC output an inverter and other equipment is needed to deliver the power to a building or the grid in an acceptable AC form. The cost of the inverter and these 'balance of system' (BOS) components can approach 50% of the total cost of a PV system.

There are several issues which will need to be considered further if one or more photovoltaic arrays are to be included. Consideration must be given to any over-shading provided by surrounding buildings as well as orientation and elevation of the panels.

In areas with a predominance of large bird species such as seagulls, the birds may need to be discouraged from perching near the systems to prevent the need for regular cleaning. Also, the photovoltaic arrays will need some plant room space to house the inverters, meters and switchgear.

Applicability to the Darwin Close, Reading Development

The roof area limitations, access and shadowing effects outlined for SHTW in the previous section are also applicable to PV technology. The development will have a constant usage throughout the year, including the summer period. This will be the period when the output from the PV panels will be at maximum levels.

An advantage of solar PV, even over other types of LZC technology, is that running costs are very low (requires no fossil fuel for operation) and, since there are no moving parts, very little maintenance is required. As for STHW the roof of the building has the potential for PV mounting as depicted in Figure 9 of the previous section. The height of the building compared to the surrounding buildings would need to be considered so no shadowing from adjacent structures occurs. It should be noted that the entire south facing roof space may not be usable due to the presence of skylights.

For the reasons detailed above, PV technology may be considered as a potential option LZC option for the proposed development.

4.2.4 Wind Turbines

Technical Overview

The UK has 40% of Europe's total wind resource which remains largely untapped. At present, there is a wide range of available off-the-shelf wind products for attaching to ground mounted masts/towers, many manufactured in the UK and EU with proven good performance and durability. Capacity ranges from 500W to more than 2.0MW.

Wind technology is currently one of the most cost-effective renewable energy technologies, which is attributable to the large scale of installations reducing the unit output cost. Individual building or community wind projects, although smaller, have the advantage of feeding electricity directly into the buildings electricity circuit, thus sparing costly distribution network development and avoiding distribution losses. The downside is the still high capital cost per kW installed for smaller turbines, plus location constraints, such as visual intrusion and noise.

In most cases, wind turbines are connected to the electrical grid and all generated energy is used regardless of the building demand fluctuations. The output largely depends on the wind speed and the correlation between the two is a cube function. This means that in short periods of above-average wind speeds the generation increases exponentially. Thus, it is difficult to make precise calculations of the annual output of a turbine; nevertheless, average figures can provide useful guidance. Installing a wind turbine requires planning permission. Main considerations that are considered by the planning authorities are the visual impact and health and safety issues, such as noise and vibration. Noise and vibration are related to the operation of the turbines and their proximity to buildings requires an assessment of the impact on residents' comfort.

Wind turbines are highly engineered products which require specialist installation, commissioning and maintenance. It is the supplier who carries out these tasks to ensure proper functioning and connection of the machines and to issue a warranty. This applies to all sizes of turbines.

Installing a wind turbine also includes connection to the electricity grid. Permission from the local electricity supplier is necessary as well as an up-front agreement for power purchase except where the wind power produced is always below the base load. Full installation can take as little as a single day for smaller devices. Bigger-capacity installations may require considerably more time (weeks).

Once installed and connected to the grid there is very little the user needs to worry about regarding a wind turbine. The manufacturer user manuals should describe actions in extreme conditions, such as severe weather or accidental structural damage to the machine.

Maintenance of horizontal axis wind turbines is usually on an annual basis and requires lowering of the generator to the ground.

Most turbines operate continuously throughout the year and generation and supply of electricity is fully automatic. Users have access to the metering devices showing output and export levels for which guidance is available from the turbine installers. Ensure early consultation with planners as well as residents to smooth the planning application process.

