



Thornley & Lumb
Partnership Ltd.

Reading – Palmer Park Sports Centre Energy Strategy



Project

Reading – Palmer Park Sports Centre

Document

Energy Strategy

Client

Greenwich Leisure Limited

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Executive Summary

This Energy Strategy produced by Thornley & Lumb on behalf of Greenwich Leisure Limited (GLL) details aspects of sustainable building design relating to energy and carbon emissions of the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading. The building fabric first design philosophy and efficient building services analysis are combined with the available Low and Zero Carbon L2C technology to provide a methodology for achieving a sustainable low energy use development and exceed a BREEAM rating of 'Excellent'. The low carbon building design process is illustrated by following the Energy Hierarchy which details the measures included at each stage. The Energy Hierarchy helps qualify the carbon emissions due to various measures by reporting the emission reductions at each stage.

Be Lean Measures

- Low external envelope u-values
- Low air permeability
- Low energy LED lighting with lighting controls
- Metering connected to BMS with auto monitoring and targeting of energy
- Mechanical ventilation with passive heat recovery MVHR

Be Clean Measures

- Same as Be Lean

Be Green Measures

- Air Source Heat Pump ASHP space heating to Gym, Studios, Offices, Café, and associated areas
- High efficiency Air to Water CO₂ Air Source Heat Pump ASHP hot water services
- Solar Photovoltaic panels generating on site zero carbon electricity

This Energy Strategy therefore confirms that the overall development's carbon emissions will be reduced **46%** below the Part L 2013 baseline with the percentage carbon reduction increasing to **72%** using the current electricity grid carbon factors as per the Government's SAP10 proposal for updated Part L electricity grid carbon factors.

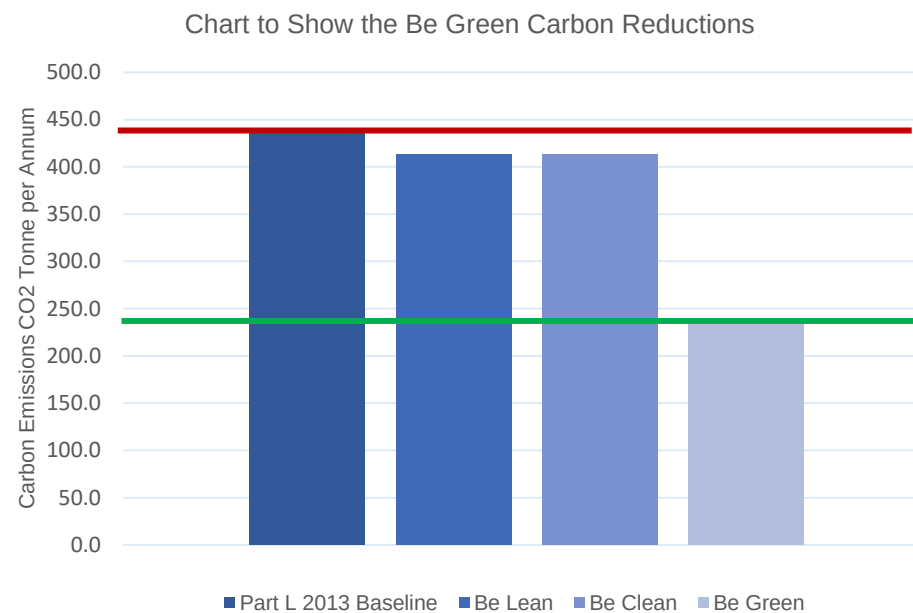


Chart to show the overall carbon reductions of the proposed development



Carbon Dioxide Emissions Per Annum for non-domestic Buildings

	Regulated CO ₂ Tonnes CO ₂ per annum	Unregulated CO ₂ Tonnes CO ₂ per annum
Baseline Part L (2013)	436.2	90.8
Including Be Lean Measures	413.7	90.8
Including Be Clean Measures	413.7	90.8
Including Be Green Measures	235.2	90.8

Regulated Carbon Dioxide Savings Per Annum for non-domestic Buildings

	Tonnes CO ₂ Per annum	Percentage Reduction %
Savings from Be Lean Measures	22.5	5.2
Savings from Be Clean Measures	0	0
Savings from Be Green Measures	178.5	43.2
Reduction Compared to Baseline	201	46.1



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1.0 Introduction

The proposed extension of Palmer Park Sports Centre on Worthington Road in Reading will consist of a two-storey building for sports centre (D2) use. The development will involve a gymnasium, swimming pool, with staff amenities, a café and reception spaces on ground level.

The proposed extension will be designed with sustainability as the principle metric and to qualify this the development achieving a BREEAM rating of 'Excellent', accordingly this Energy Strategy will detail how energy usage and carbon emissions have been minimised using the energy hierarchy, Be Lean Be Clean Be Green (as developed by the Greater London Authority GLA).

The Energy Strategy considers future electricity grid decarbonisation and uses this to influence the proposed design. The decarbonisation of the Electricity Grid is not reflected in current carbon emissions calculations for Part L of the building regulations 2013. However, this is due to be updated by the government and hence lower electricity grid carbon factors will be considered when developing this Energy Strategy.

The carbon reductions detailed in this Energy Strategy have been calculated using Part L accredited compliance dynamic simulation modelling DSM software IES VE Compliance DSM. This ensures that the proposed development's carbon emissions have been calculated using a more sophisticated carbon emissions calculations methodology, as opposed to the more simplistic standard SBEM methodology.

Accordingly, this Energy Strategy will detail how the proposed development will be a low carbon sustainable development by following the four energy strategy design principles as detailed in Section 1.1 Sustainable Low Carbon Design.

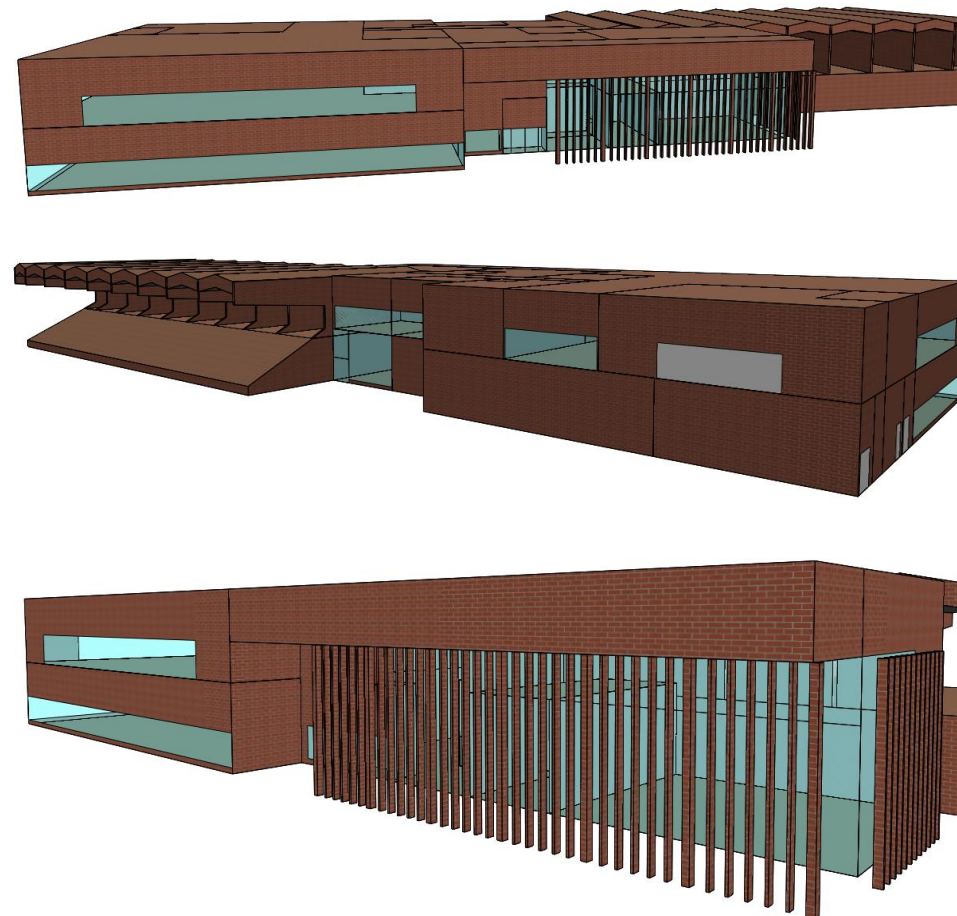


Figure 1.0 Images to show the proposed development building energy model



1.1 Sustainable Low-Carbon Design

Thornley and Lumb will consider the sustainability of the proposed extension and the building's energy usage throughout the design process by developing an energy strategy design philosophy. This will consist of four underling design principles which will be implemented to ensure the sustainability of the proposed development. The principles used to develop the energy strategy are: reduce demand, meet demand efficiently, supply from low carbon sources, supply from renewables.

Energy Strategy Design Principles

Reduce Demand

The energy demand of the building is intrinsically linked to the design of the building envelope and its services. Therefore, ensuring a thermally efficient and relatively air-tight building envelope will enable reduction in energy usage.

Meet Demand Efficiently

The application of building services which improve upon the minimum efficiencies detailed in the government's document the Non-Domestic Building Services Compliance Guide NDBSCG, will ensure that where energy is used for servicing the building, it is used efficiently with minimal wastage.

Supply from Low Carbon Sources

Where energy is used to service the building, the carbon emissions of the source will be taken into account as part of the design process. This involves using carbon factors of energy sources to calculate potential carbon emissions.

Supply from Renewable Sources

The further reduction of carbon emissions will be met with energy supply from renewable sources. These are zero carbon energy sources which provide servicing for the building without increasing the carbon emissions of the building.





2.0 Design Considerations

This section discusses the design considerations for the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading. This section will detail the design methodology and detail the planning criteria established by national and local policy.

2.1 Design Methodology

The energy usage figures used in this Energy Strategy have all been calculated using industry recognised software. The geometry of the building is modelled in the software and then all fixed building service efficiencies are integrated with the model to provide annual operational energy usage figures.

