RIDGE

OXFORD UNITED FOOTBALL CLUB – NEW STADIUM DEVELOPMENT SUSTAINABILITY STATEMENT

February 2024

SUSTAINABILITY STATEMENT

February 2024

Prepared for

Oxford United Football Club

Prepared by

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1. INTRODUCTION

This report has been produced by Ridge & Partners LLP on behalf of Oxford United Football Club to outline the sustainability strategy for the proposed new stadium development at Land to the east of Stratfield Brake and west of Oxford Parkway Station, known as The Triangle. The strategy first and foremost responds to the national and local policy which shape the baseline performance. Recognising Oxfordshire County Council's strong ambition for sustainable development, it was considered important to highlight how the development goes above and beyond compliance to implement best practice principles that deliver tangible sustainable benefits for occupants and the surrounding communities.

In addition to the above, Cherwell District Council's Local Plan emphasises that all new development must be designed and constructed to the highest quality, so that it is an asset to its environment. Developments in the District must satisfy policy requirements to ensure that it is sustainable, addresses climate change, achieves high standards of design and layout and contributes to a sense of place-making. The Council also seeks to reduce traffic impacts therefore the Sustainability Strategy should address this theme.

As part of the full planning application, reference is made to the following reports were relevant to the Sustainability Strategy:

- Design and Access Statement
- Environmental Statement
- Security Consultation

In light of the national and local policy requirements, various themes have been reviewed to help illustrate the varied and holistic approach to sustainability adopted by the development. To inform the sustainability strategy, consultation has been undertaken with key members of the design team, such as the architect, landscape architect, civil engineers, and BREEAM Assessor.

A BREEAM Assessment is in the process of being prepared and will be submitted as part of the planning application. As part of the Pre-Assessment Stage, various recommendations have been made and this report includes some of the emerging principles. Once these are refined and reviewed further by the project team, it will be submitted for reviewal.

2. SUMMARY POLICY REQUIREMENTS

To ensure a holistic sustainable approach to development it is essential that consideration is given to, and clearly relates to, relevant policy and guidance. A policy review indicates the relevant international, national, regional and local policies which should be considered to ensure that the appropriate standards and principles are adopted. The key planning policy and guidance documents that were used to frame and inform this approach are as follows:

- United Nations 2030 Agenda for Sustainable Development
- United Nations 26th Conference of the Parties (COP26)
- National Planning Policy Framework (NPPF) December 2023
- Sustainability Standards Checklist for Planning: Major Applications

2.1. International Policy

United Nations 2030 Agenda for Sustainable Development

The 2030 Agenda for Sustainable Development, set out in 2015 by the United Nations, highlighted 17 Sustainable Development Goals (SDGs) to work towards, each with corresponding targets and indictors. The SDGs are an international urgent call for action and aim to inform the policy and targets of individual nations.

- SDG 3: Good health and Well-being: Ensure healthy lives and promote well-being for all at all ages.
- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy.
- SDG 8 Promote inclusive and sustainable economic growth, employment and decent work for all.
- SDG 11Make cities inclusive, safe, resilient and sustainable
- SDG 12: Ensure sustainable consumption and production patterns.
- SDG 13: Climate Action: Take urgent action to combat climate change and its impacts.
- SDG15 Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
- SDG17 Revitalize the global partnership for sustainable development.

2.2. National Policy

National Planning Policy Framework (NPPF), December 2023

The National Planning Policy Framework (NPPF) was revised in December 2023 and indicates government planning policies for England and how these should be applied. The policies in the document, taken as a whole, constitute the Government's view of what sustainable development in England means in practice for the planning system.

Fundamentally for the proposed development, paragraph 8 of the NPPF states that:

Achieving sustainable development means that the planning system has three overarching objectives, which are interdependent and need to be pursued in mutually supportive ways (so that opportunities can be taken to secure net gains across each of the different objectives):

> a) an economic objective – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types 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.
>
> b) a social objective – to support 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 well-designed, beautiful and safe places, with accessible services and

open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and

c) an environmental objective – to protect and enhance our natural, built and historic environment, including making effective use of land, improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy

Paragraph 10 of the NPPF states that:

"So that sustainable development is pursued in a positive way, at the heart of the Framework is a presumption in favour of sustainable development."

Paragraph 11 of the NPPF states that:

"Plans and decisions should apply a presumption in favour of sustainable development."

For plan-making this means that:

a) all plans should promote a sustainable pattern of development that seeks to: meet the development needs of their area; align growth and infrastructure; improve the environment; mitigate climate change (including by making effective use of land in urban areas) and adapt to its effects.

b) strategic policies should, as a minimum, provide for objectively assessed needs for housing and other uses, as well as any needs that cannot be met within neighbouring areas, unless:

i. the application of policies in this Framework that protect areas or assets of particular importance provides a strong reason for restricting the overall scale, type or distribution of development in the plan area.

or ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

For decision-taking this means:

c) approving development proposals that accord with an up-to-date development plan without delay.

or d) where there are no relevant development plan policies, or the policies which are most important for determining the application are out-of-date, granting permission unless:

i. the application of policies in this Framework that protect areas or assets of particular importance provides a clear reason for refusing the development proposed.

or ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

Meeting the challenge of climate change is addressed in section 14 of the NPPF, and paragraph 152 states.

"The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure."

Further to the above paragraphs 158, 159 and 160 state:

"158. Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures53. Policies should support appropriate measures to ensure the future resilience of communities and infrastructure to climate change impacts, such as providing space for physical protection measures, or making provision for the possible future relocation of vulnerable development and infrastructure.

159. New development should be planned for in ways that:

a) avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and *b) can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards.*

160. To help increase the use and supply of renewable and low carbon energy and heat, plans should:

a) provide a positive strategy for energy from these sources, that maximises the potential for suitable development, while ensuring that adverse impacts are addressed satisfactorily (including cumulative landscape and visual impacts).

b) consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure their development; and

c) identify opportunities for development to draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers."

Conserving and enhancing the natural environment are addressed in Chapter 15.

Paragraph 180 states.

"Planning policies and decisions should contribute to and enhance the natural and local environment by:

a) protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan).

b) recognising the intrinsic character and beauty of the countryside, and the wider benefits from natural capital and ecosystem services – including the economic and other benefits of the best and most versatile agricultural land, and of trees and woodland.

c) maintaining the character of the undeveloped coast, while improving public access to it where appropriate.

d) minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures.

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans.

and f) remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate."

2.3. Regional and Local Policy

The Sustainability Statement sets out how the project will meet the requirements as set out in the regional and local policy. It sets out the methods by which the project will address sustainability adhering to the themes and requirements set out below.

Climate and ecological emergency declarations

Cherwell District Council declared a climate emergency in July 2019 and declared an ecological emergency in February 2021. Following the climate emergency declaration, Cherwell District Council (CDC) have developed a Climate Action Framework which confirms they will:

- Ensure own operations and activities are net zero by 2030.
- Do their part to achieve a net zero carbon district by 2030 and to lead through example.

The ecological emergency declaration focusses on protecting and restoring the natural environment. Actions following this declaration include incorporating the climate and ecological emergencies and nature recovery as strategic priorities in planning policy, and setting measurable targets for biodiversity increase within the district.

Theme One: Protecting & Restoring Natural Ecosystems

- the restoration of natural ecosystems and biodiversity are delivered widely and consistently.
- everyone feels they have access to wildlife-rich sites, to the benefit of their health and wellbeing.
- partnership with national, regional, county, district and local partners and communities continues to progress clear and positive outcomes for climate action.
- everyone feels they can work collectively to make a difference, taking climate action at home, at work and as part of their local communities.

Theme Two: Energy

- clean and local energy is commonplace, providing local communities with energy independence and resilience.
- partnership with national, regional, county, district and local partners and communities continues to progress clear and positive outcomes for climate action.
- everyone feels they can work collectively to make a difference, taking climate action at home, at work and as part of their local communities.

Theme Three: Active Travel & Low-Carbon Transport

- active forms of travel including cycling and walking are widely adopted and ultra-low emission transport infrastructure is equipped to meet rising demand.
- growth and new development are designed to the highest standards of energy performance and environmental sustainability.
- partnership with national, regional, county, district and local partners and communities continues to progress clear and positive outcomes for climate action.
- everyone feels they can work collectively to make a difference, taking climate action at home, at work and as part of their local communities.

Theme Four: Standards in New Development

- the restoration of natural ecosystems and biodiversity are delivered widely and consistently.
- everyone feels they have access to wildlife-rich sites, to the benefit of their health and wellbeing.
- clean and local energy is commonplace, providing local communities with energy independence and resilience.
- active forms of travel including cycling and walking are widely adopted and ultra-low emission transport infrastructure is equipped to meet rising demand.
- growth and new development are designed to the highest standards of energy performance and environmental sustainability.
- partnership with national, regional, county, district and local partners and communities continues to progress clear and positive outcomes for climate action.

Theme Five: Engage, Support & Educate

- partnership with national, regional, county, district and local partners and communities continues to progress clear and positive outcomes for climate action.
- everyone feels they can work collectively to make a difference, taking climate action at home, at work and as part of their local communities.

Cherwell District Council's Local Plan 2011-2031

- Policy BSC 5: Area Renewal

- Policy BSC 8: Securing Health and Wellbeing
- Policy BSC 9: Public Services and Utilities
- Policy BSC 10: Open Space, Outdoor Sport and Recreation Provision
- Policy BSC11: Local Standards of Provision –Outdoor Recreation
- Policy BSC 12: Indoor Sport, Recreation and Community Facilities
- Policy ESD 1: Mitigating and Adapting to Climate Change
- Policy ESD 3: Sustainable Construction
- Policy ESD4 Decentralised Energy Systems
- Policy ESD5 Renewable Energy
- Policy ESD 6: Sustainable Flood Risk Management
- Policy ESD 7: Sustainable Drainage Systems (SuDS)
- Policy ESD 8: Water Resources
- Policy ESD 10: Protection and Enhancement of Biodiversity and the Natural Environment
- Policy ESD 11: Conservation Target Areas
- Policy ESD 13: Local Landscape Protection and Enhancement
- Policy ESD 14: Oxford Green Belt
- Policy ESD 15: Character of Built and Historic Environment
- Policy ESD 16: The Oxford Canal
- Policy ESD 17: Green Infrastructure
- Policy SLE 1: Employment Development
- Policy SLE 2: Securing Dynamic Town Centres
- Policy SLE4: Improved Transport and Connections

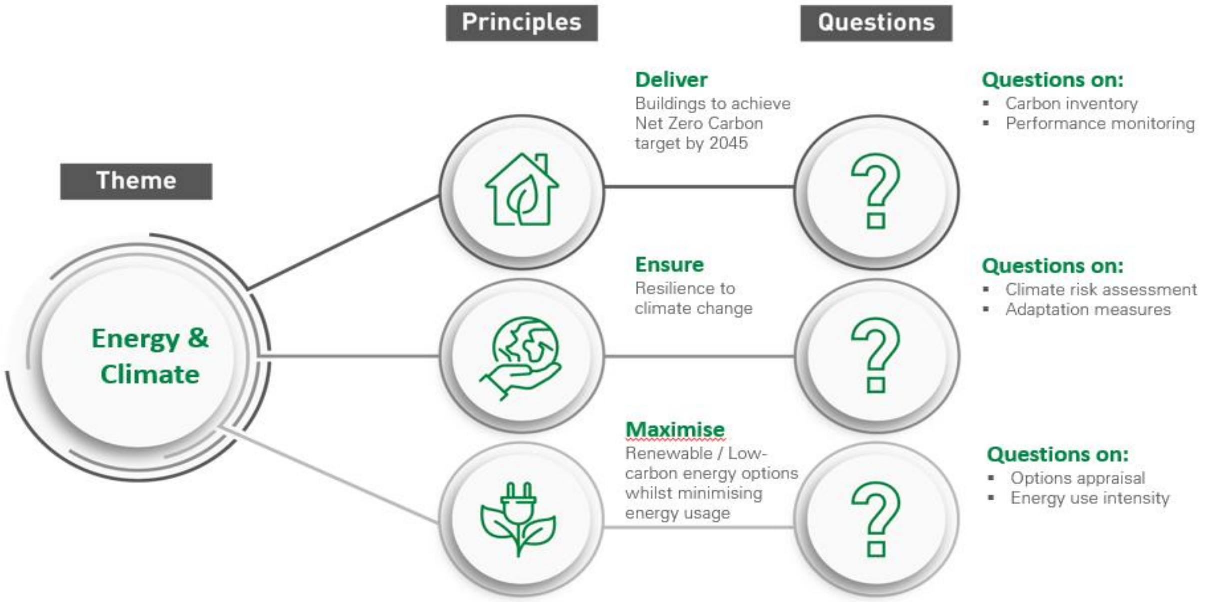
3. SUSTAINABILITY APPROACH

The 360 Framework is a bespoke methodology which highlights priority themes across the Club and defines levels of ambition, providing a mechanism to communicate sustainability initiatives, commitments, and targets. The 360 Framework is used to encourage sustainability across both the Club's activities and for the stadium development. The key aims of the Framework are:

- To embed sustainability throughout the project, reflecting the Club's ambitions.
- To encourage reflection and effective innovation across the project.
- To provide a method of measuring progress and reporting on targets, aims, and objectives.

The 360 Sustainability Framework is built around a four-tier structure outlined below.

1. Themes are identified represent priority areas to improve sustainability performance.
2. Key principles reflecting the Club's commitments and policy drivers to further define specific objectives and guide target setting.
3. Questions underpinning the sustainability themes and principles are set and designed to demonstrate impact on the stadium development.
4. Performance indicators will be carried through the design, construction and operation of the stadium to demonstrate progress.



Performance indicators are defined as

- **C: Compliance/Advisory**: Typically, a regulatory minimum e.g., minimum planning requirements
- **B: Best in Class:** Current best in class performance amongst peers and other similar sized projects. This is based on performance against sector best practice from industry guidance or peer review.

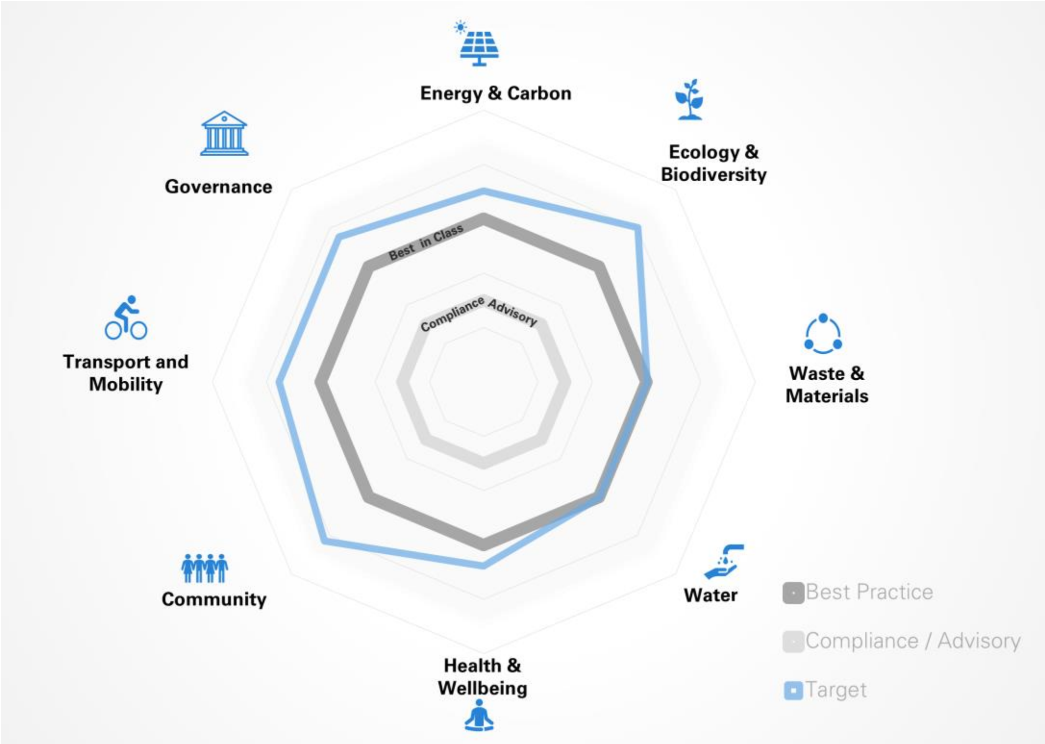
Definition of all levels is supported by appropriate legislation or guidance material relevant to the Club and the stadium.

The approach is specifically designed to encourage new ideas and innovation beyond the traditional certification routes but still providing a robust, evidence-based system for corporate and ESG reporting. The Framework also incorporates reporting mechanisms at the corporate, development and project level and is underpinned by a cost model providing clarity between attainment levels and financial impact.

IDENTIFIED THEMES AND PRINCIPLES

The themes and principles for the stadium are as indicated below. These are determined through engagement with the project team and build on any key commitments that OUFC have undertaken. These themes and principles are underpinned by key questions and target levels within the Framework.

1. **Energy & Carbon**
    - Drive towards net zero carbon emissions
    - Energy efficiency, renewable energy generation, energy reuse and on-site storage are maximised across the site.
    - Limit exposure to climate change and fluctuating energy pricing.
2. **Ecology and Biodiversity**
    - Provide Biodiversity Net Gain (BNG) by retaining existing on-site habitats and providing new and improved habitats.
3. **Waste and Materials**
    - Ensure application of embodied impacts, sourcing, conservation, and re-use
    - Sustainable use of materials and resources on a whole life value basis
    - Commitment to the management of waste through the waste hierarchy
4. **Water**
    - Minimise flood risk.
    - Reduce potable water demand through the efficient use of water and wastewater.
    - Maximise the opportunity to use natural sources of water.
5. **Transport and Movement**
    - Provide efficient, clean and healthy transport options.
    - Provide innovative mobility solutions.
6. **Health & Wellbeing**
    - Creating built environments that are healthy, safe and desirable to use.
    - Minimise the localised disturbance and pollution of the project.
7. **Community**
    - Ensure all activities support local residents, business and the local community.
    - Maximise all opportunities to enhance the reputation of the project.
8. **Governance**
    - strong and transparent governance framework
    - comply with all current legislation.
    - ensure the Club are prepared for future regulatory requirements.



