OxSRFI
OXFORDSHIRE
STRATEGIC RAIL FREIGHT INTERCHANGE

Environmental Statement

Chapter 15: Climate Change
Appendix 15.4: Energy Strategy

Document 6.15D

On behalf of
Oxfordshire Railfreight Limited

Prepared by RPS Ltd.
March 2026

Oxfordshire Strategic Rail Freight Interchange

Environmental Statement: Appendix 15.4 – Energy Strategy

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Executive summary

This Energy Strategy has been prepared as part of the application for Development Consent Order (DCO) for the proposed Oxfordshire Strategic Rail Freight Interchange (hereafter 'Proposed Development'). The Proposed Development would provide up to 603,850 m^2 of distribution warehousing including ancillary office accommodation with an allowance for additional mezzanine floor space (up to 201,283 m^2), in addition of up to 2,500 m^2 of floorspace associated with the Strategic Rail Freight Interchange (SRFI) terminal itself.

The site layout is not fixed at this stage, but the Illustrative Masterplan (Document No. 2.6) indicates a potential layout consisting of 12 distribution warehouse units which have been used to form the basis of the calculation of energy consumption.

The results of the indicative calculations should not be used for any other purpose other than those for which they are intended (namely as a basis for this Energy Strategy). Formal assessments will be required at a later stage of the development.

This report establishes how the Proposed Development will achieve (or exceed) compliance with current Building Regulations, Local Authority requirements and BREEAM requirements, including the Cherwell District Council Energy Hierarchy. In accordance with the building regulations methodology all carbon and energy calculations within this report are calculated in accordance with the National Calculation Methodology (NCM) and are based on regulated consumption only.

Reducing carbon dioxide emissions through lean measures

To maximise the energy efficiency of the Proposed Development, and thus reduce the energy demands, the following design principles and features have been incorporated:

- Building fabric elements and glazing specifications exceeding the Approved Document L volume 2 (ADL2) 2021 Building Regulation requirements.
- Reduced air permeability compared to maximum required standards within Approved Document L 2021.
- Specification of efficient heating services and control systems.
- Energy efficient lighting throughout the development.

It was identified through the modelling undertaken, that a 19.3 tonne (3%) reduction in regulated CO_2 emissions would be achieved over the baseline emissions via the implementation of proposed aspects of energy efficient design.

Reducing carbon dioxide emissions through clean measures

The inclusion of a site wide heating system was investigated. Potential options at the site included either connection to an area wide heat distribution network or a site wide heat network. It was considered that the installation of either of these options was not practical. Further information is provided in Section 3.

Reducing carbon dioxide emissions through green measures

A low or zero carbon (LZC) technology feasibility study was completed as part of this Energy Strategy which compared the feasibility of different technologies based on the energy demand of the development. Based on this, it was identified that the most appropriate technology to meet its sustainability and energy targets is the installation of Photovoltaic Panels and localised Air Source Heat Pumps. This approach will comply with the energy requirements to achieve the targeted BREEAM rating and emission savings for the site. It is proposed to install 25,870 m^2 of PV panels for a total peak of 5,774 kWp. The final area of PV will vary depending on the efficiency and manufacturer of PV panel chosen.

Based on the robust approach to the energy hierarchy, the Proposed Development has exceeded the required sustainability and energy targets including Building Regulations (ADL2 2021) and the policies outlined within Cherwell District Council's Local Plan. The proposed strategy achieves a site wide total reduction of the regulated carbon dioxide emissions of 105% over Building Regulations (ADL2) 2021. Moreover, the Proposed Development achieves a total reduction of 102% of its regulated emissions using renewables on site. Further information can be found in section 3.5.

An emission saving of greater than 100% suggests that the Proposed Development would be exporting surplus energy back to the national grid. However, it should be noted that this is for regulated carbon emissions only as per the approved document L methodology used to inform the writing of this Energy Strategy. In reality any excess energy would be used to help power the buildings' un-regulated energy.

Battery Energy Storage Systems (BESS) are proposed at the Proposed Development, totalling a capacity of circa 3 MW site-wide; however, they do not change or influence the energy demand of the building, they simply enable the use of renewable energy where this may otherwise be curtailed. In addition, the approved modelling software used to calculate the predicted CO_2 emissions from the development are not able to account for the installation of a BESS. Therefore, whilst a BESS system is to be included within the Proposed Development it is not considered further within this report.

Results

Table 1 illustrates the reductions in CO_2 emissions for the proposed non-domestic buildings including both regulated and unregulated emissions. Regulated emissions alone are covered by Part L; and include emissions associated with fixed components of the building (i.e. fixed lighting, ventilation, space heating and water heating). Unregulated emissions are not covered by Part L and include emissions associated with plug-in appliances (i.e. catering and computing within the building).

Table 1: 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 2021 of the Building Regulations Compliant Development	582.5	2,671.5
Be lean: After energy demand reduction	563.2	2,671.5
Be clean: After heat network	563.2	2,671.5
Be green: After renewable energy	-31.3	2,671.5

In Table 2 the carbon dioxide savings after each step of the energy hierarchy are presented. The savings in absolute values are calculated, for each tier, from the previous stage of the energy hierarchy. However, all savings in percentages (%) are reported against the baseline carbon emissions in order to evaluate the percentage saving against the baseline.

Table 2: Regulated carbon dioxide savings from each stage of the Energy Hierarchy for non-domestic buildings

	(Tonnes CO_2 per annum)	Savings from the baseline (%)
Be lean: Savings from energy demand reduction	19.3	3%
Be clean: Savings from heat network	-	-
Be green: Savings from renewable energy	594.5	102%
Cumulative on-site savings	**613.8**	**105%**

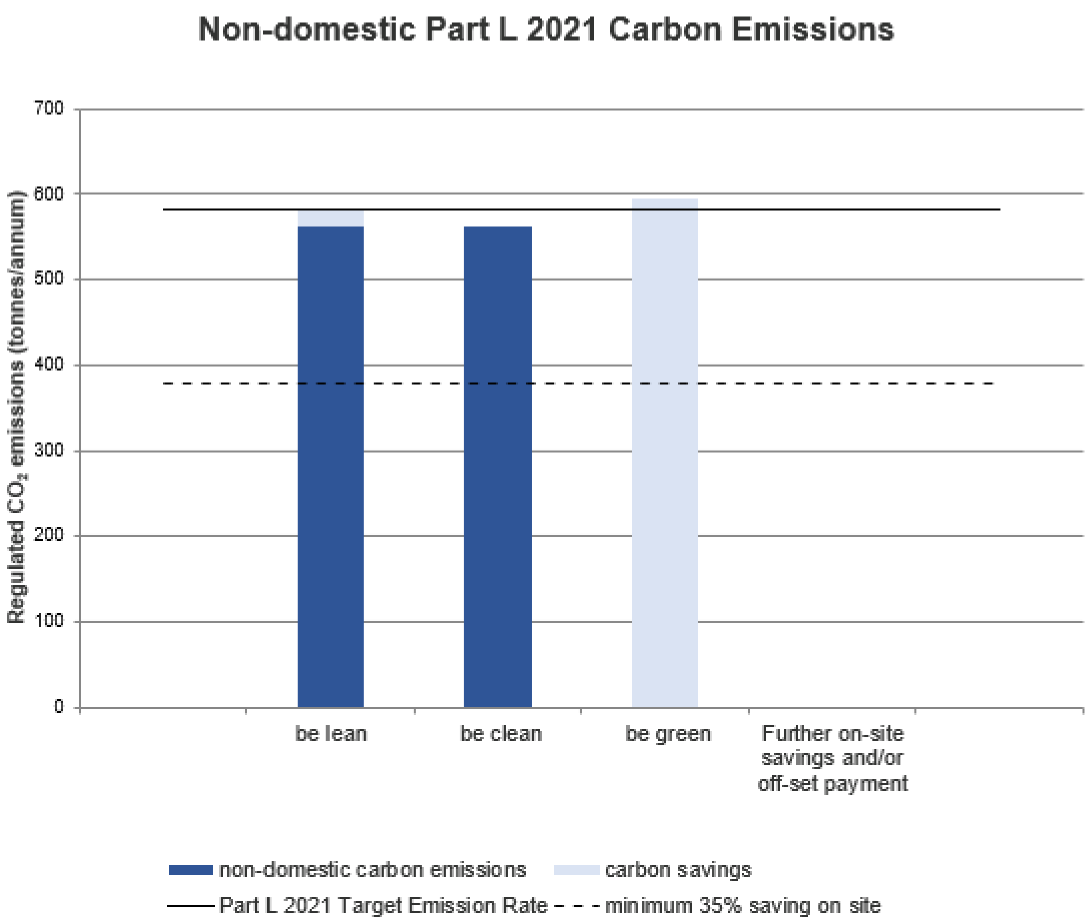

Figure 1: Step reduction in regulated CO_2 emissions for non-domestic buildings

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1 Introduction

1.1.1 RPS Consulting Services Ltd (RPS) was commissioned by Oxfordshire Railfreight Ltd (ORL, 'the Applicant') to undertake an Energy Strategy for the Oxfordshire Strategic Rail Freight Interchange scheme (hereafter the 'Proposed Development') known as Oxfordshire Strategic Rail Freight Interchange (OxSRFI). The Proposed Development comprises a rail terminal and associated infrastructure, warehousing and buildings, and highway works. This report focuses on the proposed buildings and will form part of the submission to the Planning Inspectorate for a Development Consent Order (DCO).