2.1.1 Energy Modelling Software

The IES VE software is dynamic building simulation modelling DSM application which includes industry standard thermal modelling and Part L compliance software. The dynamic simulation model utilises partial differential equations which are based on first-principles models of conductive, convective, and radiative heat transfer. The equations used in the software are then driven by real weather data, using local climate and weather data for the specific locations. This information is then combined with the proposed building geometry and fixed building services efficiencies to calculate an hourly annual analysis of the building's energy usage. This dynamic simulation modelling of building allows the operational energy of a building to be predicted at design stage, to calculate the carbon emissions of the building at design stage. Carbon factors are used to convert annual operational energy into future carbon emissions.

2.1.2 Carbon Emissions Calculations

This Energy Strategy uses Part L carbon factors from L2A 2013, however if we calculated annual carbon emissions of the development using current UK Electricity Grid carbon factors, the annual carbon emissions would be significantly lower.

The Part L 2013 carbon factors overestimate carbon emission from electric building services by over 100% hence the new carbon factors proposed by the Government's initial SAP10.1, which are closer to the current carbon emission of the UK Electricity Grid, will show the carbon emissions will be reduced significantly compared to this Energy Strategy.

The carbon factors have changed in recent years due to the increasing amount of zero carbon and renewables generation used to provide grid electricity. Last year, in 2019, low carbon electricity generation was 54.2% of total grid electricity.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875434/Press_Note_March_2020.pdf

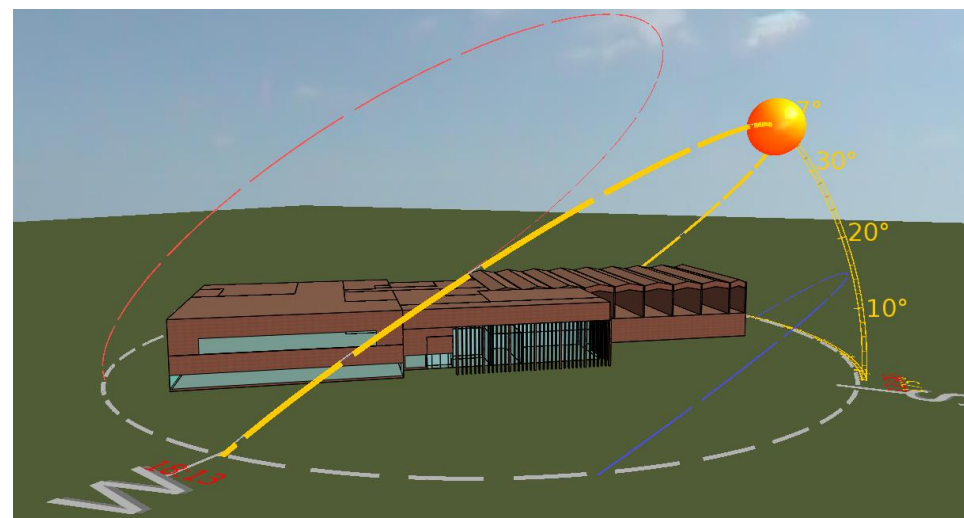


Figure 2.0 Image to show the orientation of the building in energy modelling software IES VE



2.2 National Planning Policy

The National Planning Policy Framework (NPPF) was updated in February 2019. The document details that “the purpose of the planning system is to contribute to the achievement of sustainable development”. Applications for planning permission are determined in accordance with the development plan and local planning policy. Achieving sustainable development means that the planning system has three overarching objectives, which are independent and need to be pursued in mutually supportive ways.

2.2.1 Economic

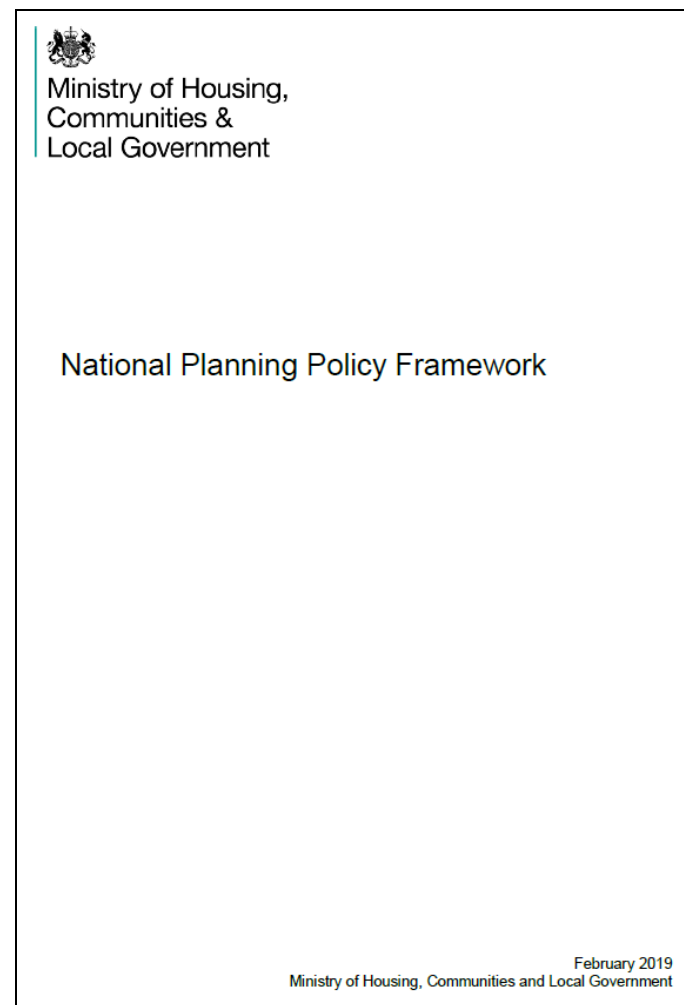
Contributing to help building a strong, responsive and competitive economy, by ensuring that sufficient land of the right type is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure.

2.2.2 Social

Supporting strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering a well-designed and safe built environment, with accessible services and open spaces that reflect current and future needs and support communities’ health, social and cultural well-being.

2.2.3 Environmental

Contributing to protecting and enhancing our natural, built and historic environment; including making effective use of land, helping to improve biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy.





2.3 Local Planning Policy

Reading Borough Council declared a Climate Emergency in 2019 and as such their planning policy is very forward thinking, consequently working towards a carbon neutral Reading by 2030. Reading Borough Council are very proud of their heritage and the town's identity, this combined with ambitious sustainability policies form the Reading Borough Council's Local Plan.

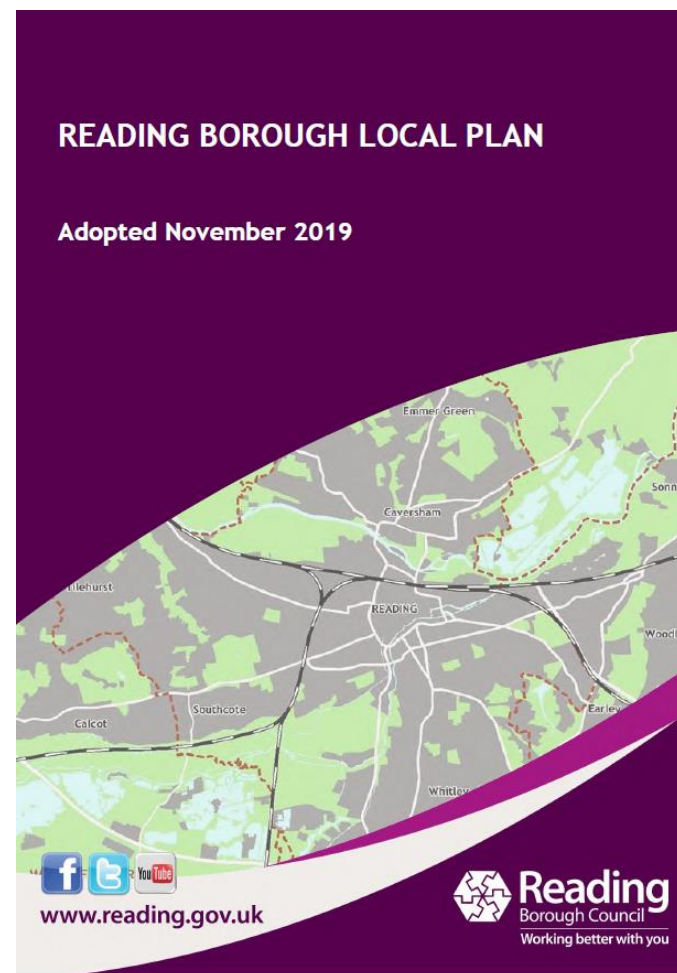
2.3.1 Policy CC1 – Presumption in Favour of Sustainable Development

The Local Plan Section 4 details Reading Borough Council's policy on new development and sustainability. This sets a presumption in favour of sustainable development influenced by the NPPF 2019 which is detailed in Section 2.2 of this Energy Strategy.

2.3.2 Policy CC2 – Sustainable Design and Construction of New Development

Section 4 also includes Policy CC2 Sustainable Design and Construction for new development. This Policy states that "all new major non-residential building should achieve BREEAM rating of 'excellent'. The Relevant Breeam credit for operational energy and carbon emissions is Breeam 2018 Ene 01. In order to achieve a Breeam excellent rating the development will need to achieve at least 4 credits.

This Energy Strategy will highlight a route to exceeding Reading Borough Council's sustainability policies with working towards a Breeam Outstanding Rating in the Operational Energy category of Ene 01. This will ensure the proposed leisure centre is as per Reading Borough Council as the forefront of zero carbon development and an exemplary building in terms of sustainability, operational energy and carbon emissions.





3.0 Be Lean: Reducing Energy Demand

Consideration of energy usage is an integral part of any proposed development and each aspect of the Low Energy Building Design includes methods of conserving energy and promoting sustainability. This section of the Energy Strategy looks at how demand has been reduced beyond the minimum required efficiency defined by building regulations, known as the ‘limiting parameter’. This minimum efficiency or limiting parameter is then compared with the Low Energy Building Design to assess the energy use of the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading.

3.1 Building Envelope and Fabric

The energy usage of a building is intrinsically linked to the efficiency of the building envelope design, accordingly this section details how energy use is minimised by following energy strategy design principles in Section 1.1 and using a Passivhaus influenced fabric first design philosophy.