For each of the themes, we have identified that the project is targeting 'Best in Class' or better across all the themes. This provides a baseline of what the project is aspiring to and will allow the design to identify the best approach possible.

3.1. Energy and Carbon

The built environment is a significant contributor to carbon dioxide emissions in the UK, with buildings accounting for 37% of total greenhouse gas emissions. There is significant opportunity for the emissions associated with new developments to be mitigated through design and operation. Current and upcoming National and Local Government requirements for low and zero carbon developments are driving new developments to reduce carbon dioxide emissions.

Cherwell District Council has committed to carbon neutral by 2030, In 2018, UK's current emissions were reported to be 44% below 1990 levels. To support this target, several multisectoral changes need to be considered including reduction in demand for energy across the economy, lower demand for carbon-intensive activities, extensive electrification, particularly of transport and heating, development of a hydrogen economy, carbon capture and storage.

Oxford United are signatories to the UNFCCC Sports for Climate Action. As part of this commitment, signatories are now requested to commit to achieving specific climate goals of halving emissions by 2030 (mid-term target) and aiming to achieve net-zero by 2040 (long-term target) which are based on a 2019 baseline (or alternatively signatories should choose the latest year for which data is available).This includes the adoption of targets which are inclusive of scopes 1, 2 and 3. Also, for organisations where scope 3 emissions constitute 40% or more of their total emissions, its necessary to both model these scope 3 emissions and establish related targets.

Sustainability Principles

- Drive towards net zero carbon emissions, Club has targeted Net Zero by 2040
- Energy efficiency, renewable energy generation, energy reuse and on-site storage are maximised across the site.
- Limit exposure to climate change and fluctuating energy pricing

Objectives and Targets

The Energy and Carbon section is to be read in conjunction with the following reports (All reports are part of the appendices below):

Oxford United FC BREEAM MAT 01 RIBA Stage 2 LCA
This report supports project teams understand the environmental impact associated with the construction products specified in their design and to help them identify the most impactful elements and areas in the assessed development. The findings of this report will inform the design decision making process to improve construction resource efficiency and to emphasize the importance of embodied carbon emissions in addition to the operational emissions.

Oxford United Football Club BREEAM Ene 04: Low and Zero Carbon Technologies Feasibility Study
This report sets out design measures which will reduce building energy consumption and associated carbon emissions to minimise the use of active building services systems.

Oxford United Football Club Energy Statement - New Football Stadium September 2023
This report determines the annual energy consumption and Carbon Dioxide (CO_2) emissions associated with the regulated services being provided within the new regulated areas of the stadium development.

Oxford United FC Match Day Carbon Footprint Report
This report to show the carbon emissions associated with a typical 'match day' for the club at the Kassam Stadium.

Energy Reduction

The stadium will be constructed to achieve the highest economically viable energy efficiency and be designed to maximise the delivery of decentralised renewable or low-carbon energy generation. A feasibility study of the Low and zero carbon technologies has been undertaken as part of the drive towards achieving carbon neutrality. The stadium will aim to reduce energy use and carbon emissions through the use of energy efficient equipment and Low and zero carbon technologies.

The project will commit to the notion that reductions in energy demand and consumption should be prioritised over all other measures. This will be done by following the Be Lean, Be Clean, Be Green energy hierarchy, as developed by the Greater London Authority.

Be Lean
Passive design measures have been adopted as part of the proposals. The adoption of these measures ensure that thermal comfort can be achieved in the development, with reduced heating and cooling needs. Heat loss is to be managed by achieving low U-values (the lower the U-value, the better is the insulating performance of the building). Air leakage is to be minimised via an airtight design, and unwanted solar heat gains are to be mitigated via shading and low g-value façade glass

- Fabric performance – the project will improve the thermal elements U-values and air tightness of the building through the design.
- Orientation – the design will aim to minimise summer solar gain overheating but maximise winter solar heating.
- Glazing percentages – the design will reduce the impact of overheating by minimising glazing in high solar gain areas. As well as reducing winter heat loss through glazing panels.
- Window specification – reduce winter heat loss and summer solar gain.
- Layout and Form – positioning rooms strategically to reduce heat loss, increase winter solar heating and reduce summer overheating.

Be Clean

- Efficient Lighting with Daylight Linking: Switching general lighting to LED and incorporating daylighting linking to minimise energy consumption in on and off-peak hours.
- Efficient Equipment: use energy efficient appliance and equipment wherever possible to reduce unregulated energy consumption.
- Pumps and fans: Variable speed drives will be considered for pumps and fans to reduce energy consumption.
- Occupancy Controls: Energy consumption that aligns with occupancy.
- Energy monitoring: An energy sub-metering strategy will be used to monitor energy use in the dwelling. This system will allow for an understanding of out-of-range values and any anomality's that could identify faults which may cause the dwelling to use more energy.

Be Green

Be Green principles consider the technical feasibility of Low and Zero Carbon (LZC) technologies to provide onsite energy to proposed development. These measures should only be considered once the Be Lean and Be Clean measures have been exhausted.

Renewable technology

The stadium will install 3,000m2 of roof mounted Solar PV that can yield enough fossil-free energy per annum to achieve Compliance with ADL 2 2021 for the entire development There are further opportunities for the Club to further their sustainable ambitions via roof optimisation, Solar PV car park canopies and potential for offsite renewable options.

Heating and cooling will be provided in the form **air source heat pumps**. to provide space heating and cooling. Heat pumps facilitate the reduction in operational energy use. It is intended, that hot water will also be provided by heat pumps. In areas with less intense demand hot water will be heated electrically at point of use. In addition, **PV panels** are also proposed as an onsite electricity generation system, further reducing the energy consumption of the building. Together these renewable and low carbon technologies will maximise energy efficiency.

Embodied Carbon

As part of the requirements of the 360 framework and supporting the BREEAM assessment, a RIBA stage 2 life cycle assessment (LCA) of the stadium has been undertaken. The assessment provides a whole life carbon assessment of the Superstructure, Substructure and Landscaping, providing differing design options, with the associated Global Warming Potential in tonnes of carbon equivalent. This is being considered by the design teams to identify suitable options for the stadium which will balance the reduced carbon options against the viability of the stadium. The information from this assessment will help inform material choices based on the requirements set out above.

As the project moves into RIBA stages 3 and 4, there will be a more detailed LCA undertaken. This will be carried out on a minimum of 95% of material cost, this will be done at the technical design stage (RIBA stage 4), and basic recommendations for reducing upfront carbon have been assessed. A further upfront carbon assessment has been specified after practical completion to represent the 'as built' carbon position, allowing final upfront carbon and any savings made to be calculated.

3.2. Ecology and Biodiversity

The loss of ecosystem services poses wide ranging threats to our health and wellbeing. Ecosystem services are linked to economic success, so protecting and enhancing these services is essential to the delivery of long-term sustainable outcomes. New developments can play a role in protecting and enhancing biodiversity and habitat connectivity.

Sustainability Principles

- Provide Biodiversity Net Gain (BNG) by retaining existing on-site habitats and providing new and improved habitats.

Objectives and Targets

- Detailed ecological surveys of the site have been undertaken to determine any habitats and species present within the site, and those which are likely to be affected by any development, and plan measures to protect them accordingly.

- One of the project drivers to is incorporate native species and local prominence landscaping elements into the design. Specifically, trees, shrubs and wildflowers, and other natural features that enhance local biodiversity. The vision has been to incorporate flexible multi-functional spaces that can be enjoyed whether it be a match day or not. The Proposed Development aims to connect the stadium to the wider countryside, woodlands, canal walks, and nearby towns in a way that is attractive, safe, and enjoyable for walkers and cyclists, while also promoting environmental and cultural stewardship.

- The Community Plaza/Fan Zone to the north of the Stadium provides a welcoming open space for everyday use, for supporters to gather and socialise before and after matches and for hosting a variety of events. This space is designed with flexibility in mind, making it the perfect location for relaxing, entertainment and health and wellbeing. Visitors can enjoy a wide range of offerings while taking in the environment and landscape, and on match days, the community plaza open layout allows for a variety of activities to enhance the overall experience for fans. On non-match days, it will be linked to the commercial spaces within the Stadium building and will provide social space which connects to the wider landscape.

- The south-east of the Stadium is another multi-functional arrival space which provides benches, bike racks and other amenities set amongst new tree and shrub planting, providing a welcoming and convenient space for fans to gather before the game.

In terms of biodiversity, the Proposed Development will deliver a 10% biodiversity net gain on-site. Strategies for increasing net gain include:

- Proposing a natural pond and associated planting
- Biodiverse Green Roof Space.
- Rain Gardens.
- Increasing the size of trees at planting.
- Variety of wildflower mixes, shade, hedgerow edge, pond edge, woodland edge; and grassland mixes; and
- Biodiverse walls

3.3. Waste and Materials

The environmental impact of materials and resources used during construction is significant to the whole life carbon performance of a development. Early commitment to reducing the embodied carbon and environmental impact of materials and resources and considering sourcing, conservation and re-use and help deliver a more sustainable outcome. Utilising materials that are also local and resilient can reduce longer term negative environmental impacts. Moving towards a more sustainable model of resource use and waste management is fundamental to achieving sustainable development. The management of waste can deliver positive environmental and economic outcomes during both the construction and operation of a development.

Sustainability Principles

- Ensure application of embodied impacts, sourcing, conservation, and re-use
- Sustainable use of materials and resources on a whole life value basis
- Commitment to the management of waste through the waste hierarchy

Objectives and Targets

The design will aim to maximise opportunities for re-use, recycling and recovery of waste materials. The design will also identify potential opportunities for reducing waste and seek to maximise opportunities for re-use, recycling and recovery of waste materials and thereby minimise the volume of waste to landfill.

A Waste Strategy will be developed for the site during construction and operation phases to provide a planned approach to resource and waste management; to identify the likely quantities and composition of waste that would be generated; and to propose appropriate waste management options that would optimise the management of waste generated during the construction and operation phases. The strategy will encourage saving space (for segregation, storage, collection, treatment and/or disposal), minimises greenhouse gas (GHG) emissions and maximise the recycling and recovery of material. The impact of traffic associated with the movement of waste should be minimised wherever possible, through careful on-site management; reducing need to import and export of materials and limiting the off-site disposal of recyclables and disposal of residual waste to landfill.

The design will adopt principles which support the use of materials in an efficient manner and should consider how the reuse, recycling and recovery of materials can be incorporated into the design to ultimately reduce the quantities of waste sent to landfill. Waste reduction would be addressed as part of the project sustainability agenda throughout the design process, by the application of principles detailed within the WRAP guidance 'Designing out Waste: A design team guide for Buildings' that would address the five principles of:

- Design for reuse and recovery of materials and components.
- Design for off-site construction/manufacture.
- Design for materials optimisation.
- Design for efficient procurement and delivery systems; and
- Design for deconstruction, flexibility and adaptation.

Designing Out Waste workshops will be conducted with the aim of identifying key material use and waste management that may be adopted by the project through the design and construction phases. Several opportunities for circular economy will be considered, which should feed into the Site Waste Management Plan, including:

- Recycling and/or reuse of existing materials and equipment
- Managing materials and waste demands with the wider site
- Engaging with to local community on material resourcing
- Prioritising local suppliers
- Donating existing or excess to local groups / organisations
- Engaging with take-back schemes
- Standardisation of materials
- Regular review and monitoring with delivery teams to manage waste recycling opportunities.

The project will focus on the following:

- A Resource Management Plan (RMP) will be produced to outline the procurement requirements for reused, recycled and locally sourced materials. The plan will provide specific targets, which will be monitored as part of the implementation.

- The Route map for Zero Avoidable Waste in Construction and/or the Zero Waste hierarchy will be applied (redesign, reduce, reuse, recycle/compost, material recovery, residuals management, unacceptable).
    - Resource efficiency:
      The amount of construction waste per 100m² is between less than 2.1m³ / 0.4 tonnes.
    - Diversion from landfill:
      Non-demolition: 85% volume or 90% tonnage
      Demolition: 85% volume or 95% tonnage
      Excavation: 95% by volume or tonnage
    - Reuse and direct recycling of materials:
      The proportion of suitable refurbishment waste either directly re-used on-site or off-site or are sent back to the manufacturer for closed loop recycling exceeds 75%.

- Sufficient waste storage options will be provided to enable staff, visitors, residents to separate and recycle their waste (external & internal storage). A monitoring strategy is implemented to establish a baseline for operational waste.

- Specific targets have been set at both building and development level for responsible sourcing in line with industry best practice. Any timber and timber-based products specified meet the 'Legal' and 'Sustainable' definition as per the UK Government's Timber Procurement Policy (TPP) and have been sourced from within the EU. Where this is not possible, and wood has to be sourced from outside the EU, only suppliers with a robust Responsible Purchasing Policy have been considered.
    - Their risk mitigation strategy includes one of the following:
    - Scientific testing to confirm species and harvest origins.
    - Field-based supply chain assessment & audits
    - Stakeholder consultation
- Careful selection of materials including sourcing local materials where possible as well as materials from sustainable sources. The material choice depends upon what is readily available from the surrounding areas. Using local sources in their natural form, reduces the need for processes and the lack of need to transport over large distances. Recyclable and recycled materials will be used where possible.

- Ensuring protection of landscape features, including important hedgerows and trees, throughout the construction period. – The project commits to protecting hedges and trees during the construction process

- Waste minimisation by ‘designing out’ from the project and limiting waste arising during the construction phase. This involves promoting the use of recycled materials, re-using on site where possible, and disposing of any waste in the most sustainable manner.

- The project will commit to using local contractors where appropriate.

- Adherence to a Construction Environmental Management Plan which will set out the project will avoid, minimise or mitigate effects on the environment and surrounding area. This will set out a framework within which the measures to maintain best practice procedures will be implemented throughout the project.

- Efficient construction techniques and materials selection will prioritise low embodied carbon where appropriate. As the design progresses, the embodied carbon of the products in the specification will be carefully considered to minimise the carbon impact of the material chosen.

- As part of the tender process, the contractor will be expected to sign up to the considerate constructor’s scheme.

- The stadium will provide adequate external storage space for bins and recycling as well as vehicles and cycles.

3.4. Water

Climate change is likely to impact on water supply and management due to increasing irregularity in precipitation patterns and a higher likelihood of droughts. Protecting and conserving water supplies and resources in a sustainable manner is seen as an urgent priority.

The design team will seek to protect and enhance the water environment through careful design. This will include identifying drains, designing operational pollution prevention measures, and incorporating sustainable drainage systems where possible and appropriate. The design should take steps so that no new pathways are opened that could cause migration of pollutants from the site into ground water.

Sustainability Principles

- Minimise flood risk.
- Reduce potable water demand through the efficient use of water and wastewater.
- Maximise the opportunity to use natural sources of water.

Objectives and Targets

Operational water use

The development will be designed to conserve water. The primary aim will be to reduce potable water consumption as much as possible, and then having reduced the demand, to provide the water, where feasible, from non-potable water collected on site. To ensure the building users can record and analyse their consumption data, a submeter will be provided on the mains water supply, and any areas consuming more than 10% of the annual water consumption will also be metered.

Additionally, to reduce wastage due to water leaks, a permanent, automated water leak detection system will be installed to detect major water leaks. This is to be activated when the flow of water passing through the meter is at a flow rate above a pre-set maximum for a pre-set period of time. Flow control devices will be provided to regulate water supply to each WC area or sanitary facility, also to minimise undetected wastage and leaks.

Surface water runoff

The implementation of the site Drainage Strategy will reduce surface water runoff rates and volumes at the site during rainfall events. The Drainage Strategy proposes that surface water run-off at the site is managed through attenuation, provided through a variety of sustainable features including ponds, swales, raingardens, and attenuation crates under the car parking area. This is then discharged to the existing culvert to the west of the site. The design accounts for additional capacity for future climate change rainfall increase.

During the construction phase, a Construction Environmental Management Plan will be prepared which will set out procedures and management measures to ensure the protection of ecological resources, including habitats (where retained) will be included. This will include, but not be limited to, best practice measures for pollution prevention of watercourses/waterbodies,

The CEMP will include best practice measures in relation to water resources including drainage and flood risk. These would include but not be limited to:

- Preventing stockpiled materials from being washed into the local watercourses.

- Training of workers onsite regarding site housekeeping and preventing material stored on site from into the local watercourses.
- Designing temporary site drainage so that sediment, litter and other foreign materials are removed from surface water runoff prior to discharge into the local watercourses.
- Signing up to extreme weather event alerts to plan for extreme rainfall events.
- Maintaining a buffer between works activities and surface water drainage system including preventing sediment entering drains and watercourses.

Surface water management during the site preparation, earthworks and construction phase will include measures to remove silt, sediment and debris and to attenuate surface water runoff prior to a controlled discharge to the drain network. Mitigation including pollution prevention measures in line with good environmental practice is proposed to ensure no significant effects are caused in particular to protect ground and surface water.

3.5. Transport and Movement

Promoting sustainable transport choices to development users can support significant sustainability gains. How users travel to site can also influence health and social gains. Reducing reliance on private cars can also reduce localised congestion which supports local air quality; reduces traffic noise; promotes healthy lifestyles and supports connectivity to the wider area. Accessibility can also significantly influence user perception of development quality. It is necessary to provide sustainable travel choices that promote reduced reliance on private cars, seeking to relieve congestion and reduce carbon emissions.

Sustainability Principles

- Provide efficient, clean and healthy transport options.
- Provide innovative mobility solutions.

Objectives and Targets

The stadium is designed to promote sustainable transport measures to promote accessibility of the site by walking, cycling, the use of personal electric vehicles and public transport. It is intended that through the provision and promotion of sustainable travel alternatives to private car use, a significant shift in travel patterns to and from the site can be achieved.

Charging points and secure parking facilities will be provided for electric bicycles and scooters to encourage greater use of these forms of personal transport. The provision of dedicated cycle/footpaths which connect to the wider cycle and footpath network. An assessment of the wider cycle network has also been prepared to identify improvements that can be made.

The project will focus on the following:

- Traffic will be adequately managed to avoid congestion as a result of development through the use of:
    - clear traffic management plans.
    - infrastructure is developed to allow pedestrian access to the site from Oxford Parkway train station.
    - incentives are used to push the use of public transport.

- Promotion of sustainable transport measures to promote accessibility of the site by walking, cycling, the use of personal electric vehicles and public transport, to encourage modal shift.