1.1.2 This report outlines the scheme and current planning context and assesses likely energy demands of the Proposed Development prior to consideration of low and zero carbon technology options. The report concludes with the proposed energy strategy.

1.1.3 This Energy Strategy comprises:

- A scheme overview.
- A review of the planning context.
- A review of any applicable legislation or sustainability targets
- An energy assessment of the project, following the energy hierarchy.
- A presentation of results and recommendations.

1.2 Scheme Overview

1.2.1 The proposed development consists of the construction of warehouse buildings with a maximum footprint of 603,850 m^2 with an allowance for the provision of additional mezzanine floor space (up to 201,283 m^2), and the inclusion of up to 2,500 m^2 of office space associated with the operation of the rail freight terminal.

1.2.2 It should be noted that the number of buildings across the Proposed Development may change in number, however the total maximum floorspace footprint is fixed. As such, the assessment of operational energy consumption accounts for the maximum proposed areas developed, presenting a conservative (worst-case) assessment. Due to the absence of a detailed layout (and associated building designs or drawings) at this stage of the process, the energy analysis to estimate the energy consumption and carbon dioxide emissions of the Proposed Development is undertaken by using prior modelled building typologies

1.3 Purpose of the Energy Assessment

1.3.1 A summary of the policy requirements relevant to energy consumption within the development are provided in Section 2 of the report. This Energy Strategy has been written in accordance with the requirements of relevant planning policies.

1.3.2 Under policy "ESD3: Sustainable Construction", the Proposed Development is required to achieve a BREEAM Very Good. This report assesses the potential for the development to meet BREEAM requirements in relation to energy (ENE01) only; other credits required to achieve the required Very Good rating under BREEAM are not considered within this report. The Proposed Development is targeting a minimum of BREEAM Excellent, with aspirations to achieve Outstanding as part of ORL's base build shell and core specification (see Chapter 2 of the Environmental Statement (ES), and Design Approach Document). A BREEAM pre-assessment has been completed to identify the credits required to achieve this.

1.3.3 It should be noted that while the building fabric plays a role in the achievement of the relevant BREEAM credits (Ene 01), they are not the only factor and there is no specific requirement or threshold outlined within credit ENE01 for the building fabric to meet.

1.3.4 The method preferred by Cherwell District Council towards the site wide Energy Strategy is the adoption of a hierarchical approach which ensures that the energy requirements and associated emissions are reduced as far as possible before applying renewable energy options. Sections 3 and 4 of this report detail the steps taken to follow the energy hierarchy. Section 4 details how the different measures implemented have followed best practice principles to mitigate overheating. A summary of findings and a suggested approach for the development is presented in Section 5.

2 Summary of Regulations and Policies

2.1.1 The relevant authority for this site is Cherwell District Council. The requirements of this Council and other relevant planning authorities have been taken into account within this Energy Strategy. The key policy framework applicable to the energy aspects of the development is set out in some detail in the main ES Chapter, but key elements are also outlined below.

2.2 National Level Policies

National Networks NPS (NNNPS)

2.2.1 The NNNPS states that the '*Secretary of State must be satisfied that the Applicant has as far as possible assessed carbon emissions at all stages of the development*'.

2.2.2 It is noted in the NNNPS that operational carbon emissions from some types of national network infrastructure cannot be totally avoided. Given the range of non-planning policies aimed at decarbonising the transport system, government has determined that a net increase in operational carbon emissions is not, of itself, reason to prohibit the consenting of national network projects or to impose more restrictions on them in the planning policy framework. However, all steps should be taken to avoid, and where unavoidable, reduce and mitigate emissions.

2.2.3 The NNNPS also emphasises in more general terms the importance of mitigating for climate change, and minimising effects of the Proposed Development on climate change, and aligns with the overall thrust of national planning policies (e.g. in the NPPF) regarding the importance of delivering 'sustainable development' which inherently includes a focus on design and energy efficiency in construction and operation.

Building Regulations Part L

2.2.4 Building Regulations are statutory instruments that seek to ensure that the policies set out within any relevant UK legislation are carried out. Building Regulations approval is required for the majority of building work carried out in the United Kingdom.

2.2.5 Part L of these regulations covers the requirements with respect to the conservation of fuel and power in all building types. It controls the insulation values of building fabric elements and openings, the air permeability of the structure, the heating efficiency of heating, ventilation and air conditioning systems together with hot water storage and lighting efficiency. It also sets out the requirements for calculating the carbon dioxide emissions and the Carbon Emission Targets for each building type.

2.2.6 Part L 2021 is split into two sections:

- Volume 1: Dwellings
- Volume 2: Buildings other than Dwellings.

2.2.7 The Proposed Development must comply with Part L Volume 2.

2.3 Local Policy

Cherwell Local Plan 2011-2031 (Cherwell District Council, 2015)

2.3.1 Policy ESD 1: Mitigating and Adapting to Climate Change

'Measures will be taken to mitigate the impact of development within the District on climate change. At a strategic level, this will include:

- *Distributing growth to the most sustainable locations as defined in this Local Plan*
- *Delivering development that seeks to reduce the need to travel and which encourages sustainable travel options including walking, cycling and public transport to reduce dependence on private cars*
- *Designing developments to reduce carbon emissions and use resources more efficiently, including water (see Policy ESD3 Sustainable Construction)*
- *Promoting the use of decentralised and renewable or low carbon energy where appropriate (see Policies ESD4 Decentralised Energy Systems and ESD5 Renewable Energy).*

The incorporation of suitable adaptation measures in new development to ensure that development is more resilient to climate change impacts will include consideration of the following:

- *Taking into account the known physical and environmental constraints when identifying locations for development*
- *Demonstration of design approaches that are resilient to climate change impacts including the use of passive solar design for heating and cooling*
- *Minimising the risk of flooding and making use of sustainable drainage methods, and*
- *Reducing the effects of development on the microclimate (through the provision of green infrastructure including open space and water, planting, and green roofs).*

Adaptation through design approaches will be considered in more locally specific detail in the Sustainable Buildings in Cherwell Supplementary Planning Document (SPD)'.

2.3.2 Policy ESD 2: Energy Hierarchy and Allowable Solutions

'In seeking to achieve carbon emissions reductions, we will promote an' energy hierarchy 'as follows:

- *Reducing energy use, in particular by the use of sustainable design and construction measures*
- *Supplying energy efficiently and giving priority to decentralised energy supply*
- *Making use of renewable energy*
- *Making use of allowable solutions'.*

2.3.3 Policy ESD 3: Sustainable Construction, requiring a least BREEAM *'Very Good'* at all non-residential development, and large sites to contribute to carbon reductions.

2.3.4 Policy ESD 4: Decentralised Energy Systems, which encourages use of decentralised systems where feasible.

2.3.5 Policy ESD 5: Renewable Energy

'The Council supports renewable and low carbon energy provision wherever any adverse impacts can be addressed satisfactorily. The potential local environmental, economic and community benefits of renewable energy schemes will be a material consideration in determining planning applications.

A feasibility assessment of the potential for significant on-site renewable energy provision (above any provision required to meet national building standards) will be required for:

- *All residential developments for 100 dwellings or more*
- *All residential developments in off-gas areas for 50 dwellings or more*

- *All applications for non-domestic developments above 1,000 m^2 floorspace.*

Where feasibility assessments demonstrate that on site renewable energy provision is deliverable and viable, this will be required as part of the development unless an alternative solution would deliver the same or increased benefit. This may include consideration of allowable solutions' as Government Policy evolves'.