Applicability to the Darwin Close, Reading Development

The urban location of the proposed development at Darwin Close does not lend itself to the use of wind turbine technology as a potential renewable energy source. The presence of several buildings in close proximity to the building will affect overall wind patterns on the site. Much of the site is also taken up by the physical foot-print of the building resulting in little or no space availability for positioning of a ground mounted wind turbine. The urban setting would also be problematic in terms of planning considerations.

The only potential option would be the use of a building mounted wind turbine. Building mounted turbines have limited outputs when compare to that of ground mounted units. Building mounted turbines also have structural implications and in many cases, result in vibration issues. Consideration must be given to potential noise shadow flicker and planning constraints in the area.

For the reasons detailed above, wind turbine technology is not considered as a viable LZC option for the proposed development.

4.2.5 Biomass Boilers

Technology Overview

Biomass is an alternative solid fuel to the conventional fossil fuels and has close to neutral carbon emissions impact providing it is sourced locally. Various types of biomass fuel are in use, the most common being the woody biomass which includes forest residues, such as tree thinning, and energy crops, such as willow short rotation coppice.

Biomass is converted into a manageable form that can be directly fed to the heat or power generation plant thus replacing fossil fuel. Thus, applications can range from large-scale heating boilers to individual house room heaters to combined heat and power generation (CHP). For building applications, the fuel usually takes the form of wood chips, logs and pellets. Wood pellets are essentially compacted high-density wood with low moisture content, thus having a higher calorific value per unit (volume or weight). Supply and storage of the biomass fuel should be carefully considered especially for larger plants.

The typical applications are:

- Biomass boilers replacing standard gas-fired boilers for space heating and hot water (for individual buildings or district heating systems)
- Standalone room heaters for space heating
- Stoves with back boilers, supplying domestic hot water
- Biomass CHP for heat and electricity generation.

Appliances can achieve efficiencies of more than 80%. Sizes start at 3-5kW capacity for room heaters up to hundreds of kW or MW industrial scale plants and community energy schemes. Many of the applications are sized to meet a specific base load with additional top-up and back-up provided by gas boilers.

Although biomass is a widespread technology in many European and North American countries, in the UK the market is not yet well-developed. However, applications of small-scale boilers and individual room heaters are increasing. These devices can run on logs, wood chip or pellets with the latter designed for either manual or automatic feed. An integrated hot water storage tank or an accumulator can enable the supply of heat to be decoupled from the actual combustion of the fuel.

Applicability to the Darwin Close, Reading Development

The location of the proposed development in an urban environment poses restrictions on biomass as a suitable technology for the development. These limitations are due to planning limitations associated with the particle emissions from the biomass boiler in a city centre environment and the logistical challenges of providing biomass fuel deliveries due to the building. The space availability for biomass fuel storage in the building is also limited. This would result in a low storage volume and therefore a higher delivery frequency which is not practical.

For the reasons detailed above, biomass technology is not considered as a viable LZC option for the proposed development.

4.2.6 Ground Source Heat Pumps (GSHP)

Technical Overview

Ground source heat pump (GSHP) technology is already widely used in North America and several European countries with over 500,000 units installed worldwide. Diverse applications include space heating, water heating, heat recovery, space cooling, and dehumidification in both the residential and commercial building sectors.

The technology makes use of the energy stored in the Earth's crust coming mainly from solar radiation. Essentially, heat pumps take up heat at a certain temperature and release it at a higher temperature. This is achieved by means of ground collectors (coils), in which a heat exchange fluid circulates and transfers heat via a heat exchanger to the heat pump. The cycle is driven by the temperature difference between the ground and the circulating fluid. The advantage of using the ground as heat source rather than air, is the relatively constant temperatures of the ground throughout the years allowing the refrigerant fluid to operate optimally.

Ground source heat pumps can be categorised as having closed or open loops, and those closed 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.

Open loop systems are often referred to as groundwater heat pump. Ground water is pumped in the secondary loop through the heat exchanger in the heat pump and released at a lower temperature back into the ground. It may be suitable where there is a source of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.