- Provision of 100 Sheffield stands onsite with access to further spaces at Oxford Parkway, including electric bike charging.

- New and improved pedestrian and cycle routes to/from the Stadium from/to Oxford Parkway, including signage and lighting to provide safe route to access; cycle parking, bus services, rail services and taxis.
- A new stepped access to Oxford Parkway from Oxford Road
- New pedestrian crossings on Oxford Road and Freize Way
- Increased frequency and longer operating hours of public bus services to the Stadium on match days, if demand/ticket sales require.
- Supporter match day shuttle buses from Park and Ride sites to intercept supporter vehicle trips – see further detail.
- Supporter coach services.
- Improvements (or contribution) to Oxford Parkway Park and Ride interchange facility.
- Support for Cowley branch line reopening.
- Promotion of the Travel Plan at initial staff induction.
- Opportunity to purchase a public transport season ticket or discounted public transport ticket for travel to and from the Stadium.
- Staff showers, changing and drying facilities within the Stadium for those who walk / cycle to work to use.
- Promotion of the Cycle to Work Scheme to all staff who work at the Stadium.

3.6. Health and Wellbeing

The impact of a large development of this scale needs to take into account the Health and Wellbeing of not only the building users but also that of the neighbouring community within which it sits. The design will focus on areas such as light and noise pollution reduction.

Sustainability Principles

- Creating built environments that are healthy, safe and desirable to use.
- Minimise the localised disturbance and pollution of the project.

Objectives and Targets

The design aims to minimise light and noise pollution impacting neighbours, both existing and planned Stadium lighting will be positioned in a way which minimises disruption, especially during darker winter evenings. Similarly design measures will appropriately mitigate noise disturbing nearby residents. Considerations will also include the materials of the stadium itself, and interventions to minimise noise from pedestrian traffic before and after games.

Lighting

- The daylighting studies have been used to optimise orientation of massing for the comfort of stadium fans, and players on the pitch. Mitigation of external light intrusion and sign luminance
- The thermal comfort of site users is ensured, both within current climate conditions and for anticipated climate change impacts. As part of this a climate risk assessment will be undertaken.

Air Quality

- Air quality monitoring on site, and CO2 monitoring in enclosed spaces.
- Construction phase - Mitigation of dust emissions

Wellbeing

- Initiatives are being developed to encourage physical activity on site, e.g., subsidised sports sessions for local residents, an affordable on-site gym. Explore connections to maximise physical activity with recommendations from 'Travel and transport'. Use of biophilia in increasing site user wellbeing, improving air quality, and regulating microclimate conditions.

3.7. Community

Community engagement will support the delivery of a successful project, and this is being done through 'Oxford United in The Community' initiative. By engaging with local and county-wide delivery partners, Oxford United in the Community uses the power of football to inspire the people and communities of Oxfordshire to have positive aspirations for their futures and the health, wellbeing, self-confidence, opportunities and resources to achieve them. Promoting local job creation and responding to local skills can support as a catalyst for economic growth. This could potentially address identified skills gaps within the local economy.

Sustainability Principles

- Ensure all activities support local residents, business and the local community.
- Maximise all opportunities to enhance the reputation of the project.

Objectives and Targets

- The design process is as transparent and collaborative with nearby residents (and users of the existing sports ground) as possible. Community feedback is being integrated into proposals.

- Maximise the integration of community infrastructure for all to use, including amenities to build social capital and enable residents to actively participate in their community. This could include dedicated, flexible spaces for use by community groups.

- Separate and secure access should be provided to this space. Respect and do not detract from nearby Character Areas by following relevant, context specific design guidance and considerations (Kidlington, Islip, and the Oxford Canal).

4. CONCLUSION

This statement provides the outline approach to the sustainability measures that will be implemented on the project and forms the basis of a framework that will ensure that this is exceeds sustainability planning requirements. It provides an assessment of the sustainability initiatives that are being undertaken on the project, in line with and often exceeding the standards set out in both national and local planning requirements.

OUFC recognise that they have a responsibility to their local communities. Delivering a sustainable development is fundamental to meeting that social, moral and economic responsibility. OUFC are committed to upholding these high standards through focus on design, community, wellbeing, materials sourcing and environmental impact. Through the stadium development, OUFC are committed to achieving an exemplary development in terms of sustainability, with focus on environmental, social and economic measures to deliver this.

5. APPENDICES

- BREEAM MAT 01 Report
- OUFC Match Day Carbon Footprint Report
- Energy Statement
- Low and Zero Carbon Technologies Study

RIDGE

OXFORD UNITED FC
BREEAM MAT 01
RIBA STAGE 2 LCA
14/11/2023

RIDGE

OXFORD UNITED FC
BREEAM MAT 01 - LCA

14/11/2023

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CONTENTS

VERSION	DATE	DESCRIPTION	CREATED BY	REVIEWED BY
1.0	29/09/2023	For Stage 2 BREEAM Submission	NT	KA / XK
1.1	14/11/2023	Updated project description	NT	KA

1. INTRODUCTION

Ridge & Partners LLP have been appointed to undertake a Bespoke BREEAM New Construction V6 assessment for the proposed new stadium development for Oxford United FC. The Proposed Development is undertaking a fully - fitted assessment and is targeting a BREEAM 'Very Good' rating.

Table 1:BREEAM Assessment target Scores

BREEAM ASSESSMENT	TARGETED SCORE
Target rating is "Very Good"	64.96%

The BREEAM assessment for the proposed development is not yet registered with the BRE, therefore a BRE number is not yet available.

To deliver on this commitment under Mat 01, the Proposed Development is targeting:

- Fully Fitted- Other – Mat 01 **6 + 1 Exemplary credits**

The purpose of the assessment is to help project teams understand the environmental impact associated with the construction products specified in their design and to help them identify the most impactful elements and areas in the assessed development. The findings of this report should inform the design decision making process to improve construction resource efficiency and to emphasize the importance of embodied carbon emissions in addition to the operational emissions.

This report summarises the results of the LCA undertaken during Concept Design stage (RIBA Stage 2) before planning permission has been submitted. The exercise will be repeated at RIBA Stage 4, where further modelling will be carried out to identify more opportunities for the Superstructure.

2. PROJECT DESCRIPTION

The Proposed Development is a 16,000-seat stadium located north of Oxford City Centre. An image of the proposed massing is provided below for context.

Figure 1: Proposed Mapping Mode. Source: AFL Architects.

3. METHODOLOGY

3.1. Life cycle assessment

LCA is a method to assess the environmental impacts associated with all stages of a product's life from raw material extraction, material processing, manufacturing, distribution, use, repair and maintenance. Throughout the assessment the constituent elements of the project are modelled and then the environmental impacts reported.

In terms of life cycle stages, there are four stages to be considered.

1. Product stage: Extraction and production of materials, and transportation to the construction site
2. Construction stage: Transporting the materials, the energy to power the construction equipment, supporting construction materials and the disposal of the waste
3. Use stage: Operational energy (e.g. heating, electricity, etc), maintenance, repairs and replacement of materials as and when needed
4. End of life stage: Demolition and recycling or disposal of materials

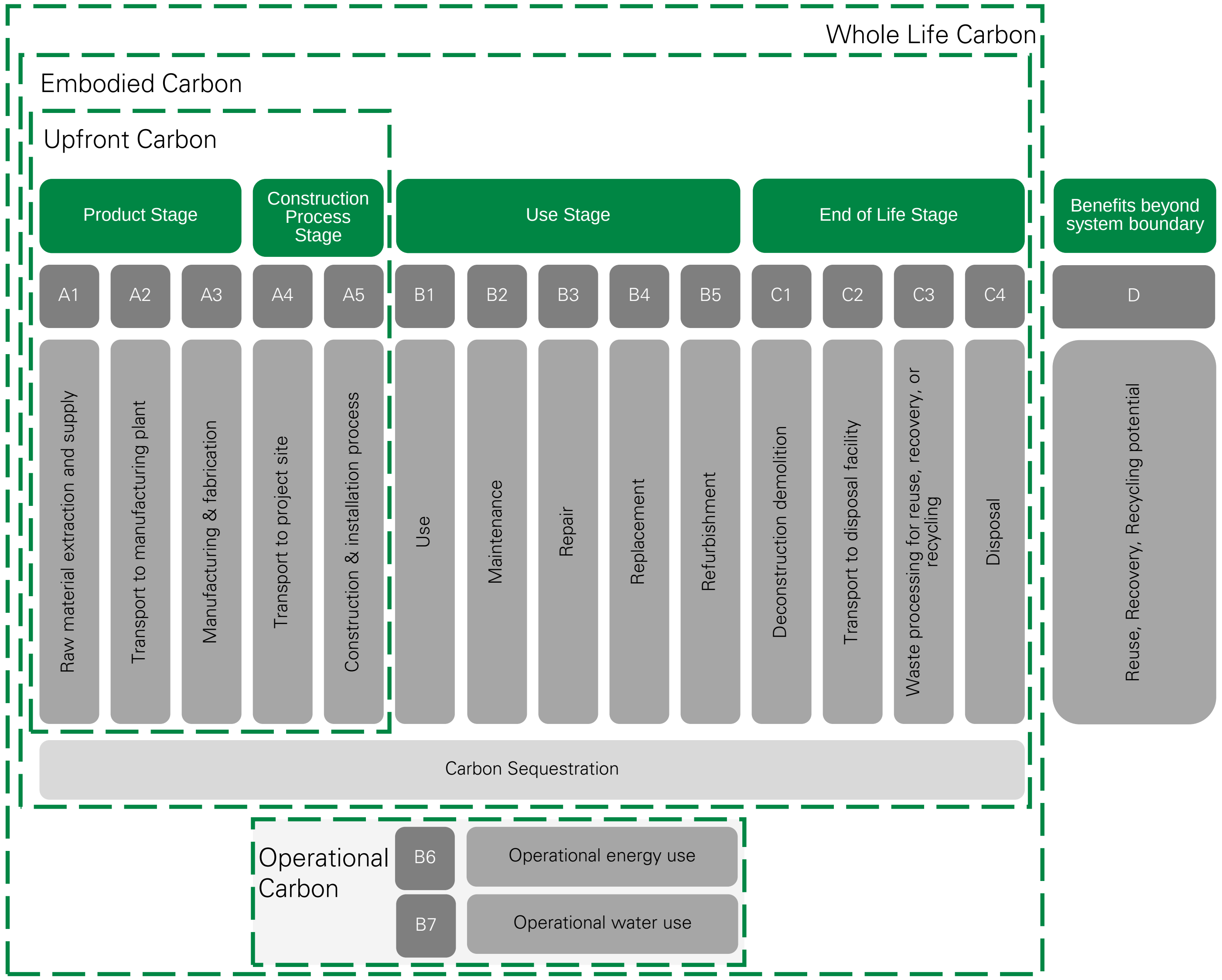


Figure 2: Life cycle stages as per EN15978:2011.

Using an LCA model, various environmental impacts can be reviewed, such as:

Global Warming Potential, GWP ($kgCO_2eq$): GWP is a relative measure of how much heat a greenhouse gas traps in the atmosphere. Greenhouse gases (GHGs) contribute to the greenhouse effect by which heat from the Sun is trapped inside the Earth's atmosphere. Main GHGs include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and volatile organic compounds (VOCs.) The GHG used as the baseline for all potential Global Warming is CO_2, therefore GWP is expressed in $kgCO_2eq$.

Ozone Depletion Potential, ODP (kgCFC-11eq): ODP is a relative value that indicates the potential of a substance to destroy ozone. For instance, many refrigerants contribute towards ozone depletion. As the ozone layer is depleted, the surface of the Earth will be exposed to more ultraviolet radiation from sunlight which can have serious effects on human health, vegetation, but also terrestrial and marine ecosystems.

Acidification Potential (EP ($kgSO_2eq$): The acidification of soils and water occurs predominantly through the transformation of air pollutants into acids, which leads to a decrease in the pH of rainwater and fog from 5.6 and below. Acidification potential is described as the ability of certain substances to build and release hydrogen (H+) ions.

Eutrophication Potential, EP ($kgPO_4eq$): Eutrophication is the enrichment of nutrients in a certain place. It can be both aquatic and terrestrial. All emissions of potassium and nitrogen to air, water, soil and of organic matter to water are aggregated into a single measure.

Global Warming Potential (GWP) is the most commonly used indicator for environmental impact due to the threat of climate change and focus on CO_2 emissions, therefore this study will focus on the development's GWP (in kgCO2eq).

3.2. BREEAM New Construction 2018 / V6 Mat 01 requirements

A Life Cycle Assessment must be undertaken to demonstrate compliance with the Mat 01 requirements in BREEAM New Construction 2018 or V6. The aim of this exercise is to encourage and facilitate the review of different options, to inform the design and promote the consideration of greener alternatives.

Depending on the building type, there are two requirements which need to be carried out to satisfy the issue.

Comparison to the BRE LCA Benchmark
This needs to be demonstrated during Concept Design (Stage 2) and are required for office, industrial and retail building types. However, where a single building use type accounts for < 50% of the net floor area, all criteria except criteria 1 to 2 (comparison with the BREEAM LCA benchmark during Concept Design and Technical Design, respectively) apply.

As the Proposed Development is a sports stadium, this requirement is not applicable to our scheme.

Options Appraisal
This can be carried out for four different specification elements (superstructure, substructure, external hard landscaping and building services). The results must be submitted to the BRE at Concept Design Stage (Stage 2), with the exercise being repeated at Technical Design Stage (Stage 4) for the Superstructure only. The following requirements must be met as per the BREEAM Methodology during RIBA Stage 2:

Superstructure: a minimum of 2, up to 4, significantly different superstructure design options

Substructure & Hard Landscaping: 6 significantly different design options (at least 2 of each)

Core Building Services: 3 significantly different options (optional for an exemplary credit) – **this is currently not**

targeted in our BREEAM assessment.

The scope of the assessment is pre-defined within tables 9.1, 9.2 and 9.3 of the Mat01 issue of BREEAM 2018 / V6 New Construction technical manual, with the elements that are out of scope detailed in tables 9.5, 9.6 and 9.7.

For the Proposed Development, an assessment has been carried out reviewing 4No superstructure options, 3No substructure options and 3No hard landscaping options. The core buildings services have not been completed for this Stage 2 LCA.

4. RESULTS

4.1. Superstructure options analysis

An embodied carbon analysis of four superstructure options has been undertaken and summarised in Table 3 and Figure 3.

The following are the material breakdowns for each options considered:

Table 2: Superstructure options.

Superstructure	Floor slabs and beams	Columns	External Walls	Roof
Option 1 (Baseline)	Steel beams	Steel columns	Ground: Natural stone cladding 1st and 2nd floor: Steel element exterior 3rd and 4th floor: Polycarbonate exterior	Timber roof construction with steel sheet roofing
Option 2	Steel beams	Steel columns	Ground: Natural stone cladding 1st and 2nd floor: Steel element exterior 3rd and 4th floor: Polycarbonate exterior	Timber roof construction with Cross laminated timber (CLT)
Option 3	Steel beams	Steel columns	Ground: Concrete block wall 1st - 4th floor: Steel element exterior	Timber roof construction with Cross laminated timber (CLT)
Option 4	Steel beams	Steel columns	Ground: Natural stone cladding 1st and 2nd floor: Steel element exterior 3rd and 4th floor: Polycarbonate exterior	Steel roof construction with steel sheet roofing

For each option, the construction materials have the most significant impact on global warming potential (GWP), and this is where there is also the most variance.

Option 2 would be expected to result in a **decrease** in GWP of **0.23mil** kg CO_{2e} in comparison to the Baseline. Option 2 uses CLT frames rather than the hybrid timber and steel roof structure. Steel has a much higher embodied carbon value than CLT due to the materiality of the structure, which accounts for the reduction in GWP.

Option 3 would be expected to result in a greater **decrease** in GWP of **0.48mil** kg CO_{2e} in comparison to the Baseline. This option includes a CLT roof structure as well as a replacement of the natural stone cladding exterior wall with concrete block. Stone has a much higher embodied carbon, therefore the replacement of this material, coupled with the use of CLT has reduced the overall GWP.

Option 4 would be expected to result in an **increase** in GWP of **0.02mil** kg CO_{2e} in comparison to the Baseline. This option considers a fully steel roof assembly. Steel has a high embodied carbon, therefore the use of more in replacement of initial timber structure has significantly increased the GWP of the overall structure.

Option 1 is currently the most favoured option for superstructure. Although not the option with the lowest embodied carbon but this structure is the most effective with the current design of the development.

Table 3: Superstructure option analysis.

Life Cycle Stages	Global Warming Potential, kg CO_{2e} (millions)			
	Option 1 (Baseline)	Option 2	Option 3	Option 4
A1-A5 Product Stage	4.99	4.89	4.96	5.14
B1-B5 Replacement and refurbishment	0.54	0.42	0.11	0.43
C1-C4 Deconstruction	0.27	0.26	0.25	0.25
Total	5.80	5.58	5.32	5.82

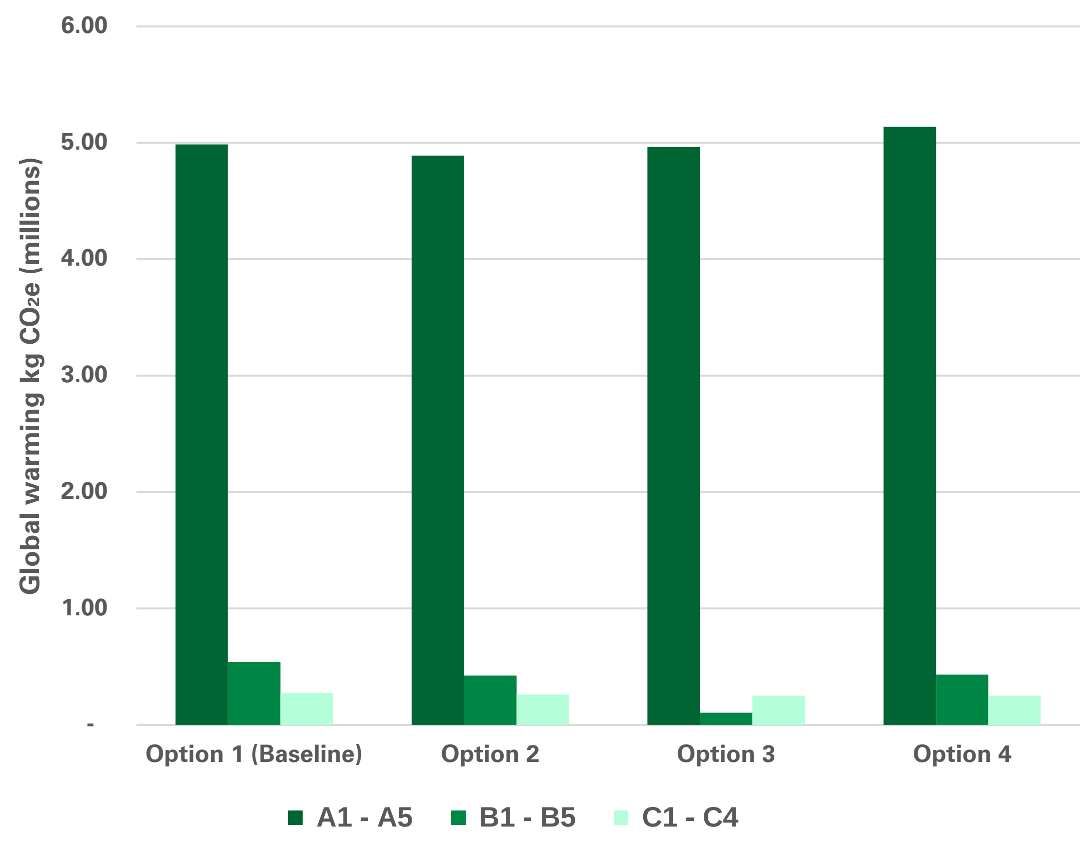


Figure 3: Superstructure option analysis.