The reduction of heat loss through the building fabric is the most effective method of passively reducing energy usage. Building services will be replaced multiple times over the life of the building but it is less likely that the building fabric will be upgraded. Therefore, the reduction of u-value and the adoption of the Passivhaus design philosophy is the most effective method of reducing energy usage and carbon emissions over the full life cycle of the building.

3.1.1 Thermal Properties of Building Fabric

The energy usage of the building services associated with controlling the space temperature is dependent on the building envelope. The efficiency of the building envelope significantly affects energy usage as this is essentially a measure of how efficiently the internal building environment is thermally isolated from the external environment. The more efficient the isolation of internal from external environment, the less energy will be required for use in servicing the internal environment to meet optimum comfort levels.

3.1.2 Thermal Bridging

The proposed development has been designed to use construction details which will limit thermal bridging and reduce heat loss through the building envelope.

	Limiting Fabric Parameters W m ⁻² K ⁻¹	Low Energy Design Parameters W m ⁻² K ⁻¹	Percentage Improvement %
Roof	0.25	0.10	60
External Walls	0.35	0.15	57
Ground Floor	0.25	0.22	12
External Glazing	2.20	1.5	38

Table 3.1.1: Table comparing the limiting fabric from Part L2A of the building regulations with the proposed Low Energy Design

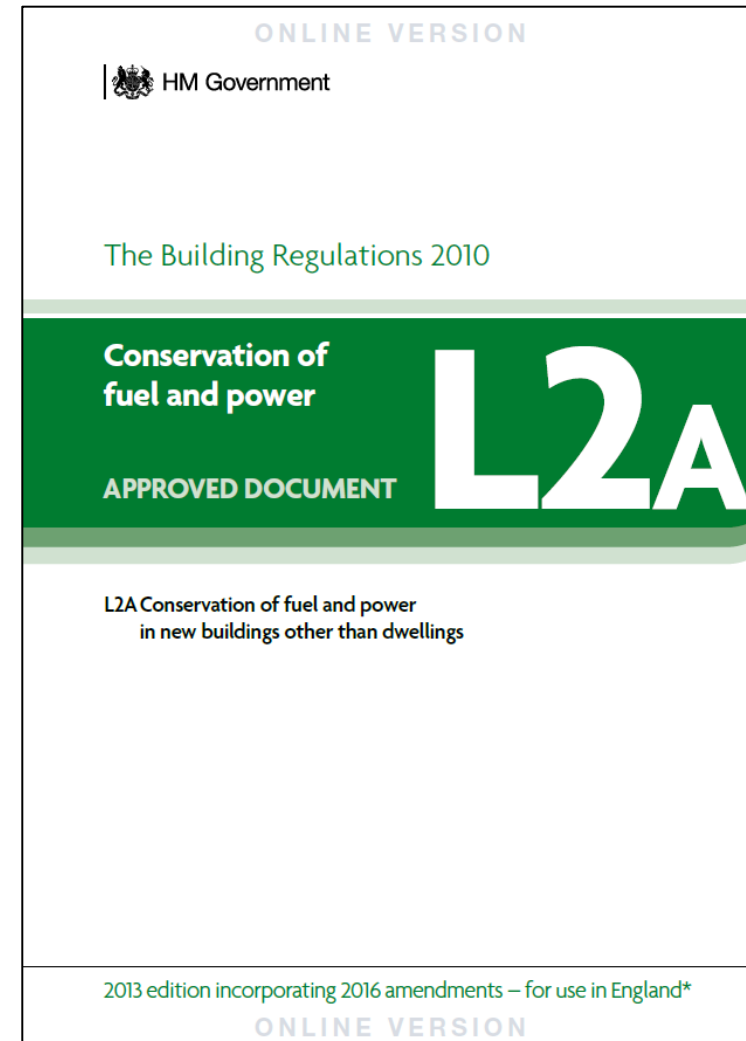


3.1.3 Air-Tightness of Structure

The energy usage of the building services associated with controlling internal environment are heavily dependent on the air-tightness of the building, which is essentially a measure of how efficient the building envelope is at resisting ingress of air from the external environment. Any ingress of air from the external environment will need to be conditioned by the building services to ensure the internal environment stays at the optimum level of comfort. Poor air tightness can result in higher operational energy costs and poor thermal comfort. Passivhaus standards specifically target very low air leakage rates associated with air-tight building to ensure operational energy is lowered and thermal comfort is improved. Accordingly, the reduction in air permeability and thereby external air ingress will reduce the demand upon the building services conditioning the area and proportionally reduce energy usage.

	Limiting Air Permeability $\text{m}^3 \text{ hr}^{-1} \text{ m}^{-2}$	Low Energy Design Permeability $\text{m}^3 \text{ hr}^{-1} \text{ m}^{-2}$	Percentage Improvement %
Air Permeability	10.0	3.0	70

Table 3.1.2: Table comparing the limiting air permeability from Part L2A with the proposed design.





3.1.4 Mechanical Ventilation

Palmer Park Sports Centre will incorporate heat recovery in all supply and extract ventilation units serving occupied areas. Heat recovery capabilities ensure a unit retains heat within the building internal environment, despite bringing in external atmospheric 'fresh' air to improve indoor air quality for the occupants.

Heat recovery units use an air to air heat exchanger to transfer heat from the internal spaces to the incoming external air. The air paths do not cross and there is no mixing of the air, the heat exchanger enables heat recovery between air streams. Thereby passively warming the external air and reducing the need for mechanical heating services to use energy to increase the temperature.

Air handling units use a thermal wheel, also known as a rotary heat exchanger as an air to air heat exchanger, a thermal wheel consists of a circular honeycomb-like matrix of heat-absorbing material, which is rotated within the supply and exhaust streams of an air handling unit.

The Specific Fan Power SFP of the heat recovery ventilation unit is a measure of how efficiently the unit can supply air to the space. This consists of a ratio of electrical absorbed power to volumetric airflow rate creating the specific fan power metric, in which a lower number is more efficient.

	Limiting Specific Fan Power SFP $\text{W l}^{-1} \text{s}^{-1}$	Low Energy Design SFP $\text{W l}^{-1} \text{s}^{-1}$	Percentage Improvement %
Specific Fan Power SFP	1.9	1.5	21
Heat Recovery Efficiency	50%	80%	60

Table 3.1.3: Table comparing the limiting ventilation efficiencies with the proposed Design.

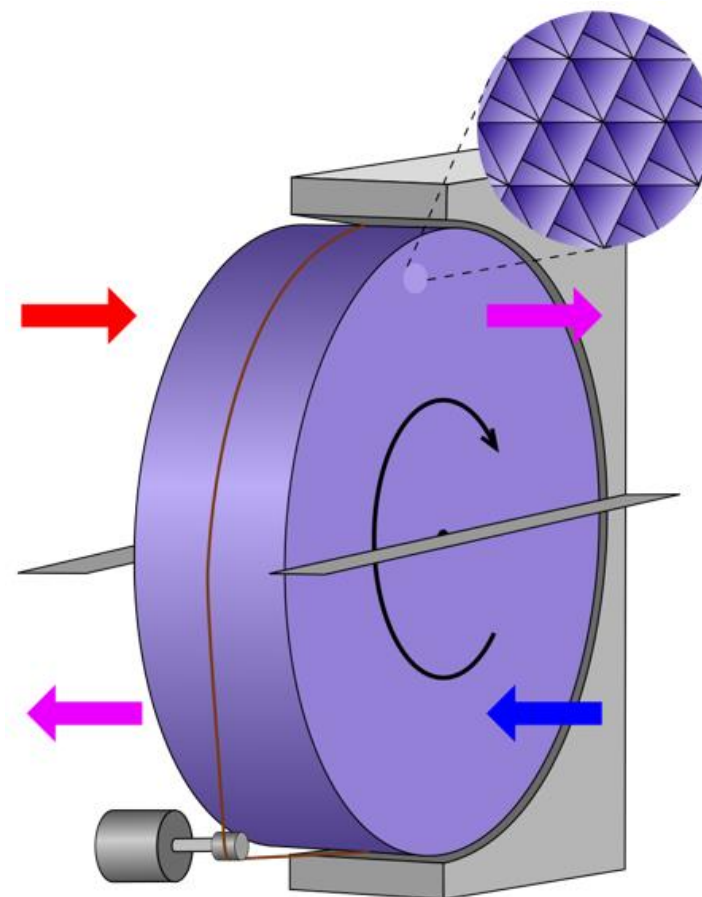


Image 3.1.1: Image to show standard operation of a thermal wheel.



3.1.5 Low Energy Lighting & Control

The energy required to illuminate the spaces of the development can be minimised by using low energy LED light fittings that minimise the energy and carbon emission used in artificial lighting. The artificial lighting has also been designed to incorporate lighting controls which will ensure that no electricity used for artificial lighting is wasted. This will ensure that carbon emissions are not created unnecessarily and that the building is a sustainable development.

The lighting controls

- Café – daylight dimming
- Gym – daylight dimming
- Soft Play – daylight dimming
- Toilet – auto on/off control
- Office – auto on/off control
- Store – auto on/off control
- Reception – daylight dimming
- Servery – daylight dimming
- Pool – daylight dimming
- Viewing Area – daylight dimming

	Limiting Lumens per Circuit Watt Lm.W ⁻¹	Low Energy Deign Value Lm.W ⁻¹	Percentage Improvement %
Lighting Efficiency	60	110	83

Table 3.1.4 Table comparing the limiting lighting efficiency with the proposed Low Energy Design Value





4.0 Be Clean: Analysis of Decentralised Energy

Reading Borough Council's Local Plan has a policy dedicated to Decentralised Energy. Reading Borough Council intend to develop innovative solutions which include district heating systems around ground source heat pumps and the use of rivers and watercourses to generate energy. Decentralising the energy supply is important for high density developments, where the per flat or apartment application of renewable and LZC technology may have practical restrictions or offer poor lifecycle costs. The annual carbon emissions are dependent on the energy sources of the district energy scheme and each development's annual carbon emissions calculations are required to determine whether decentralised energy or grid electricity would produce lower carbon emissions.