For closed loop systems, water or antifreeze solution is circulated through plastic pipes buried beneath the earth's surface. During the winter, the fluid collects heat from the earth and carries it through the system and into the building. During the summer, the system reverses itself to cool the building by pulling heat from the building, carrying it through the system and placing it in the ground. This process creates free cooling in the summer and delivers substantial savings on heating in the winter.

A system that would supply 50% of the space and water heating demand of a typical house would need 80-100m of ground coils, and for commercial buildings this can reach thousands of metres. Different space configurations of piping are possible depending on the available land, soil conditions, and excavation costs:

- Horizontal collectors require relatively large area of land free from hard rock. They are most appropriate for small installations, and particularly for new build. The pipes are buried in trenches 1-2m deep. Spatial optimisation is possible by laying pipes in group
- Loop configurations, however minimum distances should be maintained to allow for good thermal exchange.
- Vertical collectors are used where land is limited and are suitable for most soil and rock types. Vertical borehole heat exchangers could also be of various configurations (single, double, U-shaped, etc.) with typical diameters of 0.1-0.2m and between 15m and 180m deep. Minimum spacing between adjacent boreholes of 5-15m should be maintained to prevent thermal interference. Vertical boreholes are used in open loop systems to access the local water table. It should be noted that the open loop system is sensitive to Environmental Agency (EA) protocol.
- Parallel and series connection can be used where more than one horizontal loop or borehole are in place

Almost all heat pumps in operation are based on the vapour compression cycle, which combines efficiency, safety and reasonable cost.

A detailed ground survey, considering ground conditions and potentially other features such as sewers, tunnels and archaeology will be needed. Ground conditions will also affect ease of construction and performance of the system.

Applicability to the Darwin Close, Reading Development

Typically, for GSHP technology to be viable as a LZC technology, a considerable amount of area is required to locate vertical boreholes or horizontal collectors. In the case of the proposed development, most the site is taken up by the physical foot-print of the building resulting in little or no space availability for positioning of boreholes or horizontal collectors. Consideration must also be given to the suitability of ground conditions in the area, particularly for vertical borehole configurations.

For the reasons detailed above, ground source heat pump technology is not considered as a viable LZC option for the proposed development.

4.2.7 Air Source Heat Pumps (ASHP)

Technical Overview

Air source heat pumps absorb heat from the outside air. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors.

An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can get heat from the air even when the temperature is as low as -15° C. Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the ground, air, or water is constantly being renewed naturally.

Unlike gas and oil boilers, heat pumps deliver heat at lower temperatures over much longer periods. During the winter, they may need to be on constantly to heat your home efficiently. You will also notice that radiators won't feel as hot to the touch as they might do when you are using a gas or oil boiler.

Air source heat pumps can also provide cooling via a reversible type heat pump to provide space heating and cooling using external air properties to generate heat and/or cooling via piped systems.

Advantages of ASHP include;

- Little maintenance required
- Can be easily incorporated into the building providing space is available for external heat pumps
- Air Primary heat source/heat dump
- Can also provide domestic hot water
- Easier to install than Ground Source
- RHI Benefits
- More suitable for heating systems with lower operating water temperatures i.e. underfloor heating systems

Disadvantages of ASHP include;

- Electricity required to run heat pump
- Space for external heat pump(s) required. External heat pumps and space required will be considerably large for commercial buildings
- Efficiencies may be lower than ground source
- More suitable for heating systems with lower operating temperatures i.e. underfloor heating systems
- May result use high electrical use if not designed/specified correctly or in non-favourable external environmental conditions?

Applicability to the Darwin Close, Reading Development

For ASHP technology to be viable as a LZC technology, consideration needs to be given to the operation of the site along with the type of heating system and or cooling system proposed. The heating system proposed for the office and meeting areas is a variable Refrigerant Flow (VRF) system with ceiling mounted cassettes providing both heating and cooling. ASHP is therefore advised for this heating system. An external plant area is required to locate the external heat pumps for this scheme. The plant could be located around the perimeter of the building, away from the delivery routes.