2.4 Policy Summary

2.4.1 In conclusion, compliance with a number of national, and local policy standards is required for the proposed non-domestic buildings which comprise part of the OxSRFI scheme. These are presented in Table 3 below.

Table 3: Summary of applicable policies

Policy Level	Standard	Buildings
National Policies	National Network NPS	All buildings
	National Planning Policy Framework	All buildings
	Building Regulations Part L Volume 2	All buildings
Local Policies	Policy ESD 1: Mitigating and Adapting to Climate Change	All buildings
	Policy ESD 2: Energy Hierarchy and Allowable Solutions	All buildings
	Policy ESD 3: Sustainable Construction	All buildings
	Policy ESD 4: Decentralised Energy Systems	All buildings
	Policy ESD 5: Renewable Energy	All buildings

3 Energy Modelling – New Buildings

3.1.1 The National Calculation Method (NCM) for the Energy Performance of Buildings Directive (EPBD) is defined by the Department for Communities and Local Government (DCLG) and it is the procedure for demonstrating compliance with the Building Regulations for buildings other than dwellings. Depending on the complexity of the assessment, either the Simplified Building Energy Model (SBEM) or Dynamic Simulation Methodology (DSM) can be used. Both of these tools are government approved. The primary difference between SBEM and DSM is not the level of information needed on the building, but the level of detail the calculation performs at creating a more realistic prediction of energy use. A SBEM assessment is a simplified, steady state heat loss calculation (i.e. room temperature doesn't change with time), while a DSM is a detailed, dynamic, time-step calculation (picks up on temperature changes over time e.g. due to sun location).

3.1.2 In order to identify the carbon dioxide emissions for this project, a DSM assessment was carried out using a model building representative of the Proposed Development. The energy demand calculated using the NCM methodology is relative to the regulated emissions, which include the energy consumed to power space heating, domestic hot water, cooling, ventilation and internal lighting systems. The unregulated emissions (i.e. catering and computing) are calculated using benchmark figures detailed in technical publications such as CIBSE guide A. It should be noted that unregulated consumption is dependent on tenant activities within the buildings, and at this stage has been calculated without knowledge of occupier activities. As such, it should be noted that true energy consumption (and resultant emissions) will vary depending on how the end user utilises the building. The values presented are for use to inform the assessment of climate change only.

3.1.3 For the purposes of this energy calculation, the Proposed Development consists of 12 warehouses totalling 603,850 m^2 footprint with an additional allowance of 201,283 m^2 for mezzanine spaces as well as up to 2,500 m^2 of office space in the rail terminal. As no detailed drawings are available at this stage, an archetype model type has been used with the same use type (Class B8) and the energy consumption results have been informed by this model, scaled for the Proposed Development's maximum floor area.

3.1.4 The example model warehouse used has a planning use of *B8: Warehouse/Storage* and consists of a large unheated warehouse/storage area with a floor area of 93,539 m^2, and 7,594 m^2 of office space and supporting zones such as WCs and changing rooms. The rail terminal building example model has 1,570 m^2 total floor area, with 1,316 m^2 of direct office space with the remaining area utilised by supporting space such as kitchenette, WCs and changing facilities. The performance metrics for both buildings are outlined within the energy hierarchy starting from Section 3.3 of this report.

Table 4: Non-domestic units assessed

Units	Floor Area (m^2)	Planning Use
Archetype Warehouse Model	101,133	B8: Warehouse/storage
Archetype Office Model	1,570	B1: Office

3.1.5 The results of the indicative calculations should not be used for any other purpose other than those for which they are intended (namely as a basis for this Energy Strategy). Formal assessments will be required at a later stage of the development process to satisfy Building Control requirements.

3.1.6 The proposed Energy Strategy approach is based on a recognised structure of reduction in carbon dioxide emissions through:

1. Reducing the energy use (Be Lean) by optimising the design and construction of the building to ensure less energy is required.
2. Supplying energy efficiently and giving priority to decentralised energy supply (Be Clean).
3. Making Use of Renewable Energy (Be Green).
4. Making Use of Allowable Solutions

3.1.7 On the whole, it becomes more expensive to implement both carbon reduction and sustainability measures the further along the design process, as the opportunities available diminish (as displayed within Figure 2. This highlights the importance of early consideration of these measures within the design process.

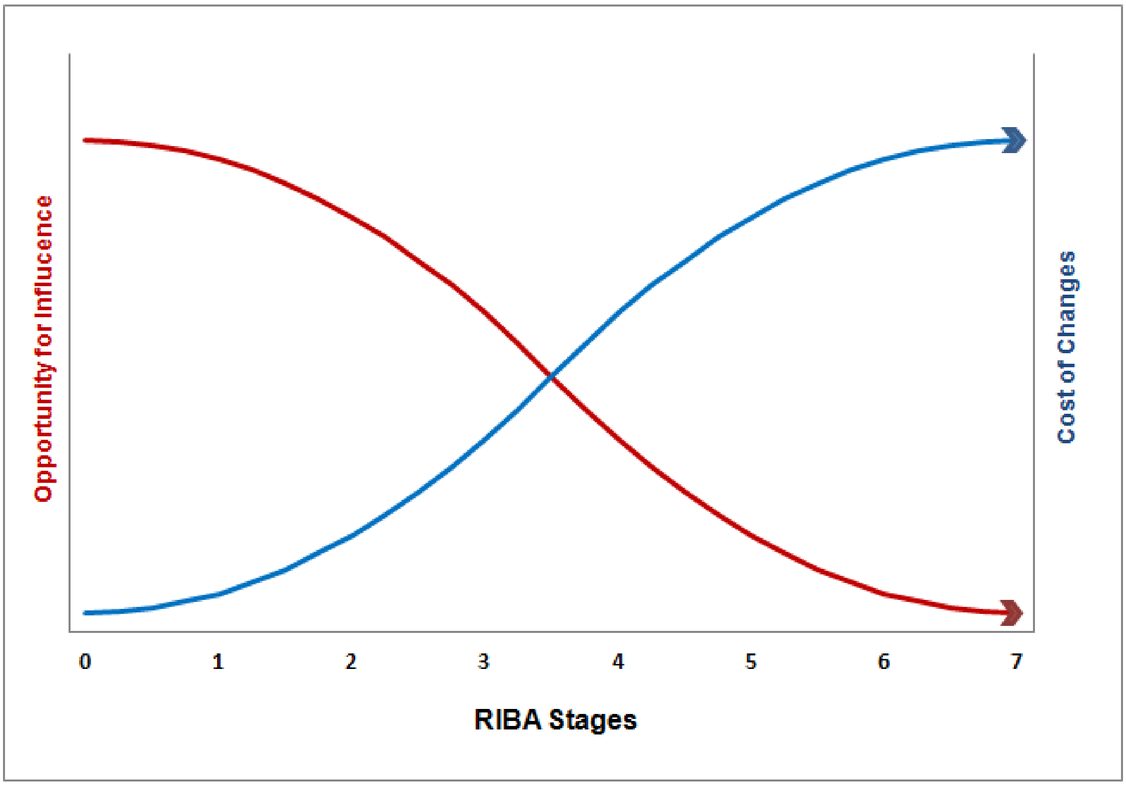

Figure 2: Opportunities to reduce CO_2 emissions and associated cost during the construction phases

3.1.8 A passive, well insulated envelope will last for the life of the building; with this being difficult to upgrade once building work is complete. The services installed within the building have a shorter life span and can be replaced or upgraded at a later date, when their lifetime will have expired and new more efficient services will be available. Once the building envelope and services are established, the installation of Low and Zero Carbon technologies should be considered.

3.1.9 The design for the Proposed Development will attain a final carbon emission rating that goes beyond the one required to comply with Part L 2021 of the Building Regulations; in line with the requirements of the Energy Hierarchy which Cherwell District Council follows for all new developments.

3.2 Baseline scenario

3.2.1 In order to establish the baseline carbon dioxide emissions for the Proposed Development, the government-approved software IESVE 2024 was used to model the buildings.

3.2.2 The baseline scenario assumes the minimum values required to meet Building Regulation 2021 Volume 2. When determining this baseline, the warehouse spaces are considered unconditioned and for the conditioned spaces it is assumed that the heating would be provided by air source heat pumps with a generator efficiency of 2.64 and that any active cooling would be provided by electrically powered equipment.