4.1 Heat Distribution Network

Reading Borough Council have commissioned studies for decentralised energy schemes within the borough and produced a map Figure 5.1 of the most suitable locations. The leisure centre is not in one of these areas and hence will not be able to connect to a district energy centre. With this in mind, annual carbon emissions calculation will likely show that on site LZC is the best method of reducing carbon emission from the leisure centre, especially as the development will be high energy usage and have significant M&E plant and also incorporate a good quality maintenance regime.

The hot water services annual carbon emissions will be calculated as part of this Energy Strategy to determine the lowest carbon method of providing hot water services. However, the hot water services could potentially be provided by a district heating or district energy scheme in the future. To facilitate this, space will be made available for plate heat exchangers in the leisure centre plant room, should a future district energy scheme be desired.

The decision whether to provide future hot water services via on site LZC or district energy scheme will need to be made once a network is available and the annual carbon emission of the network can be calculated. The analysis should take the form of a lifecycle cost analysis and balance the lifecycle costs with the annual carbon emission calculations to determine the most sustainable method of providing hot water services

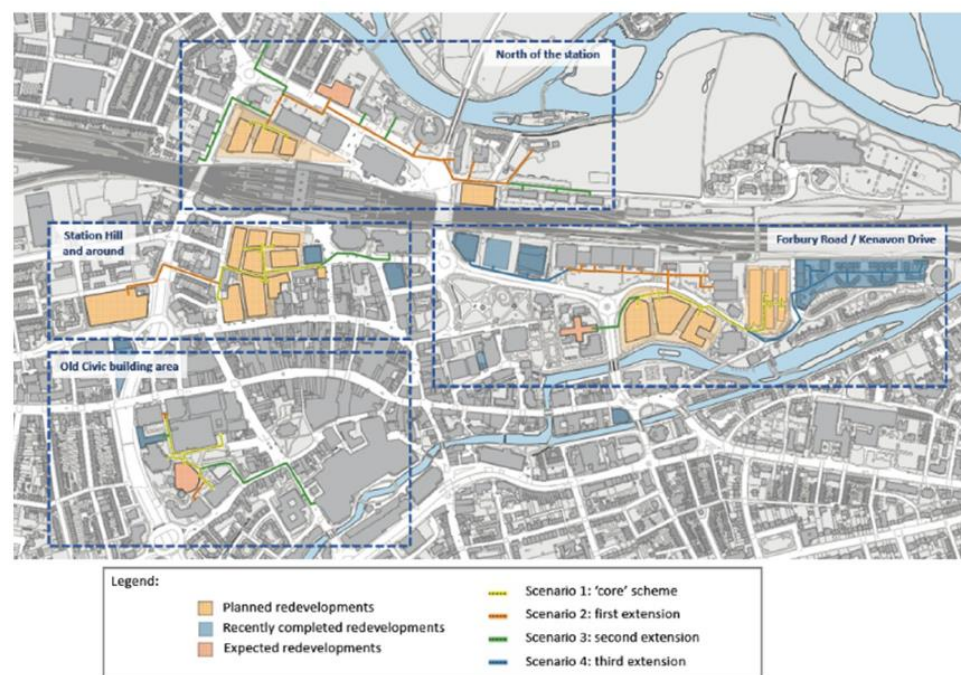


Figure 4.1 to show the proposed heat networks in the area



5.0 Be Green: Analysis of Renewable Technology

5.1 Analysis of Available Renewable Technology

The available renewable technology which will be considered for the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading is detailed in the table below, along with potential benefits and any foreseeable issues. The table is provided to give a visual overview of the appropriate renewable technology and hence determine suitable renewable technology.

Technology Type	Description of Technology	Potential Benefits	Potential Issues	Valid for Application
PV Panels (Photovoltaic)	Photovoltaic solar arrays use solar radiation to create electricity, using a similar process to photosynthesis. Electrons are freed from atoms and the subsequent flow of electrons results in electric current.	Zero carbon emissions, 100% renewable technology Additional income due to government incentives Relatively maintenance free as no moving parts Visual impact can be low as can be placed out of sight. Noise free operation	Panels should face south and have sufficient angle to maximise capture Shadowing and detritus can lower performance over time Structure must be able to accommodate the weight of the panels. Required maintenance for cleaning panels	Yes (valid and recommended)



Technology Type	Description of Technology	Potential Benefits	Potential Issues	Valid for Application
Solar Thermal (Solar water heating)	Soar thermal installations use solar radiation to heat water. Evacuated tubes are installed in an area of maximum solar radiation. The heat is then transferred to the water and the heated water is then used to supplement the hot water requirement of the building.	Zero carbon emissions, 100% renewable technology Additional income due to government RHI scheme Relatively low maintenance as few moving parts Visual impact can be low as can be placed out of sight. Noise free operation	Tubes should face south and have sufficient angle to maximise capture Shadowing can affect energy generation performance The structure of the building must be able to accommodate the weight of the filled tubes. More benefit seen during the summer months	Yes (valid but not recommended)
Wind Turbine Generation	Wind turbines installed on or around the building can generate renewable electricity. This process utilises the kinetic energy of the wind to drive electricity generating alternators.	Zero carbon emissions, 100% renewable technology Additional income due to government incentives FIT	Visual impact potentially high due to ideal location of installation Potential planning issues Requires regular maintenance Air turbulence generates a significant amount of noise	No (not valid for development)



Technology Type	Description of Technology	Potential Benefits	Potential Issues	Valid for Application
Air Source Heat Pump ASHP (Space Heating)	Air source heat pumps transfer low grade thermal energy in the atmosphere for use in heating spaces or water heating.	RHI available for each kWh of energy generated	Potential for leak of refrigerant with high GWP relative to CO ₂	Yes (valid and recommended)
		Efficient operation utilising the low grade heat in the atmosphere.	Specialist maintained due to refrigerant handling laws	
Ground Source Heat Pump GSHP	Ground source heat pumps use the Earth as a heat sink and transfer low grade thermal energy from the ground for use in the building. This energy can then be used for space heating/cooling or water heating.	Proven and reliable technology	External condenser fans create noise.	Yes (valid but not recommended)
		Additional income generated due to RHI government incentives	Not 100% renewable as electricity creates carbon emissions	
Ground Source Heat Pump GSHP	Ground source heat pumps use the Earth as a heat sink and transfer low grade thermal energy from the ground for use in the building. This energy can then be used for space heating/cooling or water heating.	Efficient operation utilising low grade heat in the ground	Ground survey required to determine feasibility of installation.	Yes (valid but not recommended)
		Noise free operation	Carbon emissions due to electricity as fuel	



Technology Type	Description of Technology	Potential Benefits	Potential Issues	Valid for Application
Air Source Heat Pump ASHP (Hot Water Heating)	Air source heat pumps transfer low grade thermal energy in the atmosphere for use in heating spaces or water heating.	RHI available for each kWh of energy generated Efficient operation utilising the low-grade heat in the atmosphere. Proven and reliable technology	Potential for leak of refrigerant Specialist maintained due to refrigerant handling laws External condenser fans create noise.	Yes (valid and recommended)
CHP (Cogeneration)	A cogeneration plant is a combustion engine using natural gas or biogas fuel to drive an alternator which produces electricity. The combustion process is cooled using water as a refrigerant. This low-grade heat can then be transferred for use in building services.	Income generated by RHI (if served by renewable gas) Efficient generation of energy, minimising losses. Potential to export Electricity	Need to have sufficient, constant simultaneous heat and electrical load Needs to operate for a majority percentage of the year	Yes (valid but not recommended)

Table 5.1 Detailing the Low and Zero carbon technology options available for the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading.



5.2 Lifecycle Cost Analysis

Table 5.1 has presented the options of low and zero carbon technologies and these should be also viewed with a lifecycle cost analysis

	Benchmark Installed Cost £	LZC Installed Cost £	Cost Uplift of LZC Installed Cost £	Benchmark Energy kWh	LZC Energy kWh	LZC Energy Generated kWh	Benchmark Op Energy Cost £	LZC Op Energy Cost £	Annual Saving £	Payback years
ASHP Space Heating	£110,000	£120,000	£10,000	44,657	30,446	0	£1,786	£3,653	-£1,867	No payback vs. nat gas
ASHP HWS	£60,000	£100,000	£40,000	1,577,909	121,175	0	£63,116	£14,541	£48,575	1
Solar PV	£0	£11,458	£11,458	-	-	7,131	£0	£856		13
Insulation	-	-	£98,294	153,720	127,800	0	£18,446	£15,336	£3,110	32
Solar Thermal	-	£50,000	£50,000	-	-	12,998	-	£1,560	-	32
GSHP Space Heating	£110,000	£270,000	£160,000	44,657	38,917	0	£1,786	£4,670	-£2,884	No payback vs. nat gas
CHP	£60,00	£120,000	£60,000	1,577,909	2,118,823	113,311	£63,116	£71,156	£5,558	11

Table 5.2 Lifecycle cost analysis for available low and zero carbon technology including insulation



5.3 Analysis of Available Renewable Technology

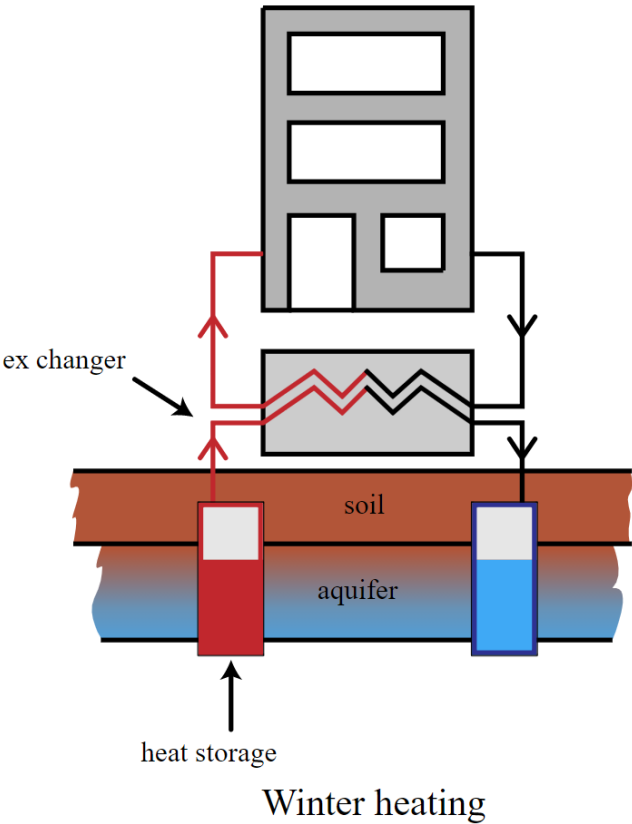
Table 5.1 has detailed the analysis for the available renewable technology for the Leisure Centre with potential benefits and issues and a comment as to whether the specific LZC is valid for the leisure centre LZC / building services application.