4.2. Substructure options analysis

An embodied carbon analysis of two substructure options has been undertaken and summarised in Table 5 and Figure 4.

The following options were considered:

Table 4: Substructure options.

Substructure	Foundations	Lowest Floor Construction
Option 1	Steel piles, 25m depth - GGBS concrete content at 10%	Concrete ground floor slab assembly - GGBS concrete content at 10%
Option 2	Steel piles, 25m depth - GGBS concrete content at 10%	Pre-cast concrete ground floor assembly
Option 3	Steel piles, 25m depth - GGBS concrete content at 50%	Concrete ground floor slab assembly - GGBS concrete content at 50%

For each option, the construction materials have the most significant impact on global warming potential (GWP), and this is where there is also the most variance.

Option 2 would be expected to result in a **decrease** in GWP of **0.16mil** kg $CO_{2e.}$ Pre-cast concrete typically uses half the amount of concrete in comparison to full concrete blocks due to the hollow core voids present. It is also a much stronger materials as it is made in tightly controlled precast factories. The reduction in concrete has resulted in the decrease in GWP.

Option 3 use the same material foundations as Option 1 but with concrete with greater GGBS content at 50%. This is expected to result in a **decrease** in GWP of **0.15mil** kg $CO_{2e.}$ Higher GGBS content means that a higher recycled content is present in the structure, therefore GWP is lower.

Table 5: Substructure options analysis.

Life Cycle Stages	Global Warming Potential, kg CO_{2e} (millions)		
	Option 1 (Baseline)	Option 2	Option 3
A1-A5 Product Stage	2.68	2.60	2.53
B1-B5 Replacement and refurbishment	0.14	0.14	0.14
C1-C4 Deconstruction	0.19	0.11	0.19
Total	3.01	2.85	2.86

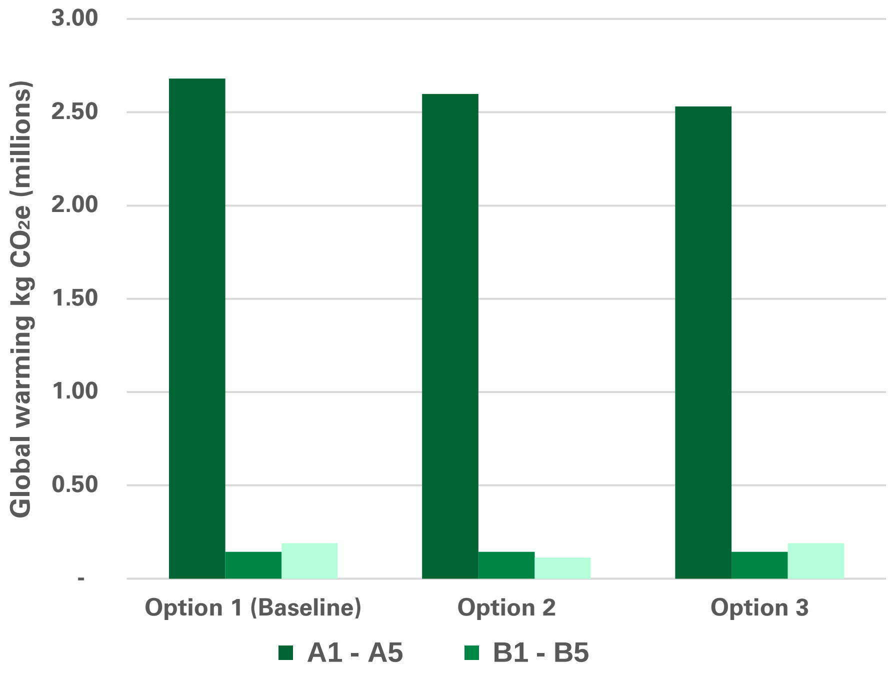


Figure 4: Substructure options analysis.

4.3. Hard landscaping options analysis

An embodied carbon analysis of three landscaping options has been undertaken and summarised in Table 7 and Figure 5.

The following options were considered:

Table 6: Hard landscaping options.

Hard Landscaping	Car Park	Paving	Road
Option 1 (baseline)	Asphalt	Block Paving	Flexible Carriageway
Option 2	Asphalt	Concrete Paving	Flexible Carriageway
Option 3	Permeable paving (concrete paving)	Resin Bound / Flexible Paving	Flexible Carriageway

Option 2 would be expected to result in a **decrease** in GWP of **2.25mil** kg CO_{2e} as the sidewalk paving is replaced from clay pavers to concrete pavers. Clay has a much higher embodied carbon than concrete as they require more energy input during the production process. Although, cement has higher carbon embodiment but they are usually used with lower concentration in comparison to clay.

Option 3 would be expected to also result in a **decrease** in GWP of **2.12mil** kg $CO_{2e.}$ This option involves replacing the asphalt concrete within the car park to permeable concrete paving and the clay block paving for the sidewalks to resin bound concrete surfacing. Overall this option reduces consumption of cement within the structure therefore reducing overall GWP.

Option 1 is currently the most favoured as it is the most aesthetically preferred option. The landscaping design is still being considered and will be reviewed again in later stages.

Table 7:Landscape options analysis.

Life Cycle Stages	Global Warming Potential, kg CO_{2e} (millions)		
	Option 1 (Baseline)	Option 2	Option 3
A1-A5 Product Stage	0.39	0.41	0.30
B1-B5 Replacement and refurbishment	0.44	0.32	0.58
C1-C4 Deconstruction	0.03	0.03	0.02
Total	0.86	0.77	0.90

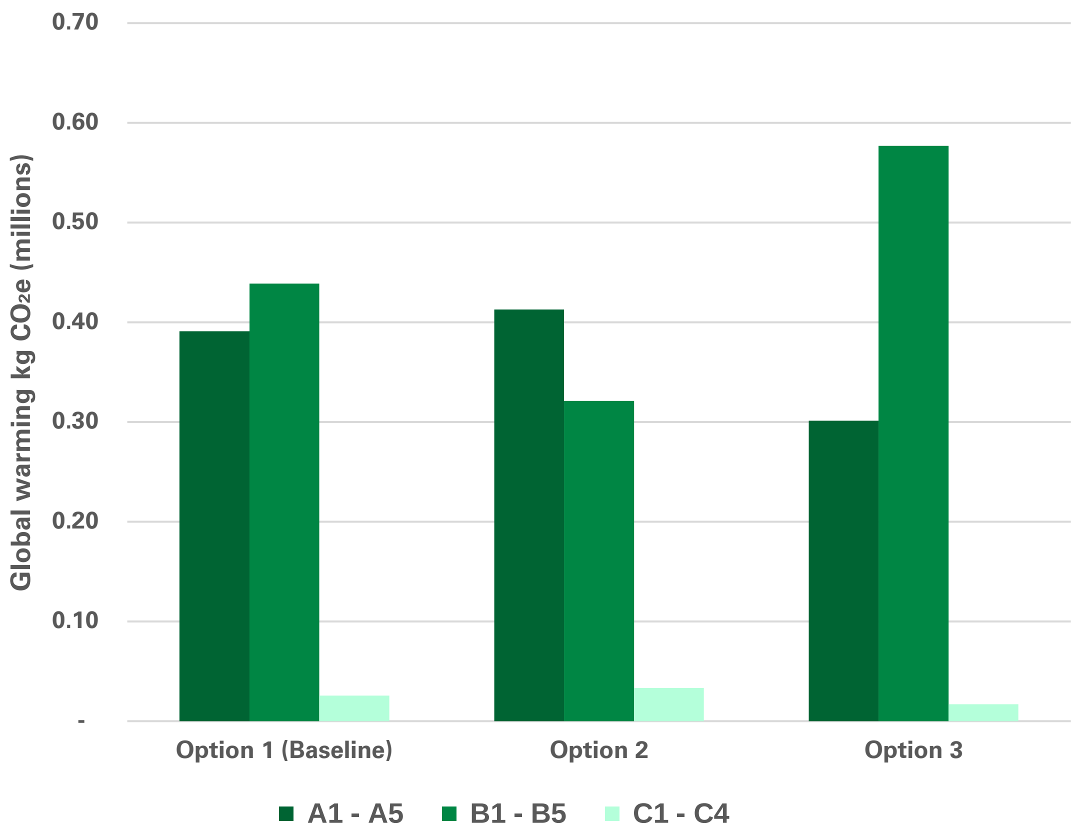


Figure 5: Landscape options analysis.

5. CONCLUSION

This report has provided a review of a variety of options for the superstructure, substructure and external works for this development in accordance with the BREEAM requirements which has allowed 5 Mat 01 credits to be achieved. Please see Appendix A, which established how this has been reviewed by a third party to support the achievement of an additional exemplary credit. If an update to this assessment for the superstructure with third party verification is completed during RIBA Stage 4 – an additional credit and the targeted exemplary credit could be achieved.

A comparison with the BRE benchmark for the proposed building wasn’t necessary as the proposed development is sports stadium.

The intention is that this report is provided to the project team for information at this early stage, with the superstructure options being reviewed again during Spatial Coordination and Technical Design Stage, with at least three more detailed options considered at that stage.

It should be noted that due to the early stage of the development, it is possible that the specifications and weights/areas used will vary from those included in this analysis, so this is an approximation based on the current proposals but is useful by way of providing a summary of the options and their potential embodied carbon impacts to inform the design considerations as they evolve during RIBA Stage 3 and 4.

When considering the design as the scheme moves forwards, the team should be aware that there are many other factors that should be taken into consideration alongside the embodied carbon impact of a material option such as financial cost, buildability, procurement and other environmental impacts.

For the purpose of the BREEAM assessment, the requirement is that an options appraisal is undertaken. This report has given the project team useful information about how the embodied carbon of the development can be reduced therefore it is hoped that the factors highlighted here will be kept under consideration as the scheme develops to help reduce the overall carbon footprint of the development.

6. APPENDIX A: THIRD PARTY VERIFICATION.

This LCA has been reviewed and verified by Xenia Kaldy of Ridge & Partners who meets the BREEAM definition of a suitably qualified third party.

The BREEAM criteria defines a Suitably Qualified Third party as follows:
Suitably qualified third party
An individual who:

- Is a third party
  Xenia Kaldy is acting as the Suitably Qualified third party (definition below) for the verification (production) of the LCA assessment. There is no further role on the project beyond assessment verification services.

- Has received training on using the building LCA tool that is recognised by the tool supplier, and has passed the associated tests or exams (if any).
  Xenia has used OneClick LCA to produce the LCA outputs. And has attended training courses on OneClick LCA. There are no associated tests or exams.

- Has completed at least three different building LCAs for paying customers in the last two years.
  Recent LCA Assessments include:
  Catherine's Junior School
  Quayside, Barking
  Furze Platt

- Is able to interpret construction documentation (drawings, specifications, schedules etc.), which may be evidenced by a suitable construction related qualification or relevant experience.
  Xenia has 3 years' experience working in sustainability and embodied carbon consulting.

Third party
"A person or body that is recognised as being independent of the parties involved, as concerns the issue in question" (BS EN 15804:2012+A1:2013).

The parties involved are typically a supplier (first party, e.g. architect, engineer, LCA practitioner who provides design advice) and a purchaser (second party, e.g. the client).

A person from an organisation not otherwise involved in the project (apart from providing other verification type services e.g. BREEAM Assessment) is a third party, providing they do not provide advice to the project as this would compromise their impartiality when verifying.

Quality requirements

Item	Concept Design	Verified?	Comments
Elemental construction quantities	± 10% of quantities shown in design documents at concept design stage.	✓	Quantities match those provided by the design team.
LCA or EPD data type	Generic or manufacturer-specific. Use the closest matching data in the tool.	✓	Generic and manufacturer-specific data utilised to find the closest matching data.
Product quantities* (mass per unit of elemental construction)	Typical or generic values. Generic (non-project specific) elemental constructions may be used.	✓	Values used from the design team information and OneClick LCA carbon designer tool.
Product transportation distances*		✓	Generic data utilised. Followed RICS Guidance
Product service lives and site wastage*		✓	Generic data utilised.
Adhesives*	Excluded if the adhesive is applied to less than 20% of the product's surface.	✓	Adhesives excluded.
Minor fixings* (e.g. brackets, nails, screws), sealants and ironmongery items	Excluded	✓	Fixings excluded.
Study period*	60 years	✓	60 year study period utilised.
Results reported via the Mat 01/02 Results Submission Tool	Results reported separately for each environmental indicator, for each BS EN 15978:2011 module as follows: – Stage A: A1, A2 and A3 (may be combined). A4 and A5 where possible in the building LCA tool – Stage B: Each module possible in the building LCA tool – – Stage C: As stage B	✓	Stage A1-4, B4-5 and C1-4 reported as per scope of the OneClick LCA BREEAM UK Scope

Oxford United FC

Match Day Carbon Footprint Report

Summary

The carbon emissions associated with a football game are significant, but can be reduced greatly with appropriate design choices and management.

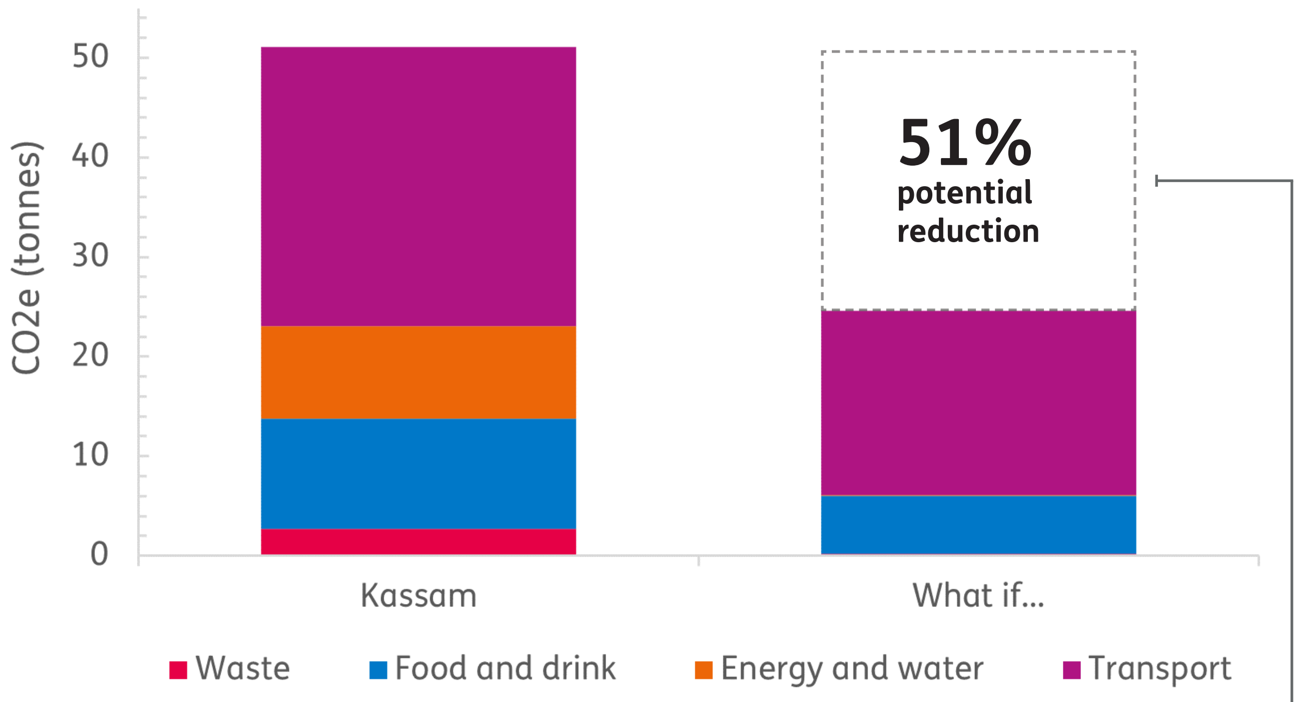
This report has been produced for Oxford United FC by Bioregional and Oxford Brookes University to show the carbon emissions associated with a typical 'match day' for the club at the Kassam Stadium.

Alongside this 'typical' Kassam stadium match day carbon footprint, a "What If..." scenario has been developed for each of the components that make up a typical carbon footprint. This shows how carbon emissions could be reduced if certain sustainable interventions were made to the club. Both by its operations and infrastructure as well as a proposed stadium move. It is important to note that any proposed stadium move would have a large embodied carbon impact that needs to be considered assessing the What If scenarios. This is discussed in more detail on this page.

Key points

- The total footprint at the Kassam Stadium per match is approximately **51 tonnes CO2e**
- Per season, assuming an average of 28 home games, this equates to **1,428 tonnes CO2e**
- The total footprint for the 'What if...' scenarios per match would be **24.8 tonnes CO2e, a reduction of 51%**

Carbon emissions from a typical match day



'What if...' reductions per match day...