AHSP does have potential for the site and is considered as the most suitable option for the scheme due to the reasons detailed above. ASHP may be used to provide heating and cooling to office areas and high density spaces and is considered suitable as the primary LZC for the scheme.

4.2.8 Summary of Results

This sustainability statement has been undertaken with a view to exploring the most viable option(s) that would provide the overall energy generation requirements for the development from renewable technologies or low carbon sources and assist with achieving Part L2A building regulation compliance. This report highlights that the following LZC technologies may be suitable for the scheme in order of suitability for building compliance and BREEAM;

Air Source Heat Pumps (ASHP) providing a portion of the building heating and limited space cooling for the office and meeting rooms.

Photovoltaics (PV)

The use of Air Source Heat Pumps has been identified as the most appropriate LZC technology for the site known as 1 Darwin Close, Reading. The technologies explored by this feasibility study are detailed in the **Table 2** below.

Technology	Details	Comments/ Minimum Required % Building Energy Generated
CHP Co-gen	Contributing towards space heating, domestic hot water and electricity generation for the building.	Not considered viable due to the limited hot water load within the proposed building.
CCHP Tri-gen (Incorporating absorption cooling)	Contributing towards space heating, domestic hot water electricity and cooling for the building	Not considered viable due to the limited hot water load within the proposed building.
Solar Thermal (STHW)	Contributing towards domestic hot water generation for the building	The roof of the building may be used to mount STHW panels. May be considered to provide domestic water however not advised due to the limited hot water load.
Photovoltaic	Contributing towards electricity generation for the building	The flat roof of the building may be used to mount PV panels. Limited shading from other adjacent buildings. Roof co-ordination and presence of skylights on the roof needs to be considered along with roof access and safety.
Wind Turbine	Contributing towards electricity generation for the building	Not appropriate considering planning constraints, wind pattern effects due to presence of other buildings near the development and the limited amount of available land area on the site for mounting the turbine.
Ground Source Heat Pumps (GSHP)	Contributing towards space heating and domestic hot water for the building	Not appropriate considering limited amount of available land area and geological conditions on the site for location of vertical bore holes or horizontal collectors.
Air Source Heat Pumps (ASHP)	Contributing towards space heating and cooling	Considered viable to provide an element of space cooling and heating for the scheme and considered viable as the primary LZC for the scheme.
Biomass	Contributing towards space heating, domestic hot water and electricity generation for the building	Not appropriate considering planning constraints, particle emission restrictions due to the developments urban environment and site constraints associated with biomass fuel deliveries and storage.

Table 2: Summary of results of the preliminary LZC feasibility study

5.0 Recommendations and Conclusions

Based on the assumptions contained within this report, it is recommended that the following preferred low carbon technology options for the Darwin Close, Reading development are considered for detailed design in order of suitability;

Air Source Heat Pumps

Air Source Heat Pumps (ASHP) are a suitable technology that may be integrated into the scheme. ASHP's may provide space heating and cooling in the Reception, Meeting Rooms, Offices and Conference Room.

The use of the proposed building efficiency measures and the proposed LZC technologies (ASHP) will result in a 1% improvement over the target emission rate (TER) required by Part L2B 2013 as depicted in **Figure 10**. Full Part L results can be found in **Appendix A**.