3.2.3 The modelling undertaken identified the total CO_2 emissions across the site as 3,253.95 $tnCO_2/yr$. This is broken down to 582.5 $tnCO_2/yr$ from regulated emissions (covered by Building Regulations) and 2,671.5 $tnCO_2/yr$ from unregulated emissions (plug-in appliances such a computers and printers or in this example potential machinery installed in the warehouses). A breakdown of the of the energy consumption by end use is presented in Table 5. The total baseline CO_2 emissions for the development are illustrated in Table 6.

Table 5: Baseline Energy Consumption Intensity per energy use for non-domestic buildings

End Use	Warehouse Total Energy Consumption (kWh/m^2)	Office Total Energy Consumption (kWh/m^2)
Heating	0.44	10.19
Cooling	0.27	2.41
Auxiliary	0.54	3.2
Lighting	3.47	6.32
Hot Water	1.67	19.93
Total (regulated)	**6.38**	**42.06**
Unregulated	30.69	37.69
Total	**37.07**	**79.75**

Table 6: Site wide regulated and un-regulated carbon dioxide emissions and savings

	Total regulated emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage saving (%)	Unregulated emissions (Tonnes CO_2/year)
Part L 2021 baseline	582.5	-	-	2,671.5

3.3 Reducing Energy Use (Be Lean)

3.3.1 Energy demand reduction within the building can be utilised to improve compliance with Part L Volume 2 2021. This development has been reviewed to maximise both passive and active design measures to reduce the energy demand within the building.

3.3.2 The site location and weather have been accounted for in the energy modelling by the use of the Swindon Test Reference Year (TRY) local weather file, in accordance to Part L Building Regulations. The site is not deemed to be located in an area with characteristics of a microclimate that would deviate from the local weather file.

3.3.3 The final design is not available, however in order to maximise solar gains in the winter to reduce heating and lighting load requirements occupied spaces (i.e. offices) should where feasible face east, south or west. Internal shading devices are anticipated to be installed by incoming tenants to mitigate any excessive summer solar gains. The simple building form has been designed, by the design team, to be cost effective and provide a beneficial ratio of surface area to volume, which also minimises heat loss in the heated areas.

3.3.4 The future occupants have been considered during the Energy Strategy by the use of appropriate NCM templates, in accordance with Part L Volume 2 Building Regulations.

Building Fabric

3.3.5 To reduce the CO_2 emissions of the development, it is important to minimise the heat losses through the building fabric. In order to achieve this, U-values for all building fabric elements and openings have been specified to exceed the levels required by Building Regulations. In addition, heat losses from infiltration have been minimised and a low air permeability target has been set. The details of these measures are summarised in the Table 7 below.

Table 7: Passive design energy saving measures

Element	Proposed values	Maximum values under Part L Volumes 2 2021
Roof	0.16 W/m^{2}K	0.16 W/m^{2}K
External wall	0.18 W/m^{2}K	0.26 W/m^{2}K
Ground floor	0.18 W/m^{2}K	0.18 W/m^{2}K
Windows	1.40 W/m^{2}K	1.60 W/m^{2}K
Rooflights	1.30 W/m^{2}K	2.20 W/m^{2}K
Doors	1.50 W/m^{2}K	1.60 W/m^{2}K
Vehicle Access Doors	1.30 W/m^{2}K	1.60 W/m^{2}K
Air permeability	2.0 m^3/hm^2@50Pa	8 m^3/hm^2@50Pa

3.3.6 The proposals would incorporate natural daylight into the building design to maximise the use of natural daylight and reduce reliance on artificial lighting. Roof lights have been proposed for the warehouse areas to, again, maximise the use of natural lighting and reduce reliance on artificial lighting.

3.3.7 The standard of specification for the building fabric has been used to provide passive energy saving solutions that exceed the Building Regulation requirements. The thermal mass that the lightweight building frame provides is considered appropriate to the building use, due to the majority of the internal area being untreated.

Building Services

3.3.8 In addition to upgrading the insulation standards, it is important that the energy used within the building is used efficiently. Therefore, the building systems will be designed to optimise the efficiency of the systems by matching installed capacity to anticipated building demand. Items of equipment, which make up the building's mechanical building services installation, will be specified to achieve an operation profile and will be serviced to maintain their performance. Please note that all systems have efficiencies and controls which will meet or exceed the requirements of Part L:2021.

3.3.9 The 'Be Lean' case should assume that the conditioned spaces will have heat provided by ASHPs (with an efficiency of 264%) and that any active cooling would be provided by electrically powered equipment. The warehouses are being treated as unconditioned.

3.3.10 Domestic hot water for the entire building will be generated via Air Source Heat Pumps heating water in a hot water storage system, there will be a secondary direct electric system to top up when demand requires. The ASHP heating the hot water will have an efficiency of 286%.

3.3.11 Due to the proposed activities in the office spaces, comfort cooling will be used. In order to minimise the carbon dioxide emissions from cooling, energy efficient VRF system with a Seasonal Energy Efficiency Ratio (SEER) of 5.6 is proposed.

3.3.12 The air quality within a building is significantly influenced by the ventilation system specified. The office areas shall be served by high efficiency heat recovery units (Lossnay or similar approved) having a minimum efficiency of 73% and minimum SPF of 1.6W/l/s. CO_2 levels within the office areas, they shall be monitored and controlled via wall mounted sensors, to ensure the optimum amount of fresh air is provided to suit the occupancy levels within the space. CO_2 sensors shall be provided that shall automatically slow the MVHR fans down to improve system efficiency. The wall mounted sensors shall contain illuminated indication giving guidance as to Good, Fair and Poor space conditions in respect to CO_2 levels. Filter grades are to be F7/M5.

3.3.13 Electrical lighting also represents a significant energy use within a building. To maximise energy savings the installation of low energy lighting (T5, LED etc) across the development has been specified.

3.3.14 From the modelling undertaken, the total site wide carbon dioxide emissions, after the inclusion of improved building fabric and systems (i.e. lean measures) are estimated as 582.5 $tnCO_2$/yr from regulated emissions and 2,671.5 $tnCO_2$/yr from unregulated emissions. This is a reduction of 19.3 $tnCO_2$/yr compared to the baseline scenario, which equates to an overall saving of 3% over the regulated emissions (Table 10).

Table 8: Energy Consumption after heat energy demand reduction for warehouse buildings

Energy Consumption by End Use (kWh/m^2)		
	Baseline	**Be Lean**
Heating	0.44	0.5
Cooling	0.27	0.37
Auxiliary	0.54	0.56
Lighting	3.47	2.98
Hot Water	1.67	1.65
Total (regulated)	**6.38**	**6.06**
Unregulated	30.69	30.69
Total	**37.07**	**36.75**

Table 9: Energy Consumption after heat energy demand reduction for office buildings

Energy Consumption by End Use (kWh/m^2)		
	Baseline	**Be Lean**
Heating	10.19	7.58
Cooling	2.41	2.76
Auxiliary	3.2	3.66
Lighting	6.32	7.66
Hot Water	19.93	19.39
Total (regulated)	**42.06**	**41.04**
Unregulated	37.69	37.69
Total	**79.75**	**78.73**

Table 10: Site wide regulated carbon dioxide emissions and savings

	Total regulated emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage saving (%)	Unregulated emissions (Tonnes CO_2/year)
Part L 2021 baseline	5,82.5	-	-	2,671.5
Be lean	563.2	19.3	3%	2,671.5

3.4 Supplying Energy Efficiently and giving priority to decentralised energy supply (Be Clean)

3.4.1 Connection to a decentralised energy network and the use of combined heat and power is a recognised method of generating energy more efficiently. The Cherwell Plan Policy ESD4: 'Decentralised Energy Systems" requires development proposals to explore the opportunities to link into existing or planned decentralised energy and informed by the renewable energy map from Appendix 5 to the Local Plan. Where an existing decentralised energy network is not present, an assessment of the feasibility of establishing a decentralised energy system for the proposed development should be undertaken, including an assessment of the feasibility of a communal heating system. The following hierarchy on selecting an energy system has been followed:

- Connect to local existing or planned heat network use zero-emission and/or local secondary heat sources (in conjunction with heat pumps, if required).
- Use zero-emission and/or local secondary heat sources (in conjunction with heat pumps, if required).
- Use low-emission combined heat and power (only where this is to enable the delivery of an area-wide heat network).