If the stadium moved to Stratfield Brake...	**9.4 tonnes CO2e** reduction per game
If the stadium used efficient, fossil-fuel free energy systems, and 100% renewable electricity...	**9 tonnes CO2e** reduction per game
If the concessions menu were plant-based...	**5.2 tonnes CO2e** reduction per game
If single use plastics and excess packaging were removed from concessions...	**2.5 tonnes CO2e** reduction per game
If all the above were implemented...	**26.1 tonnes CO2e** reduction per game **(730.8 tonnes CO2e reduction per season)**

Note on embodied carbon

While some of the 'What if' scenarios would be possible in theory at the Kassam Stadium, such as a change in menu, and measures to reduce waste, the scenarios for energy and fan travel are only feasible through a move to a new stadium site due to the stadiums geographical context, and the current ownership and contractual situation .

The construction of a new stadium, even using the most sustainable materials and practices, would result in a huge amount of embodied carbon being emitted.

Hence it will be essential to address the choice of sustainable materials, design and embodied carbon, to reduce this upfront impact.

An estimate for the embodied carbon of a new stadium was made using the London Olympic Stadium as a benchmark. While the proposed new stadium is larger than at the Kassam Stadium, to keep the footprint calculations comparable, our analysis has imagined a stadium of the same seating capacity as Kassam, built to best practice standards.

At 0.6 tCO2e per seat, and 12,500 seats, this would give an embodied carbon figure of 7,500 tCO2e.

Over a 60 year lifespan, this would equate to 125 tCO2e per year, and based on an average of 28 home games per season, equates to ~4.5 tCO2e per match.

These figures are highly sensitive to the assumed life-span of the new stadium.

Put another way, it could take over 10 seasons worth of OUFC games for the operational savings to 'pay back' the upfront carbon if all 'What if...' interventions were implemented (or significantly less if other uses of the stadium are also considered).

Fan travel

Fan travel is the largest contributor to OUFC's match-day footprint by a considerable margin. It contributes approximately 55% of the total, with 28 tonnes CO_2e.

This is due to a combination of factors, though can mainly be attributed to the limited access to the stadium via public transport, resulting in a high reliance on private cars to travel to games.

How?

Face to face surveys were conducted with fans over two match days to collect travel data, including postcode of origin, mode of transport used, and the size of the group travelled with.

Statistical modelling techniques were used to scale the responses to accurately represent an average match turnout, accounting for differences in home and away ratios, and games played on different days of the week.

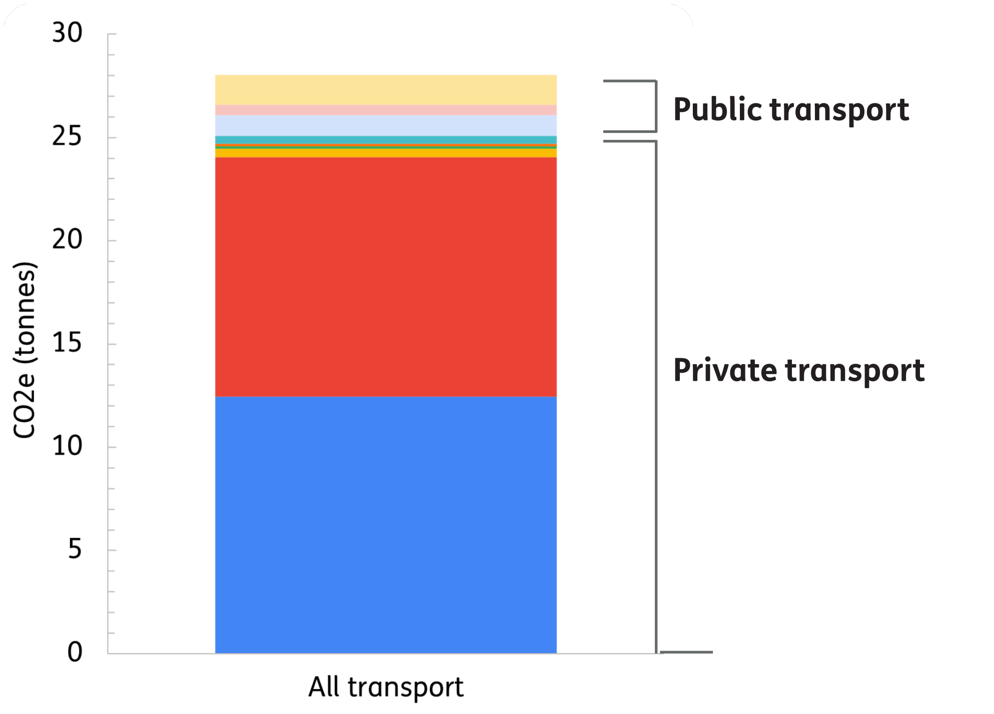
Following this, the distances travelled for all fans were calculated, which were then converted to carbon equivalent emissions using DEFRA carbon conversion factors.

What if?

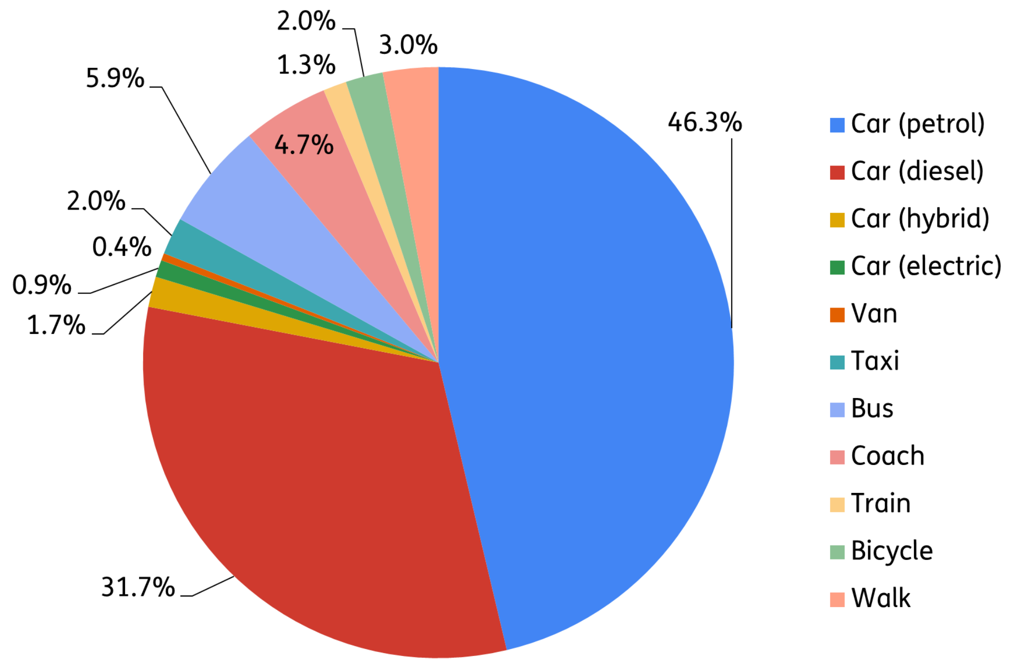
This 'what if?' scenario saw us model the carbon emissions based upon how fans stated they would prefer to travel to games, if the stadium were to move to Stratfield Brake, sourced from an additional survey.

Note: as this survey was likely to be majority OUFC fans, and the transport categories do not fully align between the two studies, some adjustments were necessary to represent away fans, and where necessary data were assigned to the closest related category.

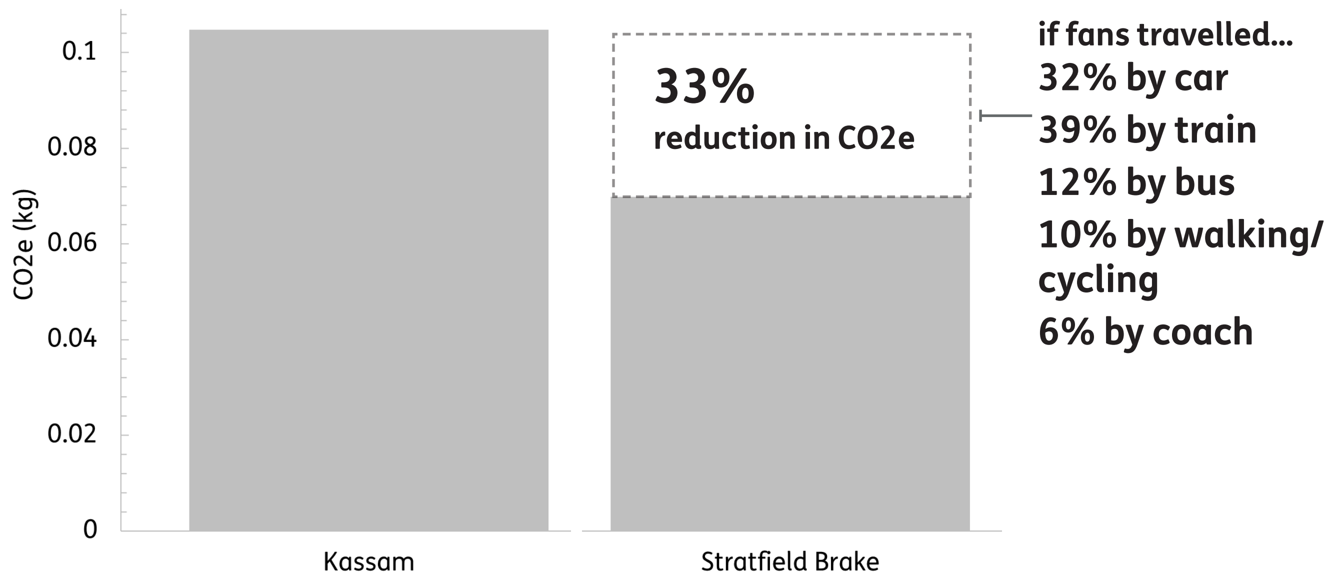
Emissions from fan travel at the Kassam Stadium per game



How fans travel to games to the Kassam Stadium



How do emissions from the 'What if...' scenario compare?



Average emissions per km of fan travel

So what?

This shows us that the location and connectivity of a stadium is incredibly important in influencing carbon emissions.

By having a well connected stadium with strong and accessible public transport links, there is an opportunity to greatly reduce dependence on car travel to get to games, and lower a typical match-day footprint significantly. This 'What if...' scenario resulted in a reduction in emissions by 9.4 tonnes per game, though in reality, this could be lowered much further if sustainable travel options are incentivised and encouraged at the new stadium.

Energy and water use

Significant carbon emissions from energy use are caused by reliance on energy from fossil fuels. This is predominately through the use of gas boilers for heating and hot water, and no generation of renewable electricity or heat.

Resultantly, at the Kassam Stadium, OUFC is responsible for 254.4 tonnes CO2e per season through operational energy consumption – approx. 9 tonnes CO2e per game (assuming 28 games incl. cup and friendly fixtures).

How?

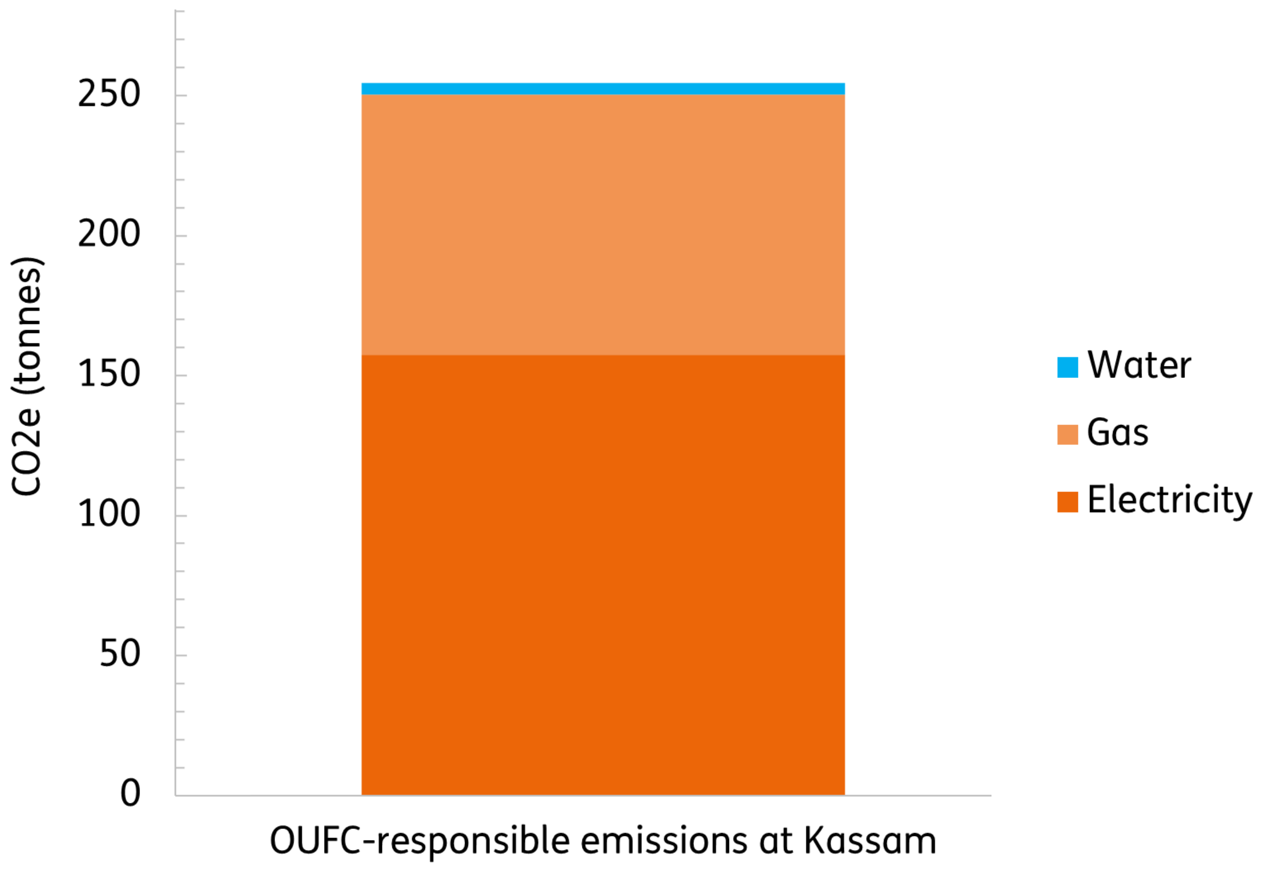
Modelled from OUFC utility bills (adjusted for the fact that not all energy use from the Kassam Stadium is used by OUFC). Electricity and gas charges were converted to kWh consumption using data from BEIS. kWh energy use was then converted into carbon emissions via DEFRA conversion factors.

A similar process was undertaken to calculate emissions from water, using Thames Water to convert charges into m^3 water use, and subsequently converted into carbon emissions for water supply and treatment again using DEFRA factors.

What if?

This 'what if?' scenario assumes a zero fossil fuel energy system being implemented if the stadium were to move to Stratfield Brake, and all electricity used to be from renewable sources. Water efficiency measures are also assumed to be implemented, such as low flow fixtures and fittings, and rainwater harvesting, to reduce water consumption by 40%, to RIBA best practice standards.

Emissions from energy use for an average season



How much lower would the 'What if...' emissions be?

Emissions (tCO2e)	Kassam	'What if...'
Gas	92.9	0
Electricity	157	0
Water	4.1	2.5
Total	254.4	2.5

over
250 tCO2e
reduction per season

Note on grid decarbonisation

While the carbon emissions from gas combustion remain largely constant, emissions relating to electricity from the UK grid are decreasing over time as the grid decarbonises and shifts to renewable sources.

Therefore, it can be expected that the emissions from electricity use at Kassam will decrease over time and become a smaller proportion of total emissions relating to energy.

So what?

The amount of carbon emissions associated with using gas as a fuel, and electricity from non-renewable sources, are vast and must be addressed to limit the Club's climate change impact.

A move away from fossil-fuel based energy, and increasing water efficiency, would save around 9 tonnes CO2e per match.

Consumption

The food and drink purchased at games, and associated waste, currently contribute approximately 13.8 tonnes CO2e per match, 22% of the total footprint. Animal products, especially meat, have high associated emissions. 8/10 of the hot menu items at match day concessions contain meat as a main ingredient, and all the items contain animal products.

The emissions calculations include those related to producing, packaging, and transporting an item to the point it reaches a fan, and subsequently the emissions involved in disposing of waste associated with the item.

How?

Food and drink - modelled from concessions sales data for each menu item. Each menu item was been broken into ingredients and weight, and converted to carbon emissions via bespoke conversion factors.

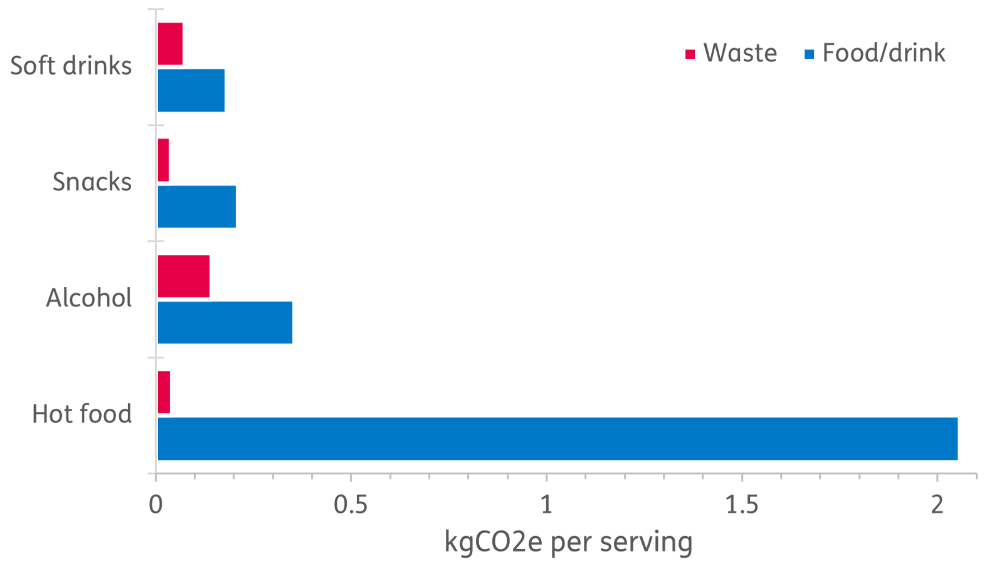
Waste - the components and weight of packaging materials associated with each menu item were calculated. The total waste figures were then converted to emissions via DEFRA factors, and were combined with the emissions associated with waste disposal.