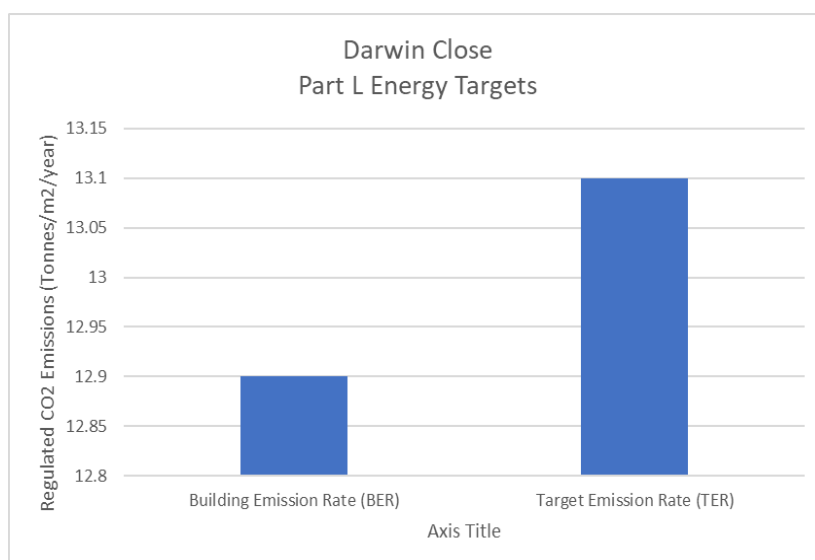


Figure 10: Darwin Close, Reading Building Emission Rate (BER) vs Target (TER) Emission Rate

Photovoltaics (PV)

PV panels mounted on the roof of the building providing electricity may be considered as a potential alternative or addition to the systems proposed.

It should be noted that PV has not been incorporated within the energy model.

An additional study has been conducted which indicated that 35m² of PV panels (with an efficiency of 17%) would provide a CO₂ reduction of 10%.

Fabric

The solution proposed utilises the benchmark standards for 'U' values. If further energy reductions are required or desired then fabric improvements could achieve this. Similarly, an air permeability of 7m³/m²(at 50Pa) has been utilised, whereas a tighter fabric construction would provide further energy savings.

The Reception area failed criterion 3 of the Part L compliance, due to the large amount of glazing to this area. Several options are available to overcome this including reducing the glazed area, the addition of Brise Soleil or the inclusion of blinds. For the purpose of this analysis blinds were added to this space resulting in a compliant space.

Mechanical Services

Efficient mechanical heating and ventilation systems have been incorporated within the design to achieve compliance, refer to the BRUKL document for system efficiencies. Further carbon savings could be realised with even more efficient mechanical systems. Hot water shall be provided by point-of-use, instantaneous, electric, hot water heaters which incur no storage heat losses.

Electrical Services

High efficiency LED lighting with zonal daylight dimming and occupancy sensors provide an energy efficient lighting system. Metering shall be provided for all major plant items with lighting and power separately metered. Power factor correction equipment has also been included within the analysis.

BREEAM

Additional procedures, practices, reports and design measures shall be included within the final design and construction which will contribute to achieving the desired BREEAM status. A BREEAM rating of “Good” would be reasonable and place the project within the top 50% of new build non-domestic buildings and would represent an intermediate level of good practice. This should be achievable with minimal cost implications. A higher rating of “Very Good” would place the project within the top 25%, but may come with some additional management, costs or procedures. The BREEAM rating shall be agreed at the earliest possible stage to ensure that all credits available at the start of a project are obtained.

APPENDIX A - PART L BRUKL FULL RESULTS

BRUKL Output Document



HM Government

Compliance with England Building Regulations Part L 2013

Project name

20170928-DARWIN CLOSE READING

As designed

Date: Thu Sep 28 16:14:49 2017

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.7

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.7

BRUKL compliance check version: v5.3.a.0

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO₂ emission rate for the building must not exceed the target

CO ₂ emission rate from the notional building, kgCO ₂ /m ² .annum	13.1
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	13.1
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	12.9
Are emissions from the building less than or equal to the target?	BER ≤ TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	U _{a-Limit}	U _{a-Calc}	U _{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.24	0.26	RM00000A:Surf[8]
Floor	0.25	0.22	0.22	RM000018:Surf[6]
Roof	0.25	0.18	0.18	GH000001:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.69	2	GH000001:Surf[1]
Personnel doors	2.2	2.2	2.2	RM000018:Surf[1]
Vehicle access & similar large doors	1.5	1.49	1.49	RM000018:Surf[4]
High usage entrance doors	3.5	-	-	No High usage entrance doors in building
U _{a-Limit} = Limiting area-weighted average U-values [W/(m ² K)] U _{a-Calc} = Calculated area-weighted average U-values [W/(m ² K)] U _{i-Calc} = Calculated maximum individual element U-values [W/(m ² K)]				
* There might be more than one surface where the maximum U-value occurs. ** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows. *** Display windows and similar glazing are excluded from the U-value check. N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.				