3.4.2 A feasibility assessment for DH/CHP, including consideration of biomass fuelled CHP, will be required for:

- All residential developments for 100 dwellings or more
- All residential developments in off-gas areas for 50 dwellings or more
- All applications for non-domestic developments above 1000 m^2 floorspace.

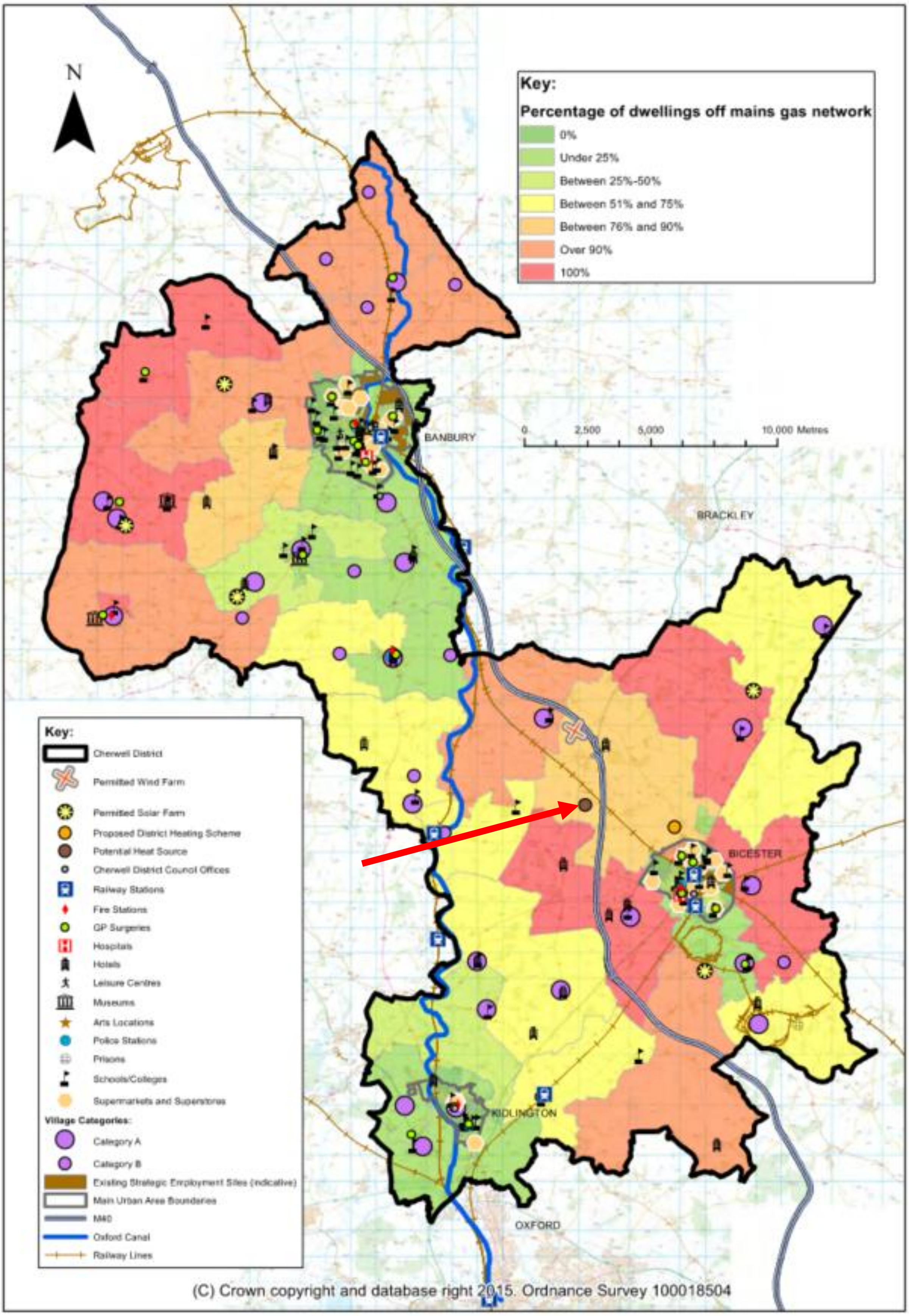

Figure 3: Renewable Energy Map from Appendix 5 of the Cherwell Local Plan.

Connect to local existing or planned heat network use zero-emission and/or local secondary heat sources

3.4.3 The renewable energy map from Appendix 5 of the Local Plan indicates that there is a potential heat source for decentralised energy at the approximate location of the Proposed Development. The source of decentralised energy is from the nearby Viridor Energy from Waste (waste incineration plant) east of the B4030. Following communication with the provider, it has been confirmed that the network is not suitable for connection.

3.4.4 The carbon emissions associated with the waste plant are circa 450 gCO_2e/kWh, this is approximately 2-3 times higher than the emissions associated with grid supplied electricity. There is currently no scope to reduce this as carbon capture technology is not currently suitable for installation, therefore this would actively increase the Proposed Development's emissions significantly.

3.4.5 Communication with the design team and Viridor with respect to the Waste Incineration plant has raised the following points regarding the network infrastructure and potential connection to the decentralised energy plant. The Distribution Network Operator (DNO) does not permit both the Strategic Rail Freight Interchange (SRFI) and Viridor Energy Recovery Facility (ERF) sites to be simultaneously connected behind the meter, as this "paralleling" limits their network control. Consequently, a "break before make" arrangement would be required, where the SRFI disconnects from the grid when supplied by the ERF and vice versa. This switching process introduces a risk of supply loss to the SRFI during transfers, such as steam turbine trips or ERF faults.

3.4.6 From an operational perspective, an Independent Distribution Network Operator (IDNO) setup is preferred by Scottish and Southern Electricity Networks (SSEN) due to its lower cost, risk, and standardised approach. However, this arrangement cannot support license-exempt electricity supply from the ERF to tenants. A Private Network would be necessary to enable such supply but comes with increased contractual complexity. One possible configuration is for Viridor's DNO connection to be active by default, with SRFI's connection disconnected and Viridor contracting directly with tenants. When faults or imports occur on the ERF connection, supply would revert to licensed grid suppliers via the SRFI connection under the "break before make" protocol. While feasible for planning, this arrangement is likely unattractive to tenants, SSEN, and suppliers due to its technical and commercial complexities and supply risks.

3.4.7 Under normal conditions in the Private Network setup, any excess generation from solar PV or ERF beyond SRFI demand would be exported. However, due to the lack of agreed export capacity and network constraints, this surplus would likely be curtailed, resulting in lost export revenue. Additionally, rooftop solar PV and ERF electricity generation could compete against each other, potentially undermining their respective business cases when operating simultaneously.

3.4.8 In summary, despite the presence of a nearby decentralised energy source from the Viridor Energy from Waste Plant, there are technical, operational, environmental, and commercial challenges which prevent its practical and beneficial connection to the Proposed Development . This has been discussed comprehensively and confirmed with Viridor, the operators of the waste incineration plant.

Use low-emission combined heat and power (CHP) (only where this is to enable the delivery of an area-wide heat network)

3.4.9 The use of CHP should be limited to low-emission CHP and only in instances where it can support the delivery of an area-wide heat network at large, strategic sites. Applicants proposing to use low-emission CHP will be asked to provide sufficient information to justify its use, ensure that the carbon and air quality impact is minimised, for example through the selection of a lower emission unit and use of abatement technology, and undertake emissions testing to demonstrate that the installed system meets emission limits prior to occupation.

3.4.10 The installation of a CHP unit for the development has also been considered, however its size does not justify a CHP that allows for the delivery of an area wide heat network as the system losses would be too large making the operation uneconomical and resource wasteful. Despite the scale of the development only a small area of each warehouse, the office zones, will be conditioned space, the rest will be unconditioned.