What if?

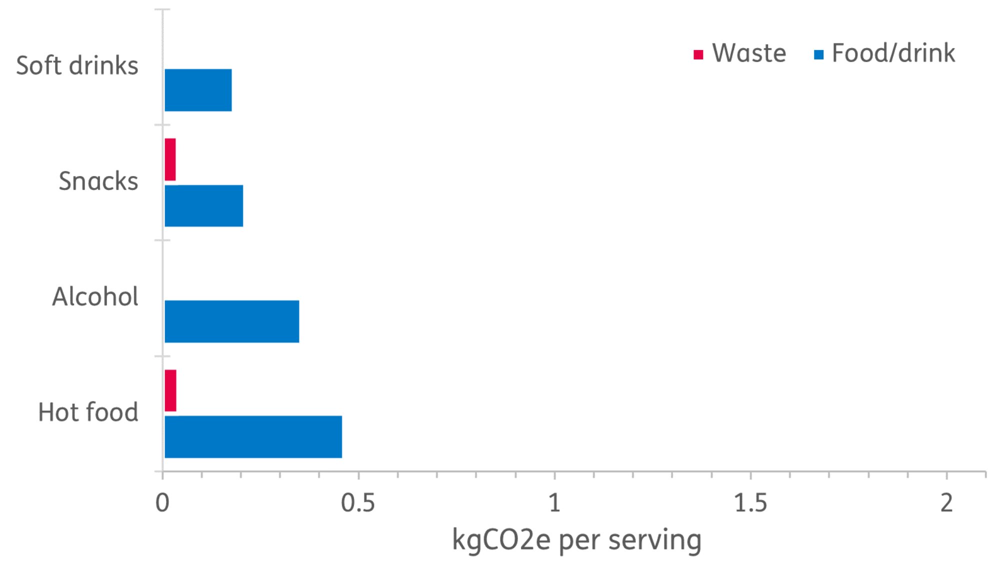
Food and drink - replacing the emissions associated with every meat/ animal ingredient in the current concessions hot food menu with a plant-based substitute/alternative.

Waste - all emissions related to single-use plastics and unnecessary packaging were removed.

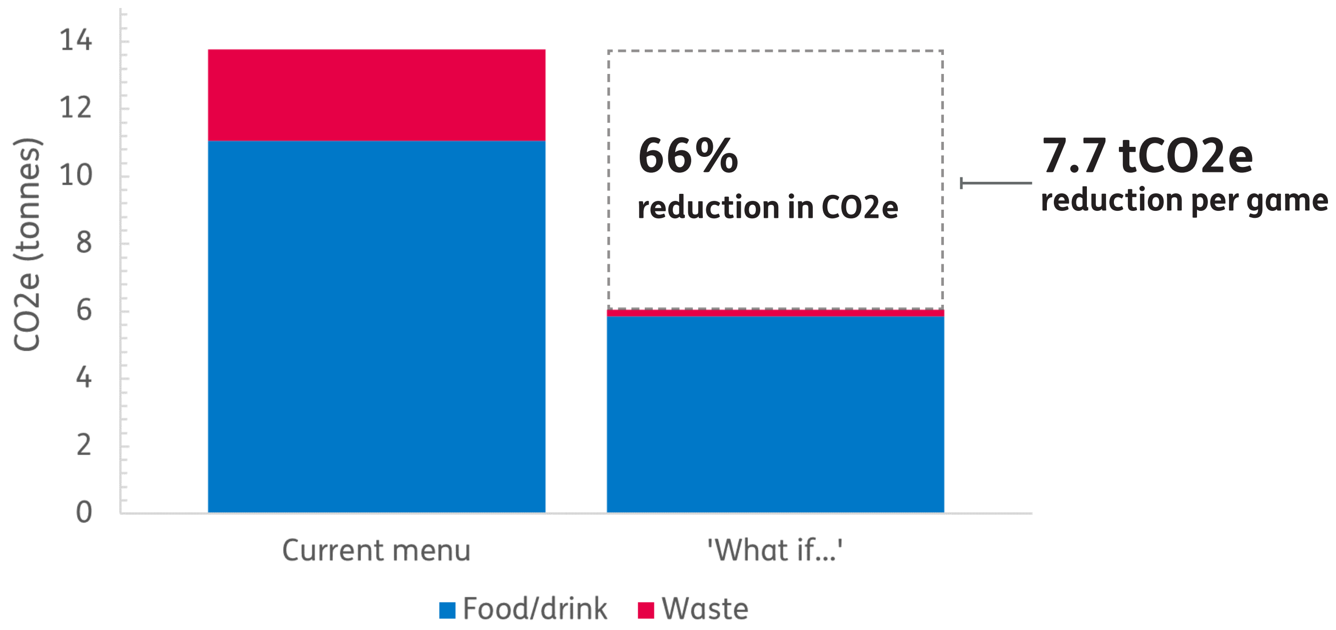
Average emissions per serving from current menu



Average emissions per serving from 'What if...' scenario



Total emissions from consumption on an average match day



So what?

The type of food on offer from concessions is one of the simplest ways in which the match-day footprint can be reduced. Switching to a plant-based menu would decrease the carbon emissions from food consumption by 5.2 tCO2e.

This, combined with the elimination of single use plastics and other unnecessary packaging, would reduce consumption-based emissions by 66%. This would provide the largest percent reduction in emissions of all the 'What if...' scenarios presented in this report.

Produced by Bioregional and Oxford Brookes University for Oxford United Football Club

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Oxford United Football Club

Energy Statement - New Football Stadium

September 2023

Confidential

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Energy Statement - New Football Stadium

September 2023

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Issue and Revision Record

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Information class: Standard

Contents

A.1.1 Figures

Executive Summary

The following document is intended to provide input data and results from a Building Regulations Part 2 IES model assessment for the proposed Oxford United Football Club Stadium development. It aims to deliver the required evidence for the purposes of Building Regulations compliance.

A computer model was generated using Integrated Environmental Solutions Virtual Environment software (IES-VE) to assess the improvement the Building Emission Rate (BER) can make over the calculated Target Emission Rate (TER) in compliance with the calculation procedures of the Approved Document Part L2 of the Building Regulations 2021.

The model reflects the proposed development including:

- A fabric-first approach using high performing building materials to minimise heat losses and heat gains, to minimise the energy demand of the development.
- Use of highly efficient systems to serve the development with the minimum quantity of energy usage.
- Use of renewables to generate heat and power on site to minimise the quantity of primary energy imported into site to serve the development.

For the proposed Stage 2 design it has been found that the development is compliant with the requirements of Building Regulations Part L2 (2021) achieving a 6.27 $kgCO_2/m^2$.annum BER (Better than the required 6.31 $kgCO_2/m^2$.annum TER) and 66.29 $kgCO_2/m^2$.annum BPER (Better than the required 68.5 $kgCO_2/m^2$.annum TPER).

1 Introduction

This document describes the energy assessment carried out for the proposed Oxford United Football Club (OUFC) stadium development regulated under Approved Document Part L2 2021 (ADL2 (2021))of the Building Regulations. It aims to deliver compliance with the Part L 2021 regulations through an improvement over the Target Primary Energy Rate (TPER) and Target Emission Rate (TER).

1.1 Purpose

The purpose of this Energy Assessment is to:

- Determine the annual energy consumption and Carbon Dioxide (CO_2) emissions associated with the regulated services being provided within the new regulated areas of the stadium development.
- Demonstrate how compliance with Building Regulations ADL2(2021) can be achieved, by producing calculations to show that the building has the potential to meet both of the following as a minimum, as required in line with Regulation 26 and 26C of the Building Regulations Part L:
  - Target Primary Energy Rate and
  - Target Emission Rate.

1.2 Scope

The Scope of this Energy Assessment is to determine the regulated energy consumption and associated CO_2 emission levels associated with the regulated services being provided within the new regulated areas of the proposed OUFC Stadium development. It is understood that compliance with ADL2(2021) is sought as a minimum.

In order to determine the regulated energy consumption and associated CO_2 emission levels, the National Calculation Methodology (NCM) for ADL2(2021) has been followed and the building has undergone Dynamic Thermal Modelling (DTM) in line with the Approved Document Part L 2021, Volume 2: Buildings other than dwellings.

It should be noted that Regulation 25B of the Building Regulations Part L stipulates that 'where a building is erected, it must be a nearly zero-energy building'. As such, it is expected that the final combination of energy efficiency solutions for the building will be determined following analysis of the technical, environmental and economic feasibility of using high efficiency systems and solutions to maximise improvement over the ADL2(2021)baseline.

1.3 Building Regulations Part L Volume 2 (2021)

The new building shall comply with Building Regulations Approved Document Part L Volume 2: Buildings other than dwellings, 2021 edition (ADL2(2021)).

ADL2(2021)sets the legal requirements for the energy efficiency and carbon emissions for new buildings, other than dwellings. Target levels are set for building envelope performance and plant efficiencies as opposed to specifying materials and schemes. Further plant efficiency limits are outlined in the Non-domestic Building Services Compliance Guide.

In order to comply with ADL2(2021), the carbon emissions of the completed development (Building Emissions Rate – BER) must be below a calculated target value (Target Emission Rate – TER), based on the comparison of the real and notional buildings.

A.1.2 Tables

2 Thermal Model

2.1 Calculation Methodology

The National Calculation Methodology (NCM) 2021 is used to calculate the CO_2 emission rates (BER and TER) and the primary energy rate (PBER and PTER) for the assessed regulated spaces for the proposed OUFC Stadium development. The IES-VE 2023.1.0 software was utilised for this assessment - an approved building energy calculation software listed by UK NCM.

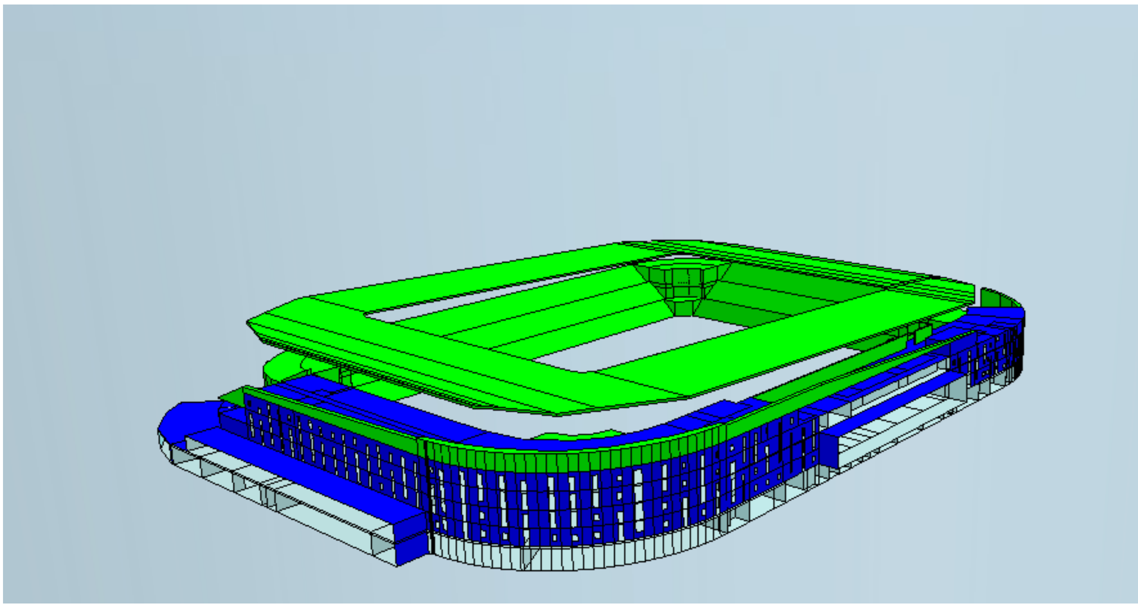
2.2 Building Modelled

A 3D model of the proposed development was generated in the above software based on the architectural Revit Model (OUFC-AFL-ZZ-XX-M3-A-00002_Central Model_P03) provided by AFL Architects received on 15/08/2023.

All models reflect the latest architectural design available at the time of carrying out the assessments, as described above. If any later updates of the architectural design occur, these may impact the energy and thermal comfort assessments and will be modelled at subsequent design stages as appropriate.

The figure below illustrates the geometry of the 3D thermal model simulated under dynamic climatic conditions.

Figure 1: Screenshot of IES-VE Model



Source: Mott MacDonald IES-VE Model

2.3 Building Elements and Fabric Performance

2.3.1 Fabric Specification

The following fabric specification was utilised in the creation of the IES-VE model based upon discussion between Mott MacDonald and AFL Architects on 06/09/2023. The proposed U-values are selected to represent a highly performing building development. The construction of the U-values reflects suggested excellent U-values, and these will be updated with final material selections at a later Stage.

The chosen values exceed the ADL2(2021) notional building values. 'Notional Values' are the performance level upon which the ADL2(2021) TER and TPER are based.

Table 1 below gives the envelope thermal properties used for the modelling exercise.

Table 1 U-values of Building Elements

Element	Part L 2021 Limiting Value	Part L 2021 Notional Building	Stadium Development Proposed U-Values
External Wall	0.26	0.18	0.17
Ground/Exposed Floor	0.18	0.15	0.12
Roof	0.18	0.15	0.12
Window, rooflights, doors	1.60	1.40 g-value: 0.29, VLT: 60%	1.30 g-value: 0.34, VLT: 50%
External Door	1.60	1.40	1.20

Source: Technical Handbook: Non-Domestic

2.3.2 Air Tightness

The building has been modelled with a low (good performing) air permeability rate of $3m^3/m^2h@50Pa$.

2.3.3 Thermal Bridging

Default thermal bridging values have been used for the building following the NCM for ADL2(2021) energy and CO_2 emission calculations.

2.4 Building Services Strategies

2.4.1 Lighting Specification

The lighting specification is important in achieving the targeted energy efficiency results. CO_2 emissions associated with lighting systems are commonly the highest individual element contributing to the total regulated BER. It is therefore important to identify lighting solutions to achieve the target efficacy.

At the time of writing (RIBA Stage 2 design), no detailed lighting calculations have been carried out other than definitions of lux levels for each space type and identification of the associated control strategies. Therefore, all lighting efficacy values for this assessment are based upon estimated values derived from detailed design calculations from a similar project. Any unknown values have been set to the ADL2(2021) minimum requirement as a worst-case scenario. This strategy was confirmed by the Mott MacDonald Electrical team on 08/09/2023. The lighting gain for each room can also be found in the IES-VE model. Daylight linking has only been applied to rooms with external windows, and in those spaces only the first 7 metre zone from the external wall.

Throughout the proposed building, the following lighting control types have been used in corresponding areas and can be referred to within the IES-VE model for full details.

Table 2 Occupancy Sensing and Associated Room Type

Occupancy Sensing	Room Type
AUTO-ON-OFF	Plant Rooms, Match Delegates, Media Area, Plunge Pool and Office.

Occupancy Sensing	Room Type
None	General Access (GA) Concourse, Associated toilets and Circulation
AUTO-ON-DIMMED	Non-GA Toilets, Commercial Areas and Entrances.
AUTO-ON-OFF	Dressing Rooms, Changing Room, Facilities Area, Storage, NHS Centre, Gym, Players & Officials Area, Cleaner's Store and Indoor Play.

Light metering has been incorporated in line with ADL2(2021).

Building lighting controls have been assigned with automatic monitoring and targeting, with alarms for out-of-range values.

2.4.2 Heating, Cooling and Ventilation Strategy

Table 4 below provides an outline of the heating, cooling and ventilation strategies applied to the various room types. These are based on the RIBA Stage 2 heating, cooling and ventilation philosophy design.

Note, the system efficiencies are based on a combination of manufacturer data (preliminary selections) and NCM modelling guide. For spaces where there was no heating, cooling or ventilation applied on the strategies, the adjacent strategies were adopted in line with NCM modelling guidelines to assess those spaces against ADL2(2021). All assumed parameters have been marked in italics in Table 3, below.

Table 3 Heating, Cooling and Ventilation Specification

Room Type	Strategy	Seasonal Coefficient of Performance (SCoP)	Seasonal Energy Efficiency Ratio (SEER)	Weighted Specific Fan Power (SFP) (W/l/s)	Heat Recovery Thermal Efficiency
Players Officials Area/ Media Area/ Hospitality/ GA Concourse	Stadium AHU	3.31	5.36	1.8	*76%*
Hotel Area	Hotel HVRF	3.31	5.36	1.8	*76%*
Kitchen	Kitchen (No heating), and cooling. Just tempered supply via kitchen canopy)	3.31	-	1.8	*76%*
Commercial & Community Areas	Commercial Local VR & MVHR	3.96	6	1.8	*76%*
Stairs / WCs / Showers / Cleaners Store	Low Temperature Hot Water (LTHW) Heating - Radiant Panel	3.31	-	-	*80%*

Demand control of ventilation has been assumed through variable fan speed control based on CO_2 sensors to minimise flow rate to maintain CO_2 levels.

For detailed system assignment, please refer to the IES-VE model.

2.4.3 Domestic Hot Water Strategy

The following Tables 4 ,5 and 6 sets out the performance of the Domestic Hot Water (DHW) systems based on manufacturer quote from Mitsubishi. Loop length is estimated as double the perimeter of the designated areas plus 20%.

Table 4 DHW - Commercial

Specification	Proposed Design Model
Fuel Type	Direct or electric storage heater
Heat Source	Heat Pump Electric
Seasonal Thermal Efficiency – SCOP	3.43
Delivery Efficiency	95%
Storage Volume	1,000 litres
Loop Length	10 m

Table 5 DHW - Hotel

Specification	Proposed Design Model
Fuel Type	Direct or electric storage heater
Heat Source	Heat Pump Electric
Seasonal Thermal Efficiency – SCOP	3.43
Delivery Efficiency	100%
Storage Volume	9,000 litres
Loop Length	302 m

Table 6 DHW - Stadium

Specification	Proposed Design Model
Fuel Type	Direct or electric storage heater
Heat Source	Heat Pump Electric
Seasonal Thermal Efficiency – SCOP	3.43
Delivery Efficiency	95%
Storage Volume	13,950 litres
Loop Length	1198.7 m

2.4.4 HVAC Monitoring

Metering provision, central time control, optimum start/stop control, local time control, local temperature controls have been assigned throughout the development.