Air Permeability	Worst acceptable standard	This building
m ³ /(h.m ²) at 50 Pa	10	7

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	NO
Whole building electric power factor achieved by power factor correction	>0.95

1- ELECTRIC HEATING WITH NATURAL VENT

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

2- ASHP HEATING & COOLING & MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	2.5	3.2	0	0	0.85
Standard value	2.5*	3.2	N/A	N/A	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. For types <=12 kW output, refer to EN 14825 for limiting standards.					

3- ELECTRIC HEATING WITH MECHANICAL EXTRACT

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

4- GAS FIRED RADIANT HEATING WITH NATURAL VENTILATION

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	-	0	0	-
Standard value	0.91	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

1- DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	1	-
Standard value	1	N/A

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]										HR efficiency	
	ID of system type	A	B	C	D	E	F	G	H	I		
	Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1-CONFERENCE		-	0.8	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]										HR efficiency	
	ID of system type	A	B	C	D	E	F	G	H	I		
	Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1-OFFICE		-	0.8	0.5	-	-	-	-	-	-	-	N/A
1-WC-E-1		-	-	0.4	-	-	-	-	-	-	-	N/A
1-WC-E-2		-	-	0.4	-	-	-	-	-	-	-	N/A
1-WC-E-3		-	-	0.4	-	-	-	-	-	-	-	N/A
1-WC-W-1		-	-	0.4	-	-	-	-	-	-	-	N/A
1-WC-W-2		-	-	0.4	-	-	-	-	-	-	-	N/A
1-WC-W-3		-	-	0.4	-	-	-	-	-	-	-	N/A
G-MEETING-E		-	0.8	0.5	-	-	-	-	-	-	-	N/A
G-MEETING-W		-	0.8	0.5	-	-	-	-	-	-	-	N/A
G-RECEPTION		-	0.8	0.5	-	-	-	-	-	-	-	N/A
G-WC-E		-	-	0.4	-	-	-	-	-	-	-	N/A
G-WC-W		-	-	0.4	-	-	-	-	-	-	-	N/A

General lighting and display lighting		Luminous efficacy [lm/W]			General lighting [W]
Zone name		Luminaire	Lamp	Display lamp	
	Standard value	60	60	22	
1-CIRCULATION		-	90	-	80
1-CONFERENCE		90	-	-	399
1-OFFICE		90	-	-	1665
1-STAIR-E		-	90	-	58
1-WC LOBBY		-	90	-	7
1-WC-E-1		-	90	-	31
1-WC-E-2		-	90	-	27
1-WC-E-3		-	90	-	27
1-WC-W-1		-	90	-	32
1-WC-W-2		-	90	-	27
1-WC-W-3		-	90	-	29
G-HALL-E		90	-	-	2026
G-HALL-W		90	-	-	4741
G-MEETING-E		90	-	-	260
G-MEETING-W		90	-	-	222
G-RECEPTION		90	-	-	844
G-STAIR-W		-	90	-	98
G-WC-E		-	90	-	71
G-WC-W		-	90	-	66
1-STORE		90	-	-	425