Ground Source Heat Pump

The ground source heat pump is not suitable for hot water services due to the type of energy usage demand and the constant annual demand for heating without cooling. The ground source heat pump could be suitable for space heating and comfort cooling however this is only renewable in space heating application. Ground Source Heat Pumps are renewable when heating water for hot water services however in the winter months the heat would be drawn from the ground and not replenished in the summer months via comfort cooling as it would in the space heating and cooling application, therefore the ground source heat pump is not suitable for providing the heat for the hot water services. The efficiency seasonal efficiency of a typical air source heat pump is 3.19 contrasted with the seasonal efficiency of a ground source heat pump at 3.37. The ground source heat pump represents a 5.6% increase in efficiency of the heat pump due to the higher average temperature of the heat sink, thereby providing greater heat exchange whilst consuming less electrical energy due to refrigerant compression.

	ASHP	GSHP	Percentage Difference
Seasonal Efficiency SCOP	3.19	3.37	5.6

The ground source heat pump therefore has potential to reduce the annual building energy usage for space heating by 6.3% of the total building energy usage, hence we can see that a 5.6% improvement in space heating efficiency by utilising a ground source heat pump would results in a 0.4% reduction in overall building energy usage. This shows the leisure centre does not have sufficient space heating demand to provide significant benefit from the adoption of ground source heat pump technology.





Solar Thermal Water Heating

Solar thermal water heating could provide water for hot water serves as the hot water services demand is not seasonal like space heating and benefits from significant demand during the warmer months where solar radiation can deliver more energy over a longer period. However, the air source heat pump proposed is a dedicated water heater which can achieve very high efficiencies in high external ambient when solar thermal generation is highest and can also supply renewable hot water services all year around. In addition, to work efficiently the air source heat pump needs very low incoming water temperatures, the lower the incoming mains water temperature to the air source heat pump the higher the efficiency. A low incoming water temperature ensures the CO₂ refrigerant does not operate a fully trans-critical cycle, significantly reducing the efficiency of the refrigeration cycle by increasing the electrical energy absorbed by the compressor. When considering this, the solar thermal pre-heat for hot water services would conflict with the air source heat pump technology reducing the seasonal efficiency of the heat pump and increasing the energy usage and carbon emission of the development.

	Solar Thermal Water Heating
Seasonal Efficiency	100% renewable technology

CHP Cogeneration

The application of cogeneration CHP engine technology is valid for the leisure centre due to the high hot water services demand. However, as all practical CHP engines will emit carbon and nitrogen dioxide NO_x this technology is not preferred. The UK electricity grid carbon factor has reduced dramatically in recent years, in 2019 54.2% of electricity was generated using low carbon technology. Therefore it can be shown that electrification will deliver lower carbon emission at present and the carbon emission will reduce as the electric grid decarbonises over the life of the

building services and LZC technology reducing the ability of on-site gas fired CHP to provide carbon emissions reductions..

	Elec Efficiency	Heat Efficiency	Total Efficiency
CHP	29.8%	57.6%	87.3%

Predicted Building Energy Rates (kWh.m⁻²)

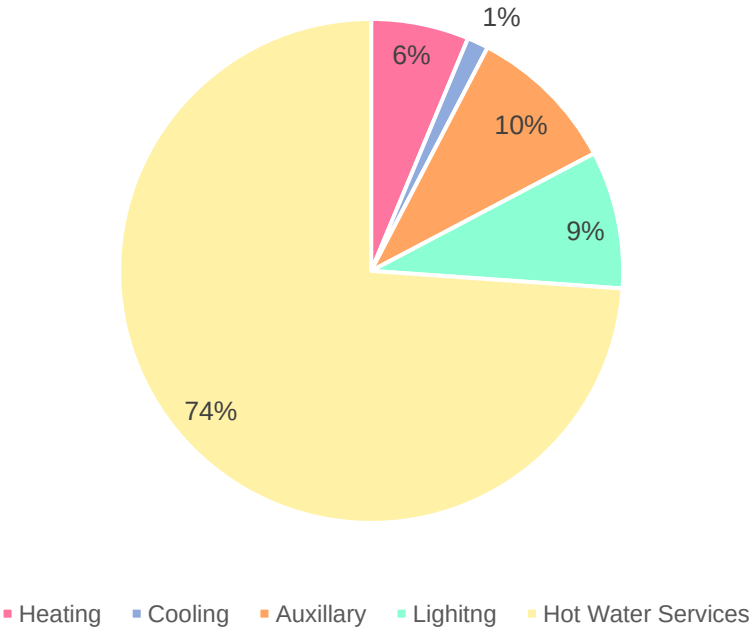


Chart to show the predicted building energy rates for Palmer Park Sports Centre



6.0 Carbon Emissions Reductions Energy

6.1 Low Energy Building Design and Energy Hierarchy

The Low Energy Building Design building and services design process uses the design principles outlined in Section 1.1 to ensure the energy use of the proposed development is as low as possible and that where energy is used, as little as possible is wasted. The design concepts used in the Low Energy Building Design has taken elements of the Passivhaus fabric first approach to the building design process. This approach significantly lowers the energy demand before the building services are considered in the design process by applying passive zero energy usage measures. Once the energy use of the building is sufficiently minimised, low energy building services and LZC technology are then utilised in the design. This ensures the carbon targets can be met and that energy needed to provide services and control the building internal environment is minimised.

The energy strategy has shown passive and active carbon reduction measures as part of the low energy building design. The carbon reductions for these measures will now be illustrated using the Energy Hierarchy. The energy hierarchy has been developed by the GLA for The London Plan and helps illustrate carbon reductions throughout each step of the low energy building design process. The sustainability principles outlined in Section 1.1 are used to drive the low energy design philosophy. The energy hierarchy is used to present and visualise carbon reductions. This is a carbon reduction methodology consisting of three main stages: Be Lean, Be Clean, Be Green which highlight carbon emissions from passive measures through to LZC technology.

Be Lean

The first stage in the energy hierarchy is 'Be Lean' which includes demand reduction measures designed to reduce energy usage passively.

Be Clean

The second stage in the energy hierarchy is 'Be Clean' assessment of clean energy sources district heating and CHP.

Be Green

The third and final stage is 'Be Green' the application of renewable energy technologies.





6.2 Establishing Baseline Emissions

The baseline carbon emissions are determined by assessing the proposed extension against the building regulations Part L compliance software. The regulated carbon emissions for this project have been calculated using Part L compliance software IES VE 2019 VE Compliance DSM.

This software uses the design information for the proposed development to create a notional ‘target building’ development. The carbon emissions for the notional building are then compared with the actual building’s carbon emissions. Accordingly, a compliant development is then deemed to be one which the actual emissions BER is less than or equal to the notional ‘target building’ carbon emissions TER.

The regulated carbon emissions are calculated for Part L compliance while unregulated carbon emissions for small power items like laptops, televisions and chargers are not currently assessed for Part L building regulations compliance.

The baseline carbon emissions are qualified by multiplying the TER generated using Part L compliance software and the floor area of the development. The TER has been calculated using a notional baseline development which includes heating provided by gas boilers. This will provide the baseline metric, for which all additional carbon emissions reductions are calculated against.

The proposed baseline carbon emissions

The baseline carbon emission are 436.2 tonnes per annum

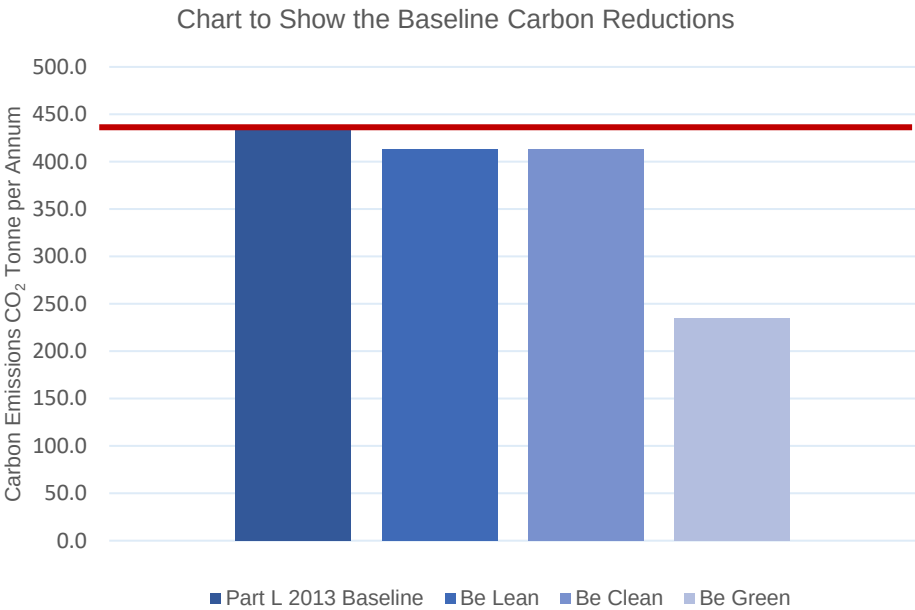


Chart 6.1 A chart to show the baseline carbon emissions of the proposed extension

The red line shows the baseline building carbon emissions TER





6.3 Be Lean

The carbon emissions baseline has been calculated as detailed in Section 6.2. The Demand reduction phase of the energy hierarchy now uses the measures discussed in Section 2.0 to illustrate the passive measures which have enabled the development to reduce carbon emissions.

The passive measures used in the proposed development are designed to reduce energy demand without using fuel in the process. Passive measures are applied before building services or low and zero carbon technology or renewable energy are applied.

This includes passive architectural design measures such as low u-value external element building fabric and low air permeability to reduce air ingress. Passive heat recovery ventilation can keep heat in the building by recovering heat from the external air using a heat exchanger. This heat can then be transferred to the incoming air without mixing of air streams or increase in energy usage of the building.