2.4.5 Power Factor Correction

A power correction factor of more than >0.95 has been assumed for the building.

2.4.6 Weather File

The CIBSE 2016 Test Reference Year (TRY) weather file for London (closest to Oxford) was used in the thermal model, as appropriate for the ADL2(2021) assessment. The default outdoor winter design temperature of -5.5°C was taken from the weather file.

2.4.7 Heat Gains and Internal Conditions

The latest NCM 2021 version 6.1.b internal conditions have been applied to the occupied spaces of the building, in-line with the requirements of the calculation methodology. Internal conditions for the NCM D2: General Assembly and Leisure (Stadium), C1:Hotel and C2:Hospital (for the NHS Centre and Medical Emergency room) type were applied respective of the space function.

Full list of the NCM Activity assignment and associated system allocation is presented in the IES-VE model.

2.4.8 On-Site Renewable Technology

ASHPs as described above have been incorporated for undersoil heating, and general LTHW heating systems. A total of 3,000 m^2 of Photovoltaic panels (PV) with a 2° tilt angle have been included within the assessment of the proposed development.

3 Building Regulations Part L

3.1 Baseline Model

The performance data for the OUFC development has been extracted from the IES-VE model in the form of a BRUKL Output Document. Table 7 indicates the target and building CO_2 emission rates and the primary energy rates, indicating baseline performance against the ADL2(2021) target values.

Table 7 Baseline Model BRUKL Report Metrics

Metric	Result
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	6.31
Building CO_2 emission rate BER), $kgCO_2/m^2$.annum	8.52
Target primary energy rate (TPER), kWh/m^2. annum	68.5
Building primary energy rate (BPER), kWh/m^2. annum	**92.48**

Source: BRUKL Report

The introduction of PV panels presented with the following performance data:

Table 8 Proposed Development BRUKL Report Metrics (Includes 3,000m^2 PV)

Metric	Result
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	6.31
Building CO_2 emission rate BER), $kgCO_2/m^2$.annum	6.27
Target primary energy rate (TPER), kWh/m^2. annum	68.5
Building primary energy rate (BPER), kWh/m^2. annum	**66.29**

Source: BRUKL Report

This BRUKL documents presented in Appendix A.

4 Appendices

A. BRUKL Document With 3,000m2 PV

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Oxford United Football Club

As designed

Date: Wed Sep 27 21:05:32 2023

Administrative information

Building Details

Address: Address 1, City, Postcode

Certifier details

Name: Yasmin Meor Azlan

Telephone number: Phone

Address: 9 Portland Street, Manchester, M1 3BE

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 3573.52

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	6.31	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	6.27	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	68.5	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	66.29	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

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

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.17	0.17	0000000B:Surf[2]
Floors	0.18	0.13	0.22	01000020:Surf[0]
Pitched roofs	0.16	0.12	0.12	00000058:Surf[0]
Flat roofs	0.18	0.12	0.12	0100000B:Surf[0]
Windows** and roof windows	1.6	1.3	1.3	0000015A:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.2	1.2	00000063:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- AHU Stadium

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	5.36	0	1.8	0.76
Standard value	2.5*	N/A	N/A	2^	N/A
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.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

2- Radiant Ceiling + AHU Stadium

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	-	0.67	0	0.76
Standard value	2.5*	N/A	N/A	N/A	N/A
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.

3- LTHW Radiant Panel

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	-	0.67	0	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
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.

4- Hotel HVRF

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	5.36	0	-	0.8
Standard value	2.5*	5	N/A	N/A	N/A
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.

5- Kitchen

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	-	0	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
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.

6- Overdoor Heater

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.31	-	0.67	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
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.

7- Commercial Local VRF

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.96	6	0	-	0.8
Standard value	2.5*	5	N/A	N/A	N/A
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.

1- DHW - Stadium

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	3.43	0.005
Standard value	2*	N/A

* Standard shown is for all types except absorption and gas engine heat pumps.

2- DHW - Hotel

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	3.43	0.005
Standard value	2*	N/A

* Standard shown is for all types except absorption and gas engine heat pumps.

3- DHW - Commercial

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	3.43	0.005
Standard value	1	N/A

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
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 balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

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	2.3	2	0.5	0.5	0.4	1	Zone	Standard
00 - Sports Med	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Cryo	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Massage A	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Team A Dressing Room	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation (Change)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Change	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Plunge Pool	-	-	-	-	-	-	-	0.3	-	-	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	2.3	2	0.5	0.5	0.4	1	Zone	Standard
00 - Change	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Doping	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Warm up	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Ref Change F&M	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Match Delegates	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Medical Emergency	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Plunge Pool	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Change	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Coach Change B	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Massage B	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Team B Dressing Room	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Media Theatre	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Media Working Area	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Reception (Players & Officials)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Perf. Analysis	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Head Coach	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Head Coach	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Coach Change A	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Kitchen/Bar 2	-	-	0.8	-	-	-	-	-	0.8	-	N/A
02 - Kitchen	-	-	0.8	-	-	-	-	-	0.8	-	N/A
03 - Board Room	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Kitchen	-	-	0.8	-	-	-	-	-	0.8	-	N/A
03 - Toilets	-	-	0.5	-	-	-	-	-	-	-	N/A
03 - Toilets	-	-	0.5	-	-	-	-	-	-	-	N/A
03 - Directors Lounge	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Sky Boxes	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Kitchen	-	-	0.8	-	-	-	-	-	0.8	-	N/A
03 - Toilets	-	-	0.5	-	-	-	-	-	-	-	N/A
03 - Sky Boxes	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Sensory Room	-	-	-	-	-	-	-	0.3	-	-	N/A
04 - Control Room	-	-	-	-	-	-	-	0.3	-	-	N/A
04 - PA/Screen	-	-	-	-	-	-	-	0.3	-	-	N/A
04 - TV Studio	-	-	-	-	-	-	-	0.3	-	-	N/A
04 - Crisis Manage	-	-	-	-	-	-	-	0.3	-	-	N/A
04 - Support	-	-	-	-	-	-	-	0.3	-	-	N/A
02 - Silver Lounge	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Toilet	-	-	0.5	-	-	-	-	-	-	-	N/A
00 - Player Tunnel	-	-	-	-	-	-	-	0.3	-	-	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	2.3	2	0.5	0.5	0.4	1	Zone	Standard
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Toilets	-	-	0.5	-	-	-	-	-	-	-	N/A
01 - Concorse Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Concorse Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Kitchen	-	-	0.8	-	-	-	-	-	0.8	-	N/A
00 - Ball Kids	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - VOC	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Staff Change	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Bin Store	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Steward Jacket Store	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium Space	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium GA	-	-	-	-	-	-	-	0.3	-	-	N/A
03 - Kitchen	-	-	0.8	-	-	-	-	-	0.8	-	N/A
02 - Hotel Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Housekeeping	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Photographers	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Player's Entrance Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Accessible Tribune	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium GA (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium GA (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium GA (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Premium GA (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Gym (P)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Gym (I)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Restaurant (P)	-	-	-	1.8	-	-	-	-	-	-	N/A
00 - Restaurant (I)	-	-	-	1.8	-	-	-	-	-	-	N/A
00 - Sports Bar (P)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Circulation (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Circulation (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
02 - Kitchen (P)	-	-	0.8	-	-	-	-	-	0.8	-	N/A
01 - Lounge Toilets (P)	-	-	0.5	-	-	-	-	-	-	-	N/A
01 - Lounge Toilets (I)	-	-	0.5	-	-	-	-	-	-	-	N/A
01 - Kitchen/Bar 2 (P)	-	-	0.8	-	-	-	-	-	0.8	-	N/A
01 - Kitchen/Bar 2 (I)	-	-	0.8	-	-	-	-	-	0.8	-	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	2.3	2	0.5	0.5	0.4	1	Zone	Standard
01 - Gold Lounge (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Gold Lounge (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Office (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Office (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - NHS Centre (P)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - NHS Centre (I)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Indoor Play	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Indoor Play (P)	-	-	-	1.8	-	-	-	-	-	-	N/A
00 - Indoor Play (I)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - GM Workshop (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - GM Workshop (I)	-	-	-	-	-	-	-	0.3	-	-	N/A
00 - Sports Bar (I)	-	-	-	1.8	-	-	-	-	-	-	N/A
00 - Sports Bar (I)	-	-	-	1.8	-	-	-	-	-	-	N/A
00 - Club Shop & Ticket Office (P)	-	-	-	0.9	-	-	-	-	-	-	N/A
00 - Club Shop & Ticket Office (I)	-	-	-	0.9	-	-	-	-	-	-	N/A
01 - Silver Lounge (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
01 - Silver Lounge (P)	-	-	-	-	-	-	-	0.3	-	-	N/A
02 - Kitchen (I)	-	-	0.8	-	-	-	-	-	0.8	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m^2]
Standard value	95	80	0.3
00 - Sports Med	100	-	-
00 - Cryo	100	-	-
00 - Massage A	100	-	-
00 - Team A Dressing Room	100	-	-
00 - Circulation (Change)	100	-	-
00 - Change	100	-	-
00 - Toilets	100	-	-
00 - Plunge Pool	100	-	-
00 - Showers	100	-	-
00 - Change	100	-	-
00 - Doping	100	-	-
00 - Warm up	100	-	-
00 - Circulation	100	-	-
00 - Ref Change F&M	100	-	-
00 - Match Delegates	100	-	-
00 - Medical Emergency	100	-	-
00 - Pitch Toilet	100	-	-
00 - Plunge Pool	100	-	-
00 - Toilets	100	-	-
00 - Change	100	-	-
00 - Showers	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Coach Change B	100	-	-
00 - Massage B	100	-	-
00 - Team B Dressing Room	100	-	-
00 - Circulation	100	-	-
00 - Multi-Faith Room	100	-	-
00 - Media Theatre	100	-	-
00 - Media Working Area	100	-	-
00 - Reception (Players & Officials)	100	-	-
00 - Perf. Analysis	100	-	-
00 - Head Coach	100	-	-
00 - Head Coach	100	-	-
00 - Coach Change A	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - Bin Store	100	-	-
00 - GA Concessions	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
01 - Hotel Plant Room	100	-	-
01 - Hotel Circulation	100	-	-
01 - Hotel Rooms	100	-	-
01 - Hotel Rooms	100	-	-
01 - Hotel Circulation	100	-	-
02 - Hotel Plant Room	100	-	-
02 - Hotel Circulation	100	-	-
03 - Hotel Circulation	100	-	-
01 - Kitchen/Bar 2	100	-	-
01 - Circulation	100	-	-
01 - SW Battery Store	100	-	-
01 - LV Switchroom	100	-	-
03 - Hotel Rooms	100	-	-
03 - Hotel Circulation	100	-	-
03 - Hotel Rooms	100	-	-
02 - Hotel Rooms	100	-	-
02 - Hotel Circulation	100	-	-
02 - Hotel Rooms	100	-	-
02 - Stad. Heating	100	-	-
02 - Kitchen	100	-	-
02 - ESR / SCR	100	-	-
03 - Board Room	100	-	-
03 - Kitchen	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
03 - Toilets	100	-	-
03 - Toilets	100	-	-
03 - Directors Lounge	100	-	-
03 - Sky Boxes	100	-	-
03 - Kitchen	100	-	-
03 - ESR	100	-	-
03 - Toilets	100	-	-
03 - Sky Boxes	100	-	-
03 - Sensory Room	100	-	-
04 - Hotel Circulation	100	-	-
04 - Hotel Rooms	100	-	-
04 - Hotel Circulation	100	-	-
04 - Hotel Rooms	100	-	-
04 - Circulation	100	-	-
04 - Secure Lobby	100	-	-
03 - Circulation	100	-	-
04 - Control Room	100	-	-
04 - PA/Screen	100	-	-
04 - TV Studio	100	-	-
04 - Crisis Manage	100	-	-
04 - SCR - A	100	-	-
04 - Support	100	-	-
04 - Hotel Rooms	100	-	-
04 - Hotel Rooms	100	-	-
04 - Housekeeping	100	-	-
04 - SCR-H	100	-	-
04 - Hotel Rooms	100	-	-
04 - Hotel Rooms	100	-	-
00 - GA Concorse Circulation	100	-	-
01 - Concorse Circulation	100	-	-
01 - Concorse Circulation	100	-	-
01 - Concorse Circulation	100	-	-
02 - Silver Lounge	100	-	-
02 - Circulation	100	-	-
01 - Circulation	100	-	-
01 - Circulation	100	-	-
00 - Office	100	-	-
00 - Luggage	100	-	-
00 - House Keeping	100	-	-
00 - Toilet	100	-	-
00 - GA Concorse	100	-	-
00 - Player Tunnel	100	-	-
00 - Pitch Irrigation	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - GA Acc Toilet	100	-	-
00 - Storage	100	-	-
00 - GA Concorse Circulation	100	-	-
01 - Concorse Circulation (E)	100	-	-
01 - Hotel Rooms	100	-	-
01 - Stairs	100	-	-
00 - Stairs	100	-	-
02 - Stairs	100	-	-
03 - Stairs	100	-	-
04 - Circulation	100	-	-
04 - Stairs	100	-	-
02 - Circulation	100	-	-
00 - Circulation P.GA Concessions	100	-	-
01 - Circulation	100	-	-
02 - Circulation	100	-	-
02 - Circulation	100	-	-
02 - Circulation	100	-	-
03 - Circulation	100	-	-
03 - Toilets	100	-	-
01 - MSB	100	-	-
01 - Concorse Circulation	100	-	-
01 - BAT & SCR	100	-	-
01 - Concorse Circulation	100	-	-
01 - Concorse Circulation	100	-	-
01 - SCR	100	-	-
03 - Kitchen	100	-	-
03 - ESR	100	-	-
00 - Toilets	100	-	-
00 - GA Concession	100	-	-
00 - Ball Kids	100	-	-
00 - Circulation	100	-	-
00 - Circulation	100	-	-
00 - VOC	100	-	-
00 - Cleaners Store	100	-	-
00 - Staff Change	100	-	-
00 - Bin Store	100	-	-
00 - Steward Jacket Store	100	-	-
00 - Mascot	100	-	-
00 - Cold Water Storage	100	-	-
00 - MCR	100	-	-
00 - Toilets	100	-	-
00 - Changing	100	-	-
00 - Toilet	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Cleaners Store	100	-	-
00 - Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - Cleaner's Store	100	-	-
00 - GA Toilets	100	-	-
00 - MSB	100	-	-
00 - T2	100	-	-
00 - GEN1	100	-	-
00 - IN1	100	-	-
01 - Support	100	-	-
01 - Support	100	-	-
01 - Support	100	-	-
01 - Circulation	100	-	-
01 - Support	100	-	-
01 - Support	100	-	-
01 - Support	100	-	-
01 - Circulation	100	-	-
01 - Circulation	100	-	-
00 - Circulation	100	-	-
00 - Bin Store	100	-	-
00 - Cold Water Storage	100	-	-
00 - MCR	100	-	-
03 - Circulation	100	-	-
00 - GA Concorse	100	-	-
00 - Premium Space	100	-	-
00 - Premium GA	100	-	-
00 - GA Concessions	100	-	-
00 - GA Concessions	100	-	-
00 - CSR	100	-	-
00 - CSR	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - GA Circulation	100	-	-
00 - GA Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-
00 - Concorse Circulation	100	-	-
00 - Concorse Circulation	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - GA Concessions	100	-	-
00 - GA Concessions	100	-	-
00 - Concorse Circulation	100	-	-
00 - Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - Concorse Circulation	100	-	-
00 - Concorse Circulation	100	-	-
00 - Storage	100	-	-
00 - Storage	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - Concorse Circulation	100	-	-
00 - Concorse Circulation	100	-	-
00 - GA Concession	100	-	-
00 - GA Concession	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-
00 - Toilets	100	-	-
00 - Toilets	100	-	-
00 - GA Concession	100	-	-
00 - GA Concession	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - GA Concorse	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-
00 - Flash	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-
00 - ESR	100	-	-