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1-CONFERENCE	NO (-48.8%)	NO
1-OFFICE	NO (-49.8%)	NO
G-HALL-E	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
G-HALL-W	NO (-38.7%)	NO
G-MEETING-E	N/A	N/A
G-MEETING-W	N/A	N/A
G-RECEPTION	NO (-3.7%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters			Building Use	
	Actual	Notional	% Area	Building Type
Area [m ²]	2394.4	2394.4	100	A1/A2 Retail/Financial and Professional services
External area [m ²]	4699.3	4699.3		A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
Weather	LON	LON		B1 Offices and Workshop businesses
Infiltration [m ³ /hm ² @ 50Pa]	7	5		B2 to B7 General Industrial and Special Industrial Groups
Average conductance [W/K]	1733.17	1423.36		B8 Storage or Distribution
Average U-value [W/m ² K]	0.37	0.3		C1 Hotels
Alpha value* [%]	10.56	10		C2 Residential Institutions: Hospitals and Care Homes
* Percentage of the building's average heat transfer coefficient which is due to thermal bridging				C2 Residential Institutions: Residential schools
				C2 Residential Institutions: Universities and colleges
				C2A Secure Residential Institutions
				Residential spaces
				D1 Non-residential Institutions: Community/Day Centre
				D1 Non-residential Institutions: Libraries, Museums, and Galleries
				D1 Non-residential Institutions: Education
				D1 Non-residential Institutions: Primary Health Care Building
				D1 Non-residential Institutions: Crown and County Courts
				D2 General Assembly and Leisure, Night Clubs, and Theatres
				Others: Passenger terminals
				Others: Emergency services
				Others: Miscellaneous 24hr activities
				Others: Car Parks 24 hrs
				Others: Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	27.21	21.67
Cooling	1.58	0.46
Auxiliary	0.84	0.84
Lighting	6.72	12.73
Hot water	1.41	1.55
Equipment*	17.7	17.7
TOTAL**	37.75	37.26

* Energy used by equipment does not count towards the total for calculating emissions.

** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO₂ Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m ²]	104.5	82.89
Primary energy* [kWh/m ²]	81.51	77.03
Total emissions [kg/m ²]	12.9	13.1

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type	Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEFF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Multiburner radiant heaters, [HS] Radiant heater, [HFT] Natural Gas, [CFT] Electricity									
Actual	80.3	0	28.3	0	0	0.79	0	0.91	0
Notional	68.9	0	22.2	0	0	0.86	0	---	---
[ST] Unflued forced-convection air heaters, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity									
Actual	216.9	0	60.3	0	0	1	0	1	0
Notional	169.2	0	54.5	0	0	0.86	0	---	---
[ST] Unflued forced-convection air heaters, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity									
Actual	160.2	0	44.5	0	8	1	0	1	0
Notional	142.4	0	45.9	0	11.4	0.86	0	---	---
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity									
Actual	101.2	73	12.5	8.9	3.9	2.25	2.27	2.5	3.2
Notional	79.3	35.6	8.6	2.6	3.6	2.56	3.79	---	---
[ST] No Heating or Cooling									
Actual	0	0	0	0	0	0	0	0	0
Notional	0	0	0	0	0	0	0	---	---

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	U _{i-Typ}	U _{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.01	RM00000C:Surf[0]
Floor	0.2	0.01	RF000003:Surf[9]
Roof	0.15	0.18	GH000001:Surf[0]
Windows, roof windows, and rooflights	1.5	1.6	RM00000A:Surf[0]
Personnel doors	1.5	2.2	RM000018:Surf[1]
Vehicle access & similar large doors	1.5	1.49	RM000018:Surf[4]
High usage entrance doors	1.5	-	No High usage entrance doors in building
U _{i-Typ} = Typical individual element U-values [W/(m²K)]			U _{i-Min} = Minimum individual element U-values [W/(m²K)]
* There might be more than one surface where the minimum U-value occurs.			

Air Permeability	Typical value	This building
m³/(h.m²) at 50 Pa	5	7

London – Twickenham

London – Central

Birmingham

Chester

Manchester

Huddersfield

Newcastle upon Tyne

Glasgow

Dubai

Sydney