Low energy LED lighting can reduce energy usage and lighting controls can further reduce energy wastage by only utilising energy for the lighting services when they are needed.

The Passive Measures included in the development design are summarised below

- Low external envelope u-values
- Low air permeability
- Low energy LED lighting with lighting controls
- Metering connected to BMS with auto monitoring and targeting of energy
- Mechanical ventilation with passive heat recovery MVHR

The carbon reductions due to the Be Lean measures

The Be Lean measures achieve a carbon reduction of 5.2%

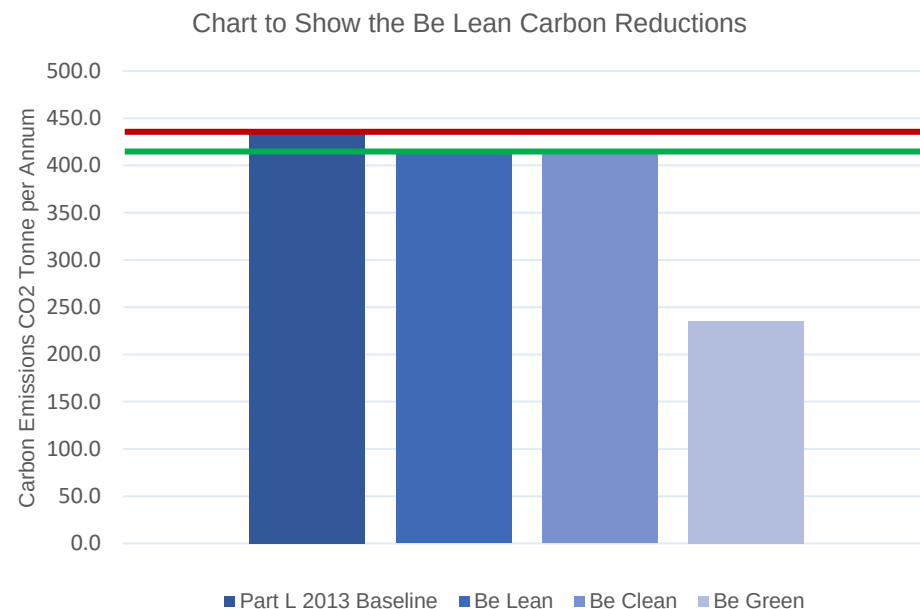


Chart 6.2 A chart to show the Be Lean carbon emissions reductions of the proposed extension

The red line shows the baseline building carbon emissions TER



The green line shows the actual building carbon emissions BER





6.4 Be Clean

The analysis presented in Section 4.0 detailed the availability of heat networks which are currently in the vicinity of the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading.

The feasibility of utilising CHP for providing the hot water services in the proposed development has been assessed as part of the preliminary building services design. However, this option for reducing carbon emissions was not deemed to be the most appropriate method of meeting the carbon reduction targets, due to the adverse effect on NOx emissions and hence air quality in the area.

The current Part L compliance software carbon factors are from L2A 2013, however new carbon factors proposed by the Government's initial SAP10.1 which more accurately reflect future grid decarbonisation and hence building lifecycle carbon emissions, will likely diminish the case for on-site generation of electricity using a natural gas fuelled CHP engine. The electricity grid carbon factors have changed in recent years due to the increasing amount of zero carbon and renewables electricity generation used to provide grid electricity. Last year in 2019 low carbon electricity generation was 54.2% of total grid electricity.

The application of a district heating network will have no effect on local air quality and as such the hot water services design could be provided by a district heat network in the future if a feasibility study determines this to be a lower carbon alternative to on site LZC.

The carbon reductions due to the Be Clean measures

The Be Clean carbon emissions are constant at 0% reduction

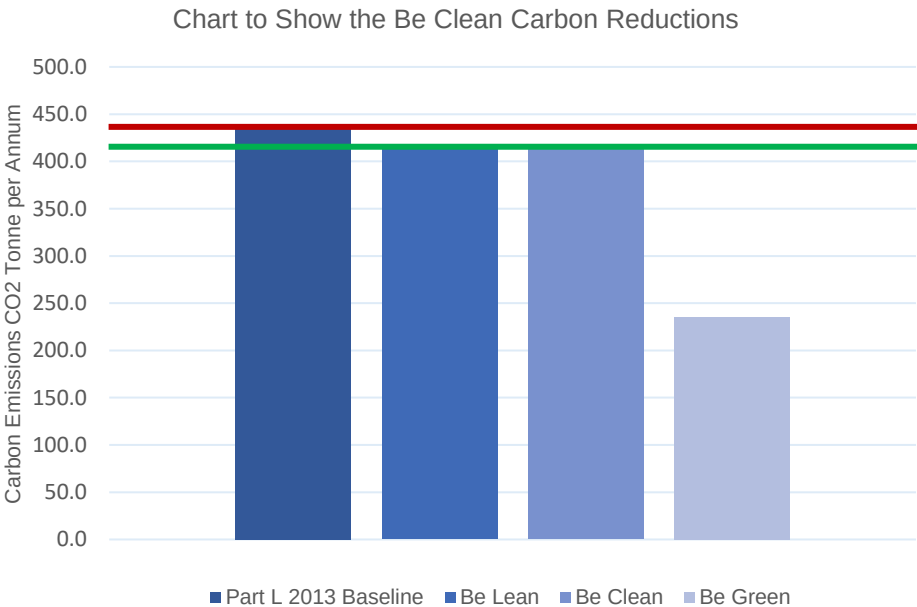


Chart 6.3 A chart to show the Be Clean carbon emissions reductions of the proposed extension

The red line shows the baseline building carbon emissions TER



The green line shows the actual building carbon emissions BER





6.5 Be Green

The final stage of the energy hierarchy utilises renewable technology to further lower the carbon emissions of the development. The building services design for the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading enables a significant reduction in carbon emissions by utilising heat pumps for HWS and space heating.

A CO₂ refrigeration cycle air source heat pump ASHP is to provide 100% of the hot water services, this enables a seasonal efficiency 440% using bin weather data for Reading. The high seasonal efficiency 4.4 SCOP of the heat pumps ensure that these are the lowest carbon method of providing hot water services. The high efficiency of the air source heat pumps reduces the energy demand for the hot water services, grid electricity usage and operational energy. The energy mix of the electricity grid is currently supplied by zero carbon sources which make up over 50% of annual electricity generation. Over the lifecycle of the building carbon emissions are expected to be reduced further than detailed in this Energy Strategy as the electricity grid continues to be decarbonised.

To provide a more sustainable building, reduce carbon emissions and operational energy the development will also include on site zero carbon electricity generation via solar photovoltaic panels. The on-site zero carbon electricity will ensure the development minimises grid electricity demand, reduces operational energy costs and that building services are powered by zero carbon electricity.

The Be Green stage of the Energy Hierarchy enables the development to meet the carbon reduction targets and as such provides a low carbon development.

- Air Source Heat Pump ASHP space heating to Gym, Studios, Offices, Café, and associated areas (carbon reduction = 6%)
- High efficiency Air to Water CO₂ Air Source Heat Pump ASHP hot water services (carbon reduction = 39%)
- Solar Photovoltaic panels generating on site zero carbon electricity (carbon reduction = 2%)

The carbon reductions due to the Be Green measures

The Be Green measures achieve a carbon reduction of 46.1%

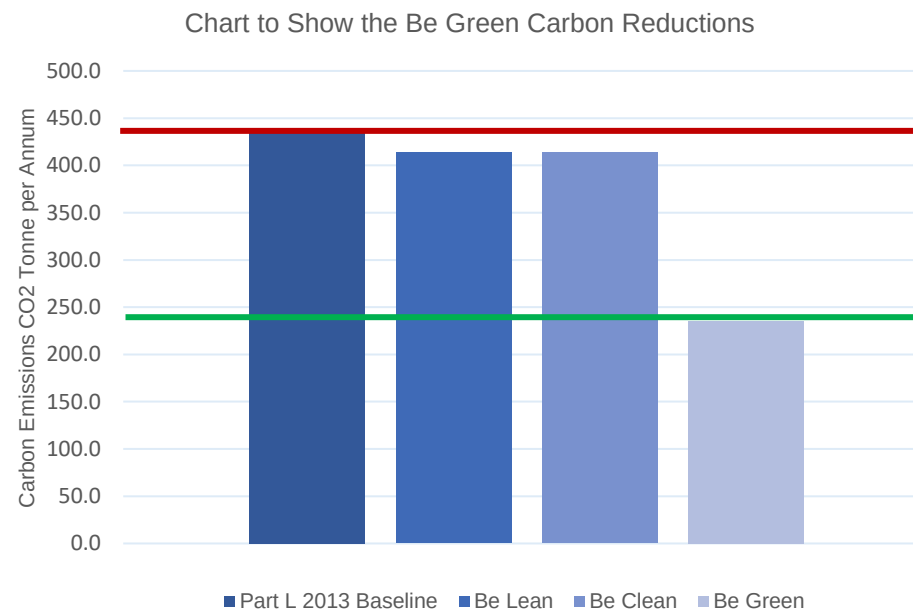


Chart 6.4 A chart to show the Be Green carbon emissions reductions of the proposed extension

The red line shows the baseline building carbon emissions TER



The green line shows the actual building carbon emissions BER





6.6 Overall Carbon Reductions

Carbon Dioxide Emissions Per Annum for Non-Domestic Buildings

	Regulated CO ₂ Tonnes CO ₂ per annum	Unregulated CO ₂ Tonnes CO ₂ per annum
Baseline Part L (2013)	436.2	90.8
Including Be Lean Measures	413.7	90.8
Including Be Clean Measures	413.7	90.8
Including Be Green Measures	235.2	90.8

Table 6.6.1 to show the carbon emissions of the proposed extension

Regulated Carbon Dioxide Savings Per Annum for Non-Domestic Buildings

	Tonnes CO ₂ Per annum	Percentage Reduction %
Savings from Be Lean Measures	22.5	5.2
Savings from Be Clean Measures	0	0
Savings from Be Green Measures	178.5	43.2
Reduction Compared to Baseline	201	46.1

Table 6.6.2 to show the carbon emissions reductions of the proposed extension



7.0 Unregulated Energy

This Energy Strategy has reported the predicted carbon emissions which result from regulated energy assessed via Part L compliance software. The Part L compliance software also includes a prediction of unregulated building energy rate based on typical plug in / unregulated energy equipment loads based on data from the BRE and CIBSE.