Table 11: Energy Consumption after district heating applied for warehouse buildings

Energy Consumption by End Use (kWh/m^2)			
	Baseline	**Be Lean**	**Be Clean**
Heating	0.44	0.5	0.5
Cooling	0.27	0.37	0.37
Auxiliary	0.54	0.56	0.56
Lighting	3.47	2.98	2.98
Hot Water	1.67	1.65	1.65
Total (regulated)	**6.38**	**6.06**	**6.06**
Unregulated	30.69	30.69	30.69
Total	**37.07**	**36.75**	**36.75**

Table 12: Energy Consumption after district heating applied for office buildings

Energy Consumption by End Use (kWh/m^2)			
	Baseline	**Be Lean**	**Be Clean**
Heating	10.19	7.58	7.58
Auxiliary	2.41	2.76	2.76
Lighting	3.2	3.66	3.66
Domestic Hot Water	6.32	7.66	7.66
Cooling	19.93	19.39	19.39
Total (regulated)	**42.06**	**41.04**	**41.04**
Unregulated	37.69	37.69	37.69
Total	**79.75**	**78.73**	**78.73**

Table 13: Site wide regulated carbon dioxide emissions and savings

	Total regulated emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage saving (%)	Unregulated emissions (Tonnes CO_2/year)
Part L 2021 baseline	582.5	-	-	2,671.5
Be lean	563.2	19.3	3%	2,671.5
Be clean	563.2	-	-	2,671.5

3.5 Making Use of Renewable Energy (Be Green)

3.5.1 This section discusses the feasibility of using low and zero carbon (LZC) technologies for the proposed scheme. Cherwell District Council aspires that all major non-residential developments achieve a BREEAM very good rating(the Proposed Development is targeting

'Excellent' as a minimum, under BREEAM V7). A BREEAM rating does not translate to a measurable carbon reduction target as it is based on a range of different sustainability measures across the development.

3.5.2 In order to address the planning requirement for make use of renewable energy on site, the installation of solar thermal panels, photovoltaics, wind turbines, biomass and heat pumps was investigated.

Table 14: Summary of LZC technologies

LZC Technology	CO_2 savings	Capital cost	Considerations
Photovoltaic panels	Medium	Medium	+ Allows on site generation of renewable electricity + Generally payback between 7-12 years + Low maintenance requirements - Efficiency effected by site factors – shading, orientation and roof/ground space - Local grid does not have capacity to allow export - Competition issues with Waste incineration plant
Solar thermal panels	Low	Medium	+ Government grants available (RHIs) + Can meet a significant proportion of the DHW demand - Efficiency effected by site factors shading, orientation and roof/ground space - Requires considerable hot water demand all year round to be financially beneficial
Air source heat pumps	Medium	Medium	+ Lower installation cost that ground source heat pump + Can provide heating and cooling + Government grants available (RHIs) - COP is lower during the heating season - Can restrict distribution strategies
Ground source heat pumps	Medium	High	+ More heat is supplied to the building than energy is consumed by the heat pump + COP is much better than air source heat pumps + Government grants available (RHIs) - Requires area for ground collector or borehole - High initial capital cost - Can restrict distribution strategies - Subject to soil conditions
Wind turbines	Low	High	+ Allows on site generation of renewable electricity - Can create structural, vibrations and noise implications - Not suited for urban environments - Electricity generation varies due to wind speed - Generally payback over 20 years
Biomass	High	High	+ Government grants available (RHIs) + Renewable source of heating - Requires large fuel storage capacity - Generally a large capital cost - Potential issue with air quality especially in urban areas

3.5.3 These technologies meet all requirements as defined by Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Full details for these technologies can be found in Appendix B.

3.5.4 After taking into consideration several different factors, including local authority requirements, land use, potential noise impacts and available space within the development, it was concluded that the best strategy for this development is the installation of photovoltaic panels and Air Source Heat Pumps (ASHP). For optimal performance the solar PV needs to be located on the roof of each warehouse building, to account for different building typologies and orientations of the buildings on site, the PV is simulated in a neutral horizontal pitch.

3.5.5 Photovoltaics (PV) panels are an established form of renewable technology which converts solar energy into electricity. The electricity is fed into an inverter which converts it from a direct current supply to an alternating current supply, which can then be used to supply the demands within the development.

3.5.6 The buildings are being designed to structurally allow for 100% of their available roof area to be filled with solar PV, however at the time of undertaking this Energy Strategy analysis it is not yet known how much capacity (if any) the local Distribution Network Operator (DNO) would allow the development to export electricity back to the grid. However, it is known there are restrictions on the ability of the grid to accept significant export of renewable energy. Currently the solar PV array is sized to achieve a 100% emission reduction for regulated emissions. To achieve this the roof area needed for the development approximates to an installed PV array of 25,870 m^2, depending on the efficiency of the solar PV installed this is an estimated 5,774 kWp of PV.

3.5.7 Air source heat pumps (ASHP) are a well-established renewable technology that extracts heat from the outside air and transfers it into a building for heating and cooling purposes. The system operates by using a refrigerant that absorbs heat from the ambient air, even at low temperatures, and then compresses it to increase the temperature before distributing it through the building's heating system. This efficient process allows ASHPs to provide a sustainable source of heating and cooling, significantly reducing reliance on fossil fuels and lowering energy costs for the building industry.

3.5.8 Upon consideration of the LZC technology, the modelling identified that a further reduction of 594.5 $tnCO_2$/yr has been achieved for the regulated emissions. The total regulated CO_2 emissions for the development after the incorporation of the LZC technologies are illustrated in Table 15. This equates to a 102% reduction in CO_2 over regulated emissions compared to the clean measures (be clean), which equates to overall savings of 105% (Table 17). The overall carbon dioxide savings compared to the baseline emissions are also presented in Table 17.

3.5.9 An emission saving of greater than 100% suggests that the development would be exporting surplus energy back to the national grid. However, it should be noted that this is for regulated carbon emissions only as per the approved document L methodology used for writing energy strategies. In reality this excess energy will be used to help power the buildings un-regulated energy.

Table 15: Energy Consumption after renewables applied for warehouse building

Energy Consumption by End Use (kWh/m^2)				
	Baseline	Be Lean	Be Clean	Be Green
Heating	0.44	0.5	0.5	0.31
Cooling	0.27	0.37	0.37	0.37
Auxiliary	0.54	0.56	0.56	0.56
Lighting	3.47	2.98	2.98	2.98
Hot Water	1.67	1.65	1.65	1.65
Photovoltaics	-	-	-	-7.01

Total (regulated)	**6.38**	**6.06**	**6.06**	**-1.14**
Unregulated	30.69	30.69	30.69	30.69
Total	**37.07**	**36.75**	**36.75**	**29.55**

Table 16: Energy Consumption after renewables applied for office building

Energy Consumption by End Use (kWh/m²)				
	Baseline	**Be Lean**	**Be Clean**	**Be Green**
Heating	10.19	7.58	7.58	4.76
Cooling	2.41	2.76	2.76	2.76
Auxiliary	3.2	3.66	3.66	3.66
Lighting	6.32	7.66	7.66	7.66
Hot Water	19.93	19.39	19.39	19.39
Photovoltaics	0	0	0	0
Total (regulated)	**42.06**	**41.04**	**41.04**	**38.23**
Unregulated	37.69	37.69	37.69	37.69
Total	**79.75**	**78.73**	**78.73**	**75.92**

Table 17: Site wide regulated carbon dioxide emissions and savings

	Total regulated emissions (Tonnes CO_2/year)	CO_2 Savings (Tonnes CO_2/year)	Percentage saving (%)
Part L 2021 baseline	582.5	-	-
Be lean	563.2	19.3	3%
Be clean	563.2	0.0	0%
Be green	-31.3	594.5	102%
Overall Savings		**613.8**	**105%**

3.5.10 In addition to reducing the total energy consumption, it is equally important to be able to accurately measure the energy consumption and to allow for demand side response. Therefore, in accordance with Building Regulations Part L the following provisions have been made:

- At least 90% of the estimated annual energy consumption of each fuel, to be assigned to the various end use categories (heating, lighting etc). This will be completed in accordance with CIBSE TM39 Building Energy Metering.
- The output of any renewable system will be separately monitored.
- In buildings with a total useful area greater than 1,000 m², automatic meter reading and data collection facilities will be provided.

3.5.11 Moreover, the inclusion of smart meters in the Proposed Development is proposed, to support the growth of demand side response. This will help enhance understanding of the potential for turning off non-essential equipment or running some equipment at a lower capacity during times of peak demand.

3.5.12 In order to achieve compliance with Part L Volume 2 2021 is achieved when the Building Emissions Rating (BER) for every building is less than the Target Emissions Rating (TER). Table 18 presents carbon dioxide emissions for all commercial units.