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General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
03 - Hotel Rooms	100	-	-
03 - Hotel Rooms	100	-	-
03 - Hotel Rooms	100	-	-
03 - Housekeeping	100	-	-
03 - SCR	100	-	-
03 - Circulation	100	-	-
03 - Hotel Rooms	100	-	-
03 - Kitchen	100	-	-
02 - Hotel Circulation	100	-	-
02 - Hotel Rooms	100	-	-
02 - Housekeeping	100	-	-
02 - Hotel Rooms	100	-	-
02 - SCR	100	-	-
02 - Hotel Rooms	100	-	-
02 - Hotel Rooms	100	-	-
01 - ESR	100	-	-
01 - Housekeeping	100	-	-
01 - Hotel Rooms	100	-	-
01 - Hotel Rooms	100	-	-
00 - Photographers	100	-	-
00 - Circulation	100	-	-
00 - Player's Entrance	100	-	-
00 - Player's Entrance Circulation	100	-	-
00 - Circulation	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concessions	100	-	-
00 - SCR	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - GA Toilets	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concessions	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Concorse Circulation	100	-	-
00 - GA Toilets	100	-	-
00 - SCR	100	-	-
00 - GA Concorse Circulation	100	-	-
01 - Hotel Rooms	100	-	-
01 - Circulation	100	-	-
00 - Flash	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
01 - Accessible Tribune	100	-	-
00 - Circulation	100	-	-
00 - Hospitality Entrance	100	-	-
00 - GA Concorse	100	-	-
00 - Premium GA (P)	100	-	-
00 - Premium GA (I)	100	-	-
00 - GA Circulation (I)	100	-	-
00 - GA Circulation (P)	100	-	-
00 - Premium GA (P)	100	-	-
00 - Premium GA (I)	100	-	-
00 - Circulation (P)	100	-	-
00 - Circulation (I)	100	-	-
00 - Gym (P)	100	-	-
00 - Gym (I)	100	-	-
00 - Hotel Entrance (P)	100	100	1.35
00 - Hotel Entrance (I)	100	100	1.35
00 - Restaurant (P)	100	100	1.5
00 - Restaurant (I)	100	100	1.5
00 - Sports Bar (P)	100	100	1.5
00 - GA Concourse Circulation (I)	100	-	-
00 - GA Concourse Circulation (P)	100	-	-
00 - Circulation (P)	100	-	-
00 - Circulation (I)	100	-	-
02 - Kitchen (P)	100	-	-
02 - Stad Cooling (P)	100	-	-
02 - Stad Cooling (I)	100	-	-
01 - Lounge Toilets (P)	100	-	-
01 - Lounge Toilets (I)	100	-	-
01 - Kitchen/Bar 2 (P)	100	-	-
01 - Kitchen/Bar 2 (I)	100	-	-
01 - Circulation (P)	100	-	-
01 - Circulation (I)	100	-	-
01 - Gold Lounge (P)	100	-	-
01 - Gold Lounge (I)	100	-	-
01 - Office (I)	100	-	-
01 - Office (P)	100	-	-
00 - NHS Centre (P)	100	-	-
00 - NHS Centre (I)	100	-	-
00 - Indoor Play	100	-	-
00 - Indoor Play (P)	100	-	-
00 - Indoor Play (I)	100	-	-
00 - GM Workshop (P)	100	-	-
00 - GM Workshop (I)	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Sports Bar (I)	100	100	1.5
00 - Sports Bar (I)	100	100	1.5
00 - T1	100	-	-
00 - T1	100	-	-
01 - Concorse Circulation	100	-	-
00 - Inc IT	100	-	-
00 - Gen	100	-	-
00 - Club Shop & Ticket Office (P)	100	100	1.5
00 - Club Shop & Ticket Office (I)	100	100	1.5
01 - Silver Lounge (P)	100	-	-
01 - Silver Lounge (P)	100	-	-
02 - Pitch Heating (P)	100	-	-
02 - Kitchen (I)	100	-	-
02 - SCR	100	-	-
02 - Pitch Heating (I)	100	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
00 - Sports Med	N/A	N/A
00 - Cryo	N/A	N/A
00 - Massage A	N/A	N/A
00 - Team A Dressing Room	N/A	N/A
00 - Circulation (Change)	N/A	N/A
00 - Change	N/A	N/A
00 - Toilets	N/A	N/A
00 - Plunge Pool	N/A	N/A
00 - Change	N/A	N/A
00 - Doping	N/A	N/A
00 - Warm up	N/A	N/A
00 - Circulation	N/A	N/A
00 - Ref Change F&M	N/A	N/A
00 - Match Delegates	N/A	N/A
00 - Medical Emergency	N/A	N/A
00 - Plunge Pool	N/A	N/A
00 - Toilets	N/A	N/A
00 - Change	N/A	N/A
00 - Coach Change B	N/A	N/A
00 - Massage B	N/A	N/A
00 - Team B Dressing Room	N/A	N/A
00 - Circulation	N/A	N/A
00 - Multi-Faith Room	N/A	N/A
00 - Media Theatre	YES (+21.8%)	NO
00 - Media Working Area	YES (+29%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
00 - Reception (Players & Officials)	YES (+18.6%)	NO
00 - Perf. Analysis	YES (+17.3%)	NO
00 - Head Coach	YES (+13.4%)	NO
00 - Head Coach	YES (+6.7%)	NO
00 - Coach Change A	YES (+4.8%)	NO
01 - Hotel Circulation	N/A	N/A
01 - Hotel Rooms	NO (-80%)	NO
01 - Hotel Rooms	N/A	N/A
01 - Hotel Circulation	N/A	N/A
02 - Hotel Circulation	N/A	N/A
03 - Hotel Circulation	NO (-53%)	NO
03 - Hotel Rooms	NO (-38.8%)	NO
03 - Hotel Circulation	N/A	N/A
03 - Hotel Rooms	NO (-61.5%)	NO
02 - Hotel Rooms	N/A	N/A
02 - Hotel Circulation	NO (-100%)	NO
02 - Hotel Rooms	NO (-68.7%)	NO
03 - Board Room	YES (+2.5%)	NO
03 - Directors Lounge	YES (+6.3%)	NO
03 - Sky Boxes	NO (-11.4%)	NO
03 - Sky Boxes	YES (+8.2%)	NO
03 - Sensory Room	N/A	N/A
04 - Hotel Circulation	N/A	N/A
04 - Hotel Rooms	NO (-32.9%)	NO
04 - Hotel Circulation	N/A	N/A
04 - Hotel Rooms	NO (-67.8%)	NO
04 - Control Room	NO (-100%)	NO
04 - PA/Screen	N/A	N/A
04 - TV Studio	N/A	N/A
04 - Crisis Manage	NO (-67.5%)	NO
04 - Support	NO (-75.8%)	NO
04 - Hotel Rooms	NO (-87%)	NO
04 - Hotel Rooms	NO (-79.7%)	NO
04 - Housekeeping	N/A	N/A
04 - Hotel Rooms	NO (-34.6%)	NO
04 - Hotel Rooms	NO (-53.3%)	NO
02 - Silver Lounge	NO (-100%)	NO
01 - Circulation	N/A	N/A
01 - Circulation	N/A	N/A
00 - Office	N/A	N/A
00 - Luggage	N/A	N/A
00 - House Keeping	N/A	N/A
00 - Toilet	N/A	N/A
00 - Player Tunnel	N/A	N/A
00 - GA Concorse Circulation	N/A	N/A
01 - Hotel Rooms	NO (-85.6%)	NO
01 - Circulation	NO (-55.7%)	NO
03 - Circulation	NO (-70.6%)	NO
01 - Concorse Circulation	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01 - Concorse Circulation	N/A	N/A
00 - Ball Kids	N/A	N/A
00 - Circulation	N/A	N/A
00 - VOC	YES (+176.9%)	NO
00 - Staff Change	YES (+146.5%)	NO
00 - Bin Store	N/A	N/A
00 - Steward Jacket Store	N/A	N/A
00 - Mascot	YES (+192%)	NO
01 - Circulation	NO (-99.9%)	NO
01 - Circulation	N/A	N/A
01 - Circulation	N/A	N/A
00 - Premium Space	NO (-99.3%)	NO
00 - Premium GA	NO (-99.5%)	NO
03 - Hotel Rooms	NO (-49.9%)	NO
03 - Hotel Rooms	NO (-79.6%)	NO
03 - Hotel Rooms	NO (-68.9%)	NO
03 - Housekeeping	N/A	N/A
03 - Circulation	NO (-24%)	NO
03 - Hotel Rooms	NO (-32.4%)	NO
02 - Hotel Circulation	N/A	N/A
02 - Hotel Rooms	N/A	N/A
02 - Housekeeping	N/A	N/A
02 - Hotel Rooms	NO (-71%)	NO
02 - Hotel Rooms	NO (-69.6%)	NO
02 - Hotel Rooms	N/A	N/A
01 - Housekeeping	N/A	N/A
01 - Hotel Rooms	NO (-83.9%)	NO
01 - Hotel Rooms	N/A	N/A
00 - Photographers	N/A	N/A
00 - Circulation	N/A	N/A
00 - Player's Entrance Circulation	N/A	N/A
00 - Circulation	N/A	N/A
01 - Hotel Rooms	N/A	N/A
01 - Circulation	N/A	N/A
01 - Accessible Tribune	N/A	N/A
00 - Premium GA (P)	YES (+130.1%)	NO
00 - Premium GA (I)	NO (-97%)	NO
00 - Premium GA (P)	YES (+77.5%)	NO
00 - Premium GA (I)	NO (-97.9%)	NO
00 - Circulation (P)	YES (+62.9%)	NO
00 - Circulation (I)	NO (-70.4%)	NO
00 - Gym (P)	NO (-27.1%)	NO
00 - Gym (I)	NO (-78.5%)	NO
00 - Hotel Entrance (P)	NO (-17.2%)	NO
00 - Hotel Entrance (I)	NO (-65.2%)	NO
00 - Restaurant (P)	NO (-15.2%)	NO
00 - Restaurant (I)	NO (-76.7%)	NO
00 - Sports Bar (P)	YES (+33.3%)	NO
00 - Circulation (P)	NO (-5.7%)	NO

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Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01 - Concorse Circulation	N/A	N/A
00 - Ball Kids	N/A	N/A
00 - Circulation	N/A	N/A
00 - VOC	YES (+176.9%)	NO
00 - Staff Change	YES (+146.5%)	NO
00 - Bin Store	N/A	N/A
00 - Steward Jacket Store	N/A	N/A
00 - Mascot	YES (+192%)	NO
01 - Circulation	NO (-99.9%)	NO
01 - Circulation	N/A	N/A
01 - Circulation	N/A	N/A
00 - Premium Space	NO (-99.3%)	NO
00 - Premium GA	NO (-99.5%)	NO
03 - Hotel Rooms	NO (-49.9%)	NO
03 - Hotel Rooms	NO (-79.6%)	NO
03 - Hotel Rooms	NO (-68.9%)	NO
03 - Housekeeping	N/A	N/A
03 - Circulation	NO (-24%)	NO
03 - Hotel Rooms	NO (-32.4%)	NO
02 - Hotel Circulation	N/A	N/A
02 - Hotel Rooms	N/A	N/A
02 - Housekeeping	N/A	N/A
02 - Hotel Rooms	NO (-71%)	NO
02 - Hotel Rooms	NO (-69.6%)	NO
02 - Hotel Rooms	N/A	N/A
01 - Housekeeping	N/A	N/A
01 - Hotel Rooms	NO (-83.9%)	NO
01 - Hotel Rooms	N/A	N/A
00 - Photographers	N/A	N/A
00 - Circulation	N/A	N/A
00 - Player's Entrance Circulation	N/A	N/A
00 - Circulation	N/A	N/A
01 - Hotel Rooms	N/A	N/A
01 - Circulation	N/A	N/A
01 - Accessible Tribune	N/A	N/A
00 - Premium GA (P)	YES (+130.1%)	NO
00 - Premium GA (I)	NO (-97%)	NO
00 - Premium GA (P)	YES (+77.5%)	NO
00 - Premium GA (I)	NO (-97.9%)	NO
00 - Circulation (P)	YES (+62.9%)	NO
00 - Circulation (I)	NO (-70.4%)	NO
00 - Gym (P)	NO (-27.1%)	NO
00 - Gym (I)	NO (-78.5%)	NO
00 - Hotel Entrance (P)	NO (-17.2%)	NO
00 - Hotel Entrance (I)	NO (-65.2%)	NO
00 - Restaurant (P)	NO (-15.2%)	NO
00 - Restaurant (I)	NO (-76.7%)	NO
00 - Sports Bar (P)	YES (+33.3%)	NO
00 - Circulation (P)	NO (-5.7%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
00 - Circulation (I)	NO (-90.7%)	NO
01 - Gold Lounge (P)	YES (+39.8%)	NO
01 - Gold Lounge (I)	NO (-100%)	NO
01 - Office (I)	NO (-84.3%)	NO
01 - Office (P)	NO (-72.9%)	NO
00 - NHS Centre (P)	NO (-10.4%)	NO
00 - NHS Centre (I)	NO (-76.8%)	NO
00 - Indoor Play	YES (+5%)	NO
00 - Indoor Play (P)	NO (-5.2%)	NO
00 - Indoor Play (I)	YES (+1670.9%)	NO
00 - GM Workshop (P)	YES (+11.2%)	NO
00 - GM Workshop (I)	NO (-49.1%)	NO
00 - Sports Bar (I)	NO (-74.8%)	NO
00 - Sports Bar (I)	YES (+277.8%)	NO
00 - Club Shop & Ticket Office (P)	YES (+80.1%)	NO
00 - Club Shop & Ticket Office (I)	YES (+734.3%)	NO
01 - Silver Lounge (P)	YES (+401.8%)	NO
01 - Silver Lounge (P)	YES (+153.1%)	NO

Regulation 25A: Consideration of high efficiency 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
Floor area [m²]	27764.7	27764.7
External area [m²]	36914.1	36914.1
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	9468.69	10971.3
Average U-value [W/m²K]	0.26	0.3
Alpha value* [%]	25.88	10

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

Building Use

% Area	Building Type
1	**Retail/Financial and Professional Services**
1	**Restaurants and Cafes/Drinking Establishments/Takeaways**
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
29	**Hotels**
2	**Residential Institutions: Hospitals and Care Homes**
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
67	**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	7.09	5.32
Cooling	2.92	2.56
Auxiliary	20.82	4.04
Lighting	8.18	8.4
Hot water	23.54	26
Equipment*	55.5	55.5
TOTAL**	**62.55**	**46.32**

* 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	17.92	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*17.92*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	122.98	95.87
Primary energy [kWh_{PE}/m²]	66.29	68.5
Total emissions [kg/m²]	6.27	6.31

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 SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	140.1	124.9	13.1	7.2	19.9	2.98	4.82	3.31	5.36
	Notional	30.6	105.3	3.1	6.3	13.6	2.78	4.63	----	----
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	137.4	39.7	12.8	2.3	0	2.98	4.82	3.31	5.36
	Notional	162.2	33.8	16.2	2	0	2.78	4.63	----	----
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	101.8	115.8	7.9	10.1	12.9	3.56	3.18	3.96	6
	Notional	24.4	146.6	2.4	8.8	7.5	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	2.4	0	0.2	0	3.4	2.98	0	3.31	0
	Notional	5.5	0	0.6	0	2.3	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	85.9	0	8	0	2.2	2.98	0	3.31	0
	Notional	99.8	0	10	0	1.6	2.78	0	----	----
[ST] Other local room heater - fanned, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	256.4	0	25.6	0	0.4	2.79	0	3.31	0
	Notional	139.4	0	13.9	0	0	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	109.3	0	10.2	0	3.4	2.98	0	3.31	0
	Notional	82.8	0	8.3	0	3	2.78	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

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Oxford United Football Club

BREEAM Ene 04: Low and Zero Carbon Technologies Feasibility Study

November 2023

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Issue and Revision Record

Contents

Tables

Figures

Executive summary

Mott Macdonald has been appointed on behalf of Oxford United Football Club (OUFC) to prepare documentation to support BREAAM assessment at RIBA Stage 2 for the proposed stadium development.

The proposed development is seeking to achieve BREEAM 'New Construction' V6 rating of "Very Good." The report provides evidence to achieve the following BREEAM energy credit targeted:

- Ene 04 – Low carbon design
  - Passive design analysis (1 credit)
  - Low and zero carbon technologies (1 credit)

All calculations and results are based upon information provided by the design team to inform RIBA Stage 2 design and are to be used for the purpose of supporting the BREEAM assessment evidence base only. It is noted that the current assessments presented demonstrate whether credits can be met based on RIBA Stage 2 and would need to be revised at RIBA Stage .

To identify opportunities for the implementation of passive design measures, an analysis of the proposed building design during concept design stage has been undertaken. The reduction of total heating, cooling, mechanical ventilation and overall energy consumption of the building has been quantified to demonstrate passive design measures. The combination of the following measures have been implemented:

- Building fabric exceeding Part L 2021 Volume 2 (For buildings other than dwellings)
- Air source heat pump providing space heating and domestic hot water
- Efficient lighting and controls
- HVAC monitoring
- Heat recovery units
- Demand control ventilation
- Power factor correction of >0.95
- Light metering that incorporates warnings for out of range values
- Variable speed pumps and fans
- Local external shading.

Results indicate a 0.47% saving in CO_2 emission per year and 0.38% primary energy reduction compared to the Part L Target Emission Rate and Target Primary Energy Rate. A further assessment was carried out to determine 3,000m^2 area of photovoltaic panels would be required to achieve further credits.

The outputs of the energy calculation carried out in line with Part L 2021 Volume 2 can be found in the appendix. The BRUKL document was used to quantify the savings due to passive design measures.

The LZC technologies have been assessed against site suitability, building function, maintenance and the impacts associated with installation. The most viable LZC technology options for this scheme that satisfy all the energy requirements set by Building Regulations Part L 2021 Volume 2 (for buildings other than dwellings) are:

- Photovoltaics (PV) Panels
- LED lighting
- Heat recovery systems
- Heat pumps
  - ASHP (Air Source Heat Pump)

1 Introduction

1.1 Purpose

The following study has been prepared by Mott MacDonald for the Oxford United Football Club (OUFC) at RIBA Stage 2 The development is seeking to achieve BREEAM rating of 'Very Good.' The following report presents evidence in achieving the following BREEAM credit:

- Ene 04 – Low carbon design
  - Passive design analysis (1 credit)
  - Low and zero carbon technologies (1 credit)

The aim of Ene 04 is to encourage design measures which reduce building energy consumption and associated carbon emissions to minimise the use of active building services systems. The suitability of multiple LZC technologies will be assessed on site suitability, the scope of energy production and resultant decrease in CO_2 emissions and the viable costs and payback for the client.

All results are based on the output from IES-VE, a government approved software and should be taken as an indication of the likely final situation but these situations cannot be guaranteed.

Figure 1: Oxford United Football Club (Source: AFL Architects)

1.2 Project scope

Mott MacDonald have been engaged by AFL Architects on behalf of Oxford United Football Club to provide mechanical, electrical, and public health (MEP) consultancy services to RIBA stage 2 for the proposed new stadium development.

The proposed stadium consists of a 4-storey hotel attached, a commercial area on the ground floor and seating to accommodate 16,000 spectators. The commercial space consists of an NHS Centre, gym, restaurant, bar, and an indoor play area. The stadium consists of a general admissions (GA) area, premium general admission, sky boxes and 2 no. lounges.

1.3 Assessors

The following work has been completed by Yasmin Meor Azlan, who holds a master's degree in Mechanical Engineering and experience in LZC feasibility studies and building modelling. This assessment was overseen by Ali Azizi, a Mechanical Building Services Engineer and Steve Mills, a Technical Principal. Ali and Steve both are very experienced in undertaking assessments and installation of low and zero carbon solutions in commercial buildings sector.

2 Ene 04 Passive Design

This section summarises how the requirements of BREEAM Ene 04 passive design has been achieved.

2.1 Site Location

The proposed development is located in a currently unoccupied area highlighted in Figure 2. This area is referred to as 'The Triangle.' It is 6km North of Oxford City Centre and is adjacent