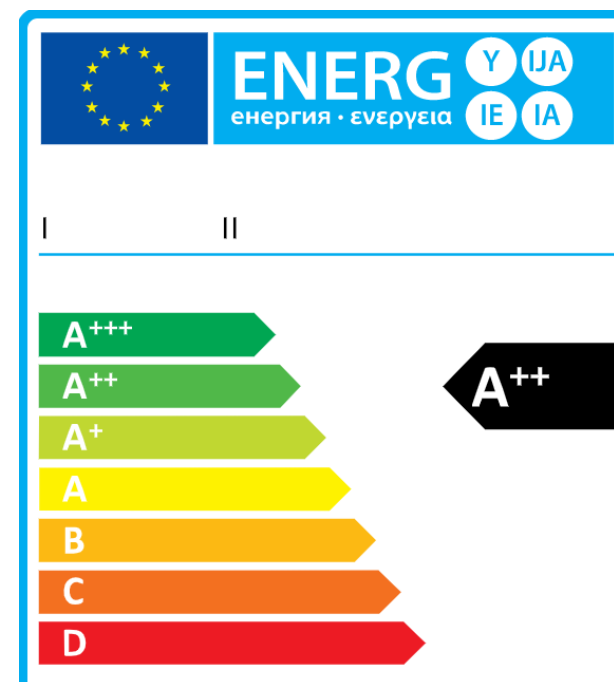
The leisure centre is targeting the Breeam Ene 01 credit to predict operational energy usage using the CISBE TM54 methodology which uses dynamic building simulation to predict building specific energy usage for regulated and unregulated building services and energy usage equipment. In addition the Breeam credit Ene 08 will be targeted which focuses specially on unregulated energy usage equipment or plug in loads and reduction of energy usage by selection of high efficiency equipment.

Following an analysis of a similar leisure centre the unregulated energy is dominated by the energy usage for swimming pool heating and energy used for the swimming pool hall ventilation system. The unregulated energy usage for swimming pool heating and swimming pool hall ventilation represented 97% of the total unregulated energy usage. It is proposed that the swimming pool includes a movable floor pool cover which will reduce the unregulated energy usage significantly, enabling a 19% reduction in unregulated energy.

	Baseline Unregulated Energy kWh per Annum	With Measures Unregulated Energy kWh per Annum	Percentage Reduction %
Energy Rate	2,573,899,485	2,074,562,985	19%

Further measures will be implemented to reduce unregulated energy usage and carbon emissions by application of minimum efficiencies based on the EU Energy Efficiency Labelling Scheme

- Minimum 'A+' for fridges, freezers or combined fridge freezers
- Minimum 'A' for washing machines and dishwasher
- Minimum 'B' for washer dryer or tumble dryer





8.0 Conclusion

The proposed extension of Palmer Park Sports Centre on Worthington Road in Reading has followed the GLA's energy hierarchy to qualify the carbon emissions reduction targets have been met and has shown that the design is exceeding the target of a BREEAM rating of 'Excellent'. This process has involved calculation of carbon emissions at each stage of the hierarchy using IES VE Compliance DSM.

The first stage **Be Lean** of the energy hierarchy incorporates the below measures

- Low external element u-values
- Low air permeability
- Low energy LED lighting with lighting controls
- Metering connected to BMS with auto monitoring and targeting of energy
- Mechanical ventilation with heat recovery MVHR

The **Be Lean** measures facilitate a carbon reduction of **5.2%**

The **Be Clean** second stage is detailed in Section 6.4.

Third stage **Be Green** of the energy hierarchy includes

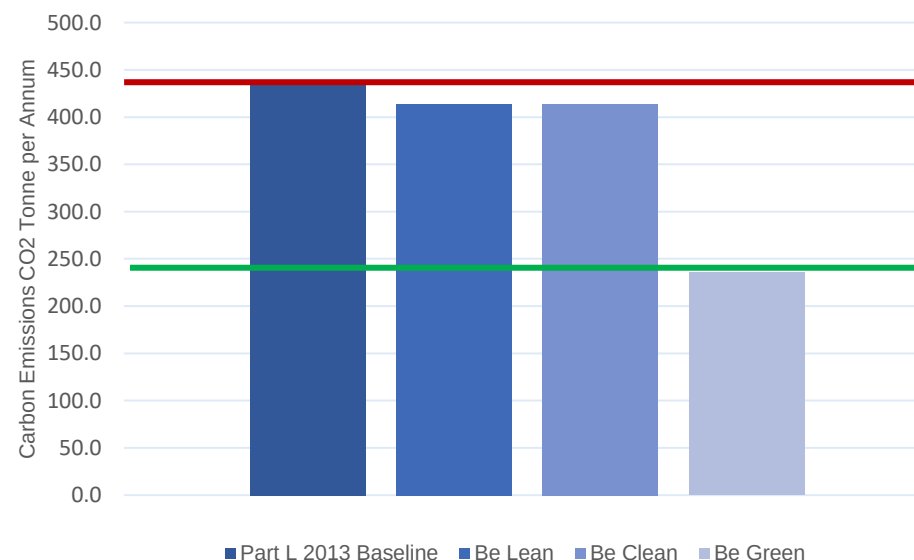
- Air Source Heat Pump ASHP space heating to Gym, Studios, Offices, Café, and associated areas
- High efficiency Air to Water CO₂ Air Source Heat Pump ASHP hot water services
- Solar Photovoltaic panels generating on site zero carbon electricity

The **Be Green** measures facilitate a carbon reduction of **46%**

This Energy Strategy proposes an all-electric hot water services strategy due to the adverse effect on local air quality proposed by decentralised or on-site combustion building services. Accordingly, this Energy Strategy confirms that the overall development's carbon emissions will be reduced **46%** below the Part L 2013 baseline, and furthermore when assessing the development using current electricity grid SAP 10 carbon factors a carbon reduction of **72%** is achieved, highlighting the effect of electrification of building services.

The energy hierarchy carbon reduction methodology has minimised energy usage, thus exceeding the target of a BREEAM rating of 'Excellent', and reduced carbon emissions of the proposed extension of Palmer Park Sports Centre on Worthington Road in Reading to provide a sustainable low energy building.

Chart to Show the Be Green Carbon Reductions





Appendices

[Appendix 1 Part L BRUKL Report Baseline/Be Lean](#)

[Appendix 2 Part L BRUKL Report Be Green](#)

[Appendix 3 Current Carbon Factor Carbon Reduction](#)



Appendix 1 Part L BRUKL Report Baseline/Be Lean

Project name

Reading Palmer Park Sport Centre - Baseline

As designed

Date: Tue Nov 24 11:16:12 2020

Administrative information

Building Details

Address: Palmer Park Sports Sport Centre, Reading, RG6 1LF

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Nikolas Sotnyk

Telephone number: 01274 687755

Address: 257 Cutler Heights Lane, Bradford, BD4 9JG

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	172.5
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	172.5
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	163.6
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	0.15	0.15	0F00000B:Surf[5]
Floor	0.25	0.22	0.22	0F000006:Surf[0]
Roof	0.25	0.1	0.1	1F000003:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.51	1.51	0F00000B:Surf[1]
Personnel doors	2.2	2.2	2.2	0F00000F:Surf[2]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	3.44	3.44	0F00000B:Surf[2]
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	3

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- xxxLondon Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	-	0.2	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
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

2- xxxLondon Central AHU

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	3.85	0	1.5	0.75
Standard value	0.91*	3.2	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

3- xxxLondon DX Cassette

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	3.85	0	0	0.75
Standard value	0.91*	2.6	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 gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

1- xxxLondon Boiler

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	0.91	0.002
Standard value	0.8	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		Zone	Standard
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1			
0F Office Cash	-	-	-	0.9	-	-	-	-	-	-	-	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
0F Concierge Reception	-	-	-	1.5	-	-	-	-	-	-	N/A
0F Office First Aid	-	-	-	0.9	-	-	-	-	-	-	N/A
0F Viewing Soft Play	-	-	-	1.5	-	-	-	-	-	-	N/A
0F Circulation Lift Lobby	-	-	-	1.5	-	-	-	-	-	-	N/A
1F Fitness Suite	-	-	-	1.5	-	-	-	-	-	-	N/A
0F Soft Play	-	-	-	1.5	-	-	-	-	-	-	N/A
1F Office Party/Meeting	-	-	-	0.9	-	-	-	-	-	-	N/A
0F Cafe	-	-	-	1.5	-	-	-	-	-	-	N/A
1F Viewing Athletics	-	-	-	1.5	-	-	-	-	-	-	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	
0F Toilet WC		-	301	-	19
0F Kitchen		-	163	-	382
0F Toilet WC Acc		-	301	-	25
0F Office Cash		178	-	-	55
0F Concierge Reception		-	161	50	26
0F Circulation Servery		-	114	-	33
0F Circulation Lobby		-	291	-	20
0F Pool Hall		-	99	-	4766
0F Change Village		-	102	-	816
0F Store Pool		96	-	-	27
0F Plant		69	-	-	407
0F Office First Aid		120	-	-	109
0F Circulation Esc Stairs		-	161	-	52
0F Store Chem		181	-	-	5
0F Store Chem		181	-	-	5
0F Viewing Soft Play		-	118	-	140
0F Circulation Lift Lobby		-	113	-	286
1F Change Female		-	117	-	203
1F Toilet UA		-	271	-	40
1F Fitness Suite		-	100	-	2495
1F Circulation Stairs		-	143	-	85
0F Soft Play		-	121	-	1539
1F Change Male		-	114	-	203
1F Office Party/Meeting		76	-	-	455
0F Cafe		-	128	-	629
1F Viewing Athletics		-	104	-	118
1F Circulation		-	112	-	321
1F Plant		63	-	-	792