Table 18: BER/TER per commercial unit

Commercial Building	Building Emissions Rating ($kgCO_2/m^2yr$)	Target Emissions Rating ($kgCO_2/m^2yr$)
Archetype Warehouse Model	0.93	-0.07
Archetype Office Model	6.15	5.33

3.5.13 The Proposed Development will include battery energy storage systems (BESS), with a capacity of circa 3 MW site-wide. The inclusion of a BESS system does not reduce the overall energy demand of the building, but does provide benefits including: peak shaving and demand reduction lowering maximum demand (in kW) from the grid, providing resilience against power outages allowing critical systems to stay online, reduce grid demand by using energy stored in sunlight hours outside of sunlight hours. The approved modelling software used to calculate the predicted CO_2 emissions from the development are not able to account for the installation of a BESS. Therefore, whilst a BESS system is to be included within the Proposed Development it is not considered further within this report.

3.6 Making Use of Allowable Solutions

3.6.1 Carbon emissions reductions can be achieved through a range of “allowable solutions”; these are measures which secure carbon savings off site.

3.6.2 Allowable solutions could include scenarios such as purchasing carbon credits, developing a renewable generation off site such as a solar farm on nearby land. At the time of the publication of the Cherwell Local plan the allowable solutions were un-defined by the government.

3.6.3 It is not proposed that the development will utilise any allowable solutions within its design. Based on the methodology outlined within sections 3.3 to 3.5 of this report, the development will successfully manage to achieve its carbon emission reduction goals via the application of on-site technologies.

3.7 Additional Analysis

3.7.1 The primary analysis of this report has focused on the regulated energy consumption, regulated energy refers to the energy used for fixed building services that are subject to building regulations, these include: energy consumption for heating, cooling, ventilation, hot water and fixed lighting.

3.7.2 Un-regulated energy forms a significant part of the predicted energy consumption and carbon emissions of a building. Un-regulated energy refers to energy not covered by building regulations because it is outside the scope of fixed building services, this typically refers to energy used by plug-in appliances and equipment such as computers, or other tenant-controlled equipment such as machines on an assembly line.

3.7.3 The National Calculation Methodology (NCM) used for demonstrating compliance with Building Regulations, provides an estimate of un-regulated energy use based on the building type, this is shown as ‘Equipment’ on the technical data sheet page of the BRUKL. The below and any further reference to unregulated energy only refers to energy consumption associated with buildings.

3.7.4 The un-regulated energy consumption based on the sample warehouse model is 30.69 kWh/m^2 per year. The emission factor for Part L 2021 is 0.136 kg CO_2 per kWh. This puts the unregulated emissions across the development at 2,663.4 tonnes CO_2 per annum.

3.7.5 The un-regulated energy consumption based on the sample office model is 37.69 kWh/m^2. The emission factor for Part L 2021 is 0.136 kg CO_2 per kWh. This puts the unregulated emissions across the development at 8.05 tonnes CO_2 per annum.

3.7.6 The Applicant is unable to control such consumption given it is dependent on tenant activities within the buildings. However, as referred to above, through the design of the buildings to structurally allow for 100% of their available roof area to be filled with solar PV, the Applicant is enabling tenants to source electricity from on-site generation. Increasing PV capacity could support the unregulated energy demand and further reduce operational emissions where there is capacity within the grid to accommodate such additional generated renewable electricity. It is not anticipated this would be provided immediately but would be expanded over time in line with tenant requirements, thereby minimising the need to export excess generated electricity to the grid.

3.7.7 It has been calculated that 100% of available roof area would provide an estimated 58,323kWp of Solar PV which would save approximately an additional 5,124.1 tonnes of CO_2 per annum.

3.7.8 Furthermore, as detailed within Appendix 15.5: Carbon Management Plan, the Applicant will explore the inclusion of green clauses within tenant leases, where possible, which may include commitments to ensure the efficient use of energy and prioritising the use of renewable electricity, alongside commitments to monitor utility consumption and provide a forum to review and agree targets and strategies to improve environmental performance. Together, such measures are expected to reduce emissions arising from unregulated energy consumption.

3.7.9 The total estimated unregulated emissions for the development is 2,671.5 tonnes of CO_2 per annum. Whilst the applicant has no control or influence over how the future tenants may use the building it is clear that 100% of the roof area would aid in reducing the un-regulated emissions.

4 Cooling and overheating

4.1.1 The section below details how the different measures implemented have followed the Cooling Hierarchy. Whilst the development has no affiliation or requirements to follow aspects of the London Plan of which the cooling hierarchy originates, it is acknowledged that the cooling hierarchy is a functional method of reducing a buildings energy consumption passively.

4.1.2 New development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and meet its cooling needs. Therefore, all new developments should also be designed to avoid the need for energy intensive air conditioning systems as much as possible. Taking this into account the following measures have been implemented into design:

- Passive Design
  - Use materials with high surface reflectivity to the sun's radiation.
  - Allow for high insulation standards, exceeding Building Regulations requirements, for all building fabric elements and openings
  - Minimise internal heat gains by using low energy equipment, including energy efficient lighting.
  - Use well insulated hot water systems.
  - Specify high efficiency appliances.
- Passive ventilation
  - Where feasible, design the building and its internal layout to enable passive ventilation, including openable windows, a shallow floor plan, high floor to ceiling heights, the stack effect, a double façade.
  - Maximise stack effect with use of roof vents in warehouses
  - Allow for cross ventilation where possible.
- Mechanical ventilation
  - High efficiency Mechanical Ventilation with Heat Recovery (MVHR) will be provided for the occupied zones of the building.
  - Extract fans for the lunch areas and toilets.
- Active cooling systems (seeking low carbon options)
  - High efficiency cooling system used (SEER: 5.6).

4.1.3 Overheating is not fully assessed by carbon dioxide emission models; hence it is encouraged to undertake dynamic thermal modelling to ensure that a development does not overheat. However, it is recognised that the Proposed Development is too early within its design development to be able to undertake a comprehensive assessment. Regardless, compliance with CIBSE Guide TM52 'The Limits of Thermal Comfort: Avoiding Overheating in European Buildings' was targeted as these are the recognised standards on predicting overheating in buildings.

4.2 Active Cooling

4.2.1 Due to the nature of the Proposed Development, in order to guarantee the occupant's comfort, air conditioning for all buildings in office areas will be specified. In order to minimise the carbon dioxide emissions from cooling, energy efficient VRF with SEER of 5.6 is proposed.

4.2.2 The cooling load of both the actual and notional building for the model archetype used within this assessment is presented in Table 19.

Table 19: Area weighted average building cooling demand for each building type

Building		Area weighted average non-domestic cooling demand (MJ/m^2)	Total area weighted non-domestic cooling demand (MJ/yr)
Warehouse Archetype	Actual	1.33	134,506.9
	Notional	0.97	98,301.3
Office Model	Actual	9.94	15,605.8
	Notional	8.68	13,627.6

4.2.3 It needs to be noted that these results are based on a typical warehouse archetype as there are no detailed designs available at this early stage of development. It is expected when a detailed assessment is carried out the cooling requirements of the actual buildings will vary to those published above.

5 Conclusions

5.1.1 This Energy Strategy has been produced in line with the Energy Hierarchy. Carbon dioxide emission savings have been achieved through the following step process. The specified 'Be Lean' measures include improved building fabric and high specification systems. As explained in Section 3.3, the use of a district heat network or centralised energy plant was deemed not to be appropriate for this project. The remaining carbon dioxide savings have been achieved through the inclusion of renewable energy technologies 'Be Green'.

5.1.2 In conclusion, based on the measures outlined in the report, the development achieves both its sustainability and energy targets including Building Regulations and the policies outlined within Cherwell District Councils Local Plan. The proposed strategy includes high insulation standards, efficient building services, individual air source heat pumps (to every unit) and approximately 25,870 m^2 of photovoltaics spread across the roofs of buildings on the development. It has been confirmed that a 105% improvement on 2021 Building Regulations will be achieved and 102% of the total regulated CO_2 emissions reduction of this development will be achieved by the incorporation of a low or zero carbon technology onsite.

5.1.3 The reduction in total carbon dioxide emissions and savings at each stage of the Energy Hierarchy process are provided in Table 20. The table presents the site wide regulated CO_2 emissions, using SAP10 carbon emission factors.