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?
0F Toilet WC Acc	N/A	N/A
0F Office Cash	N/A	N/A
0F Concierge Reception	NO (-38.5%)	NO
0F Pool Hall	NO (-15.8%)	NO
0F Change Village	N/A	N/A
0F Office First Aid	N/A	N/A
0F Viewing Soft Play	YES (+27.1%)	NO
0F Circulation Lift Lobby	NO (-32.5%)	NO
1F Change Female	N/A	N/A
1F Fitness Suite	NO (-22.3%)	NO
0F Soft Play	YES (+72.5%)	NO
1F Change Male	N/A	N/A
1F Office Party/Meeting	N/A	N/A
0F Cafe	YES (+46.4%)	NO
1F Viewing Athletics	NO (-34.1%)	NO

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

	Actual	Notional
Area [m ²]	2528.7	2528.7
External area [m ²]	4354.9	4354.9
Weather	SWI	SWI
Infiltration [m ³ /hm ² @ 50Pa]	3	4
Average conductance [W/K]	1323.67	1400.89
Average U-value [W/m ² K]	0.3	0.32
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area Building Type

A1/A2 Retail/Financial and Professional services
A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
B1 Offices and Workshop businesses
B2 to B7 General Industrial and Special Industrial Groups
B8 Storage or Distribution
C1 Hotels
C2 Residential Institutions: Hospitals and Care Homes
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
100 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	23.05	44.18
Cooling	3.05	3.88
Auxiliary	27.11	14.34
Lighting	16.94	17.12
Hot water	624	671.81
Equipment*	69.2	69.2
TOTAL **	694.15	751.34

* Energy used by equipment does not count towards the total for consumption or 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]	112	190.04
Primary energy* [kWh/m ²]	930.35	979.29
Total emissions [kg/m ²]	163.6	172.5

* 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] Constant volume system (variable fresh air rate), [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	133.2	26.8	48.5	2.1	36.6	0.76	3.57	0.91	6.4
	Notional	330.9	36.3	106.6	2.7	25.3	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	19.3	0	6.6	0	16.7	0.81	0	0.91	0
	Notional	24.4	0	7.8	0	6.4	0.86	0	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	34.5	84.6	11.3	5.2	26.6	0.85	4.54	0.91	6.4
	Notional	31.7	89.6	10.2	6.6	9.6	0.86	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	0.15	0F00000B:Surf[5]
Floor	0.2	0.22	0F000006:Surf[0]
Roof	0.15	0.1	1F000003:Surf[0]
Windows, roof windows, and rooflights	1.5	1.51	0F00000B:Surf[1]
Personnel doors	1.5	2.2	0F00000F:Surf[2]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	3.44	0F00000B:Surf[2]
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	3



Appendix 2 Part L BRUKL Report Be Green

Project name

Reading Palmer Park Sport Centre - Be Green

As designed

Date: Tue Nov 24 11:12:02 2020

Administrative information

Building Details

Address: Palmer Park Sports Sport Centre, Reading, RG6 1LF

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Nikolas Sotnyk

Telephone number: 01274 687755

Address: 257 Cutler Heights Lane, Bradford, BD4 9JG

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	135.9
Target CO ₂ emission rate (TER), kgCO ₂ /m ² .annum	135.9
Building CO ₂ emission rate (BER), kgCO ₂ /m ² .annum	93
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	0.15	0.15	0F00000B:Surf[5]
Floor	0.25	0.22	0.22	0F000006:Surf[0]
Roof	0.25	0.1	0.1	1F000003:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.51	1.51	0F00000B:Surf[1]
Personnel doors	2.2	2.2	2.2	0F00000F:Surf[2]
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	3.44	3.44	0F00000B:Surf[2]
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	3

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- Htg - LPHW Rads Extract Vent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	-	0.2	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
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

2- Htg - Split DX Cassette HR 80%

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	4.2	3.85	0	0	0.8
Standard value	2.5*	2.6	N/A	N/A	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* 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- AHU Pool Heating 80% HR 1.5 SFP

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	-	0.2	1.5	0.8
Standard value	0.91	N/A	N/A	1.5^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

4- AHU LTHW 80% HR 1.5 SFP

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.96	-	0.2	1.5	0.8
Standard value	0.91	N/A	N/A	1.5^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

1- Qton 100% 4.4

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	4.4	0.002
Standard value	2*	N/A
* Standard shown is for all types except absorption and gas engine heat pumps.		

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	
0F Office Cash	-	-	-	0.9	-	-	-	-	-	-	N/A	
0F Concierge Reception	-	-	-	1.5	-	-	-	-	-	-	N/A	
0F Office First Aid	-	-	-	0.9	-	-	-	-	-	-	N/A	
0F Viewing Soft Play	-	-	-	1.5	-	-	-	-	-	-	N/A	
0F Circulation Lift Lobby	-	-	-	1.5	-	-	-	-	-	-	N/A	
1F Fitness Suite	-	-	-	1.5	-	-	-	-	-	-	N/A	
0F Soft Play	-	-	-	1.5	-	-	-	-	-	-	N/A	
1F Office Party/Meeting	-	-	-	0.9	-	-	-	-	-	-	N/A	
0F Cafe	-	-	-	1.5	-	-	-	-	-	-	N/A	
1F Viewing Athletics	-	-	-	1.5	-	-	-	-	-	-	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	
0F Toilet WC		-	301	-	19
0F Kitchen		-	163	-	382
0F Toilet WC Acc		-	301	-	25
0F Office Cash		178	-	-	55
0F Concierge Reception		-	161	50	26
0F Circulation Servery		-	114	-	33
0F Circulation Lobby		-	291	-	20
0F Pool Hall		-	99	-	4766
0F Change Village		-	102	-	816
0F Store Pool		96	-	-	27
0F Plant		69	-	-	407
0F Office First Aid		120	-	-	109
0F Circulation Esc Stairs		-	161	-	52
0F Store Chem		181	-	-	5
0F Store Chem		181	-	-	5
0F Viewing Soft Play		-	118	-	140
0F Circulation Lift Lobby		-	113	-	286
1F Change Female		-	117	-	203
1F Toilet UA		-	271	-	40
1F Fitness Suite		-	100	-	2495
1F Circulation Stairs		-	143	-	85
0F Soft Play		-	121	-	1539
1F Change Male		-	114	-	203
1F Office Party/Meeting		76	-	-	455
0F Cafe		-	128	-	629
1F Viewing Athletics		-	104	-	118
1F Circulation		-	112	-	321
1F Plant		63	-	-	792

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?
0F Office Cash	N/A	N/A
0F Concierge Reception	NO (-38.5%)	NO
0F Pool Hall	NO (-15.8%)	NO
0F Office First Aid	N/A	N/A
0F Viewing Soft Play	YES (+27.1%)	NO
0F Circulation Lift Lobby	NO (-32.5%)	NO
1F Fitness Suite	NO (-22.3%)	NO
0F Soft Play	YES (+72.5%)	NO
1F Office Party/Meeting	N/A	N/A
0F Cafe	YES (+46.4%)	NO
1F Viewing Athletics	NO (-34.1%)	NO

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

	Actual	Notional
Area [m ²]	2528.7	2528.7
External area [m ²]	4354.9	4354.9
Weather	SWI	SWI
Infiltration [m ³ /hm ² @ 50Pa]	3	4
Average conductance [W/K]	1323.67	1400.89
Average U-value [W/m ² K]	0.3	0.32
Alpha value* [%]	10	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area Building Type

A1/A2 Retail/Financial and Professional services
A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
B1 Offices and Workshop businesses
B2 to B7 General Industrial and Special Industrial Groups
B8 Storage or Distribution
C1 Hotels
C2 Residential Institutions: Hospitals and Care Homes
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
100 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	15.48	22.94
Cooling	2.33	3.22
Auxiliary	18.48	11.17
Lighting	16.94	17.12
Hot water	141.68	226.43
Equipment*	69.2	69.2
TOTAL **	194.92	280.88

* Energy used by equipment does not count towards the total for consumption or 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	2.82	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]	104.52	124.37
Primary energy* [kWh/m ²]	557.79	802.73
Total emissions [kg/m ²]	93	135.9

* 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] Central heating using air distribution, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	12.4	0	3.6	0	11.1	0.95	0	0.96	0	
Notional	20.6	0	6.6	0	10.4	0.86	0	----	----	
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	21	0	6.8	0	13.1	0.86	0	0.96	0	
Notional	27.8	0	9	0	5.1	0.86	0	----	----	
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
Actual	34.5	91.2	2.3	5.3	25.3	4.12	4.78	4.2	6.4	
Notional	31.8	99.8	3.5	7.3	9.6	2.56	3.79	----	----	
[ST] Central heating using air distribution, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
Actual	225	0	66.1	0	18.2	0.95	0	0.96	0	
Notional	300.9	0	97	0	21.8	0.86	0	----	----	
[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	0.15	0F00000B:Surf[5]
Floor	0.2	0.22	0F000006:Surf[0]
Roof	0.15	0.1	1F000003:Surf[0]
Windows, roof windows, and rooflights	1.5	1.51	0F00000B:Surf[1]
Personnel doors	1.5	2.2	0F00000F:Surf[2]
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	3.44	0F00000B:Surf[2]
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	3



Appendix 3 Carbon Reduction with Current Carbon Factors

Non-domestic

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO ₂ per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	437.5	90.8
After energy demand reduction (be lean)	415.2	90.8
After heat network connection (be clean)	415.2	90.8
After renewable energy (be green)	241.0	90.8

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO ₂ per annum)	(%)
Be lean: savings from energy demand reduction	22.2	5%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	174.2	40%
Total Cumulative Savings	196.4	45%
Annual savings from off-set payment	241.0	-
	(Tonnes CO ₂)	
Cumulative savings for off-set payment	7,231	-
Cash in-lieu contribution (£)	686,945	

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-domestic buildings

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO ₂ per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	401.0	90.8
After energy demand reduction (be lean)	371.3	90.8
After heat network connection (be clean)	371.3	90.8
After renewable energy (be green)	112.3	90.8

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	Regulated non-domestic carbon dioxide savings	
	(Tonnes CO ₂ per annum)	(%)
Be lean: savings from energy demand reduction	29.7	7%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	259.0	65%
Total Cumulative Savings	288.7	72%
Annual savings from off-set payment	112.3	-
	(Tonnes CO ₂)	
Cumulative savings for off-set payment	3,370	-
Cash in-lieu contribution (£)*	320,178	