Table 20: Site wide regulated carbon dioxide emissions and savings

	Total regulated emissions (TonnesCO_2/year)	CO_2 Savings (TonnesCO_2/year)	Percentage saving (%)
Part L 2021 baseline	582.5		
Be lean	563.2	19.3	3%
Be clean	563.2	0.0	0%
Be green	-31.3	594.5	102%
Totals	**-31.3**	**613.8**	**105%**

5.1.4 In order to achieve compliance with Part L volume 2 2021, for non-residential buildings, compliance with Part L Volume 2 2021 is achieved when the Building Emissions Rating (BER) for every building is less than the Target Emissions Rating (TER). Table 21 presents carbon dioxide emissions for all commercial units.

Table 21: BER/TER per commercial unit

Commercial Building	Building Emissions Rating (kgCO_2/m^2yr)	Target Emissions Rating (kgCO_2/m^2yr)
Archetype Warehouse Model	0.93	-0.07
Archetype Office Model	6.15	5.33

5.1.5 Overall, the modelling undertaken shows that both Building Regulations 2021, BREEAM Rating and local authority planning requirements have been met with respect to energy and CO_2 reduction.

5.1.6 The unregulated energy has been estimated using the NCM templates, these have been supplied for information purposes only to provide an insight as to what the emissions could be pending a tenant fit out of the building spaces. Un-regulated energy consumption is highly dependent on the tenant activities within the building and will be impacted by the activities and equipment installed by the tenants and so cannot be accurately predicted at this stage.

Appendices

Appendix A Analysis of Low and Zero Carbon Technologies

Solar Thermal

Solar thermal generates energy for the provision of domestic hot water; this system typically works in tandem with a conventional boiler in the event that the hot water demand cannot be solely met by the renewable technology. The two types of solar thermal technology suitable for inclusion are flat plate collectors and evacuated tubes; with the latter typically being more efficient. The panels are most efficient when they face south at 30°.

Solar thermal is mostly suited to houses. Providing solar panels and associated pipework to each flat within the main block would not be a practical approach. For non-residential buildings, they should only be considered for buildings with high hot water demand, like hotels and gyms.

Wind Turbines

Wind technology is now a well established technology for the generation of electricity in large scale projects. Small scale wind projects within built up areas however is less common.

The lower uptake of wind turbines in urban settings is due to the reduced efficiency of smaller scale turbines as a result of the high surface roughness reducing wind speeds. Furthermore, it is likely that the surrounding buildings will create turbulence and locally reduce near surface wind speeds thus further reducing the potential of good wind speeds. In addition wind turbines integrated on buildings might cause other problems, like vibrations.

Photovoltaic panels

The photovoltaic panel converts free solar energy directly into electricity. The electricity produced is on direct current (DC). Therefore inverters are used to convert the output into alternating current (AC) for connection to the building's supply board. The electricity generated can either be used to supply communal (landlord) areas or for individual dwellings, the latter configuration tending to be more complex and costly owing to the need for multiple meters.

The panels are most efficient when they face south at 30°. Photovoltaic panels should not be considered in cases with significant overshadow (i.e. next to taller buildings)

Heat Pumps

A heat pump is a machine that moves heat from one location (the 'source') at a lower temperature to another location (the 'sink' or 'heat sink') at a higher temperature using mechanical work or a high-temperature heat source. There are two main categories of heat pumps, the Ground Source Heat Pump (GSHP) and the Air Source Heat Pump (ASHP). They operate very similarly; the difference is on the source of the heat.

Several options are possible for a GSHP, depending on local geology and hydrology. Various types of ground source heat pump arrangements are available including: vertical boreholes, horizontal coils and slinky coils, e.g. around perimeter of building.

The ASHP is an alternative system of the GSHP but they operate with the same physics. Their only difference is that the ASHP uses the ambient outdoor air to provide the low grade source heat instead of the ground. Owing to the greater seasonal variation in air temperatures, air-source heat pumps are unable to provide year-round heating requirements alone; hence they operate less efficiently, the running costs are higher and CO_2 savings lower than for a ground source heat pump.

The main advantage of a heat pump over a conventional heating system is that very high efficiencies can be achieved; typically up to around 400% compared to 90% for a modern gas boiler.

Biomass

Biomass is a term used to describe all plant and animal material. A range of biomass material can be burnt to generate energy including wood, straw, poultry litter and energy crops such as willow or poplar. Biomass material is considered carbon neutral if the fuel comes from a sustainably managed source.

The primary disadvantage for any biomass installation is that it requires large amounts of fuel storage (which will need to be fed by deliveries of biomass fuel). Developments that use biomass need to secure constant delivery of wood chips or wood pellets, from a local supplier. Finally biomass requires a suitable flue design to address air quality issues.

Table A1: LZC Technologies Matrix

LZC technology	Basic Technical Information	Technical, Environmental and Economic implications / considerations	Suited Application	Site specific comment	Further analysis
Solar thermal	Solar collectors (flat plate or tube) transfer energy into liquid to a closed loop twin coil hot water cylinder	+ Government grants available (RHIs) + Can meet a significant proportion of the DHW demand - Efficiency effected by site factors shading, orientation and roof/ground space - Requires considerable hot water demand all year round to be financially beneficial	Domestic and commercial applications with high annual hot water load; leisure centres, canteens, washrooms	The warehouses and associated offices will have a low hot water demand in proportion to total energy demand. More efficient to use PV	NO
Wind turbine	Turbine/generator converts wind energy to electrical power.	+ Allows on site generation of renewable electricity - Can create structural, vibrations and noise implications - Not suited for urban environments - Electricity generation varies due to wind speed - Generally payback over 20 years	Large sized turbines in non-urban or offshore locations	Very costly, location is relatively near to residential development and so noise pollution is a concern.	NO
Photovoltaic	Converts sunlight to electrical power.	+ Allows on site generation of renewable electricity + Generally payback between 7-12 years + Low maintenance requirements - Efficiency effected by site factors – shading, orientation and roof/ground space	Applicable to all buildings with limited solar shading and available roof	Lots of roof space available, non-intrusive, very efficient method of reducing development CO_2	YES
Air source heat pump (ASHP)	ASHP capture heat from the outside air and transfer the heat directly to the air inside the building or transferring the heat to a liquid medium that can be pumped around the building.	+ Lower installation cost that ground source heat pump + Can provide heating and cooling + Government grants available (RHIs) - COP is lower during the heating season - Can restrict distribution strategies	Wide range of building types particularly buildings designed to have low temperature heat emitters. Combines well with cooling systems	Very efficient method of providing heating and cooling to a building. Relatively inexpensive and non-intrusive.	YES

LZC technology	Basic Technical Information	Technical, Environmental and Economic implications / considerations	Suited Application	Site specific comment	Further analysis
Ground source heat pump (GSHP)	GSHP capture heat from the ground and transfer the heat to a liquid medium that can be pumped around the building.	+ More heat is supplied to the building than energy is consumed by the heat pump + COP is much better than air source heat pumps + Government grants available (RHIs) - Requires area for ground collector or borehole - High initial capital cost - Can restrict distribution strategies - Subject to soil conditions	Wide range of building types particularly buildings designed to have low temperature heat emitters and sufficient space for necessary ground works	Very efficient method of providing heating and cooling to a building, slightly more efficient but also much more expensive compared to ASHP due to associated ground works.	YES
Biomass	Uses biomass as a fuel source for space heating and hot water.	+ Government grants available (RHIs) + Renewable source of heating - Requires large fuel storage capacity - Generally a large capital cost - Potential issue with air quality especially in urban areas	Building/site with sufficient access and storage facilities. Local supply of fuel	Has high operational and maintenance costs. Is a source of on-site combustion potentially impacting local air quality	NO

Appendix B Performance Specifications for Building Fabric and Services

Table A2: Performance Specifications for Building Fabric and Services

Feature	Description	Technical Values
External walls		0.18 W/m^2K
Ground and upper floors		0.18 W/m^2K
Roofs		0.16 W/m^2K
Windows		1.40 W/m^2K
Rooflights		1.30 W/m^2K
Personnel Doors		1.50 W/m^2K
Vehicle Access Doors		1.30 W/m^2K
Air permeability		2.0 m^3/m^2h @50Pa
Ventilation	VAM with MVHR	SFP=1.60 Heat exchanger efficiency η= 73%
Heating System		High efficiency Air Source Heat Pumps SCOP = 420%
Heating Control System		Time and temperature zone control Delay start thermostat Central thermostat
Hot Water System	Hot water cylinder heated from heat pump	SCOP = 286%
Cooling		SEER = 560%
Lighting		120 lm/W
LZC Technologies	Monocrystalline PV panels	5,774 kWp on about 25,870 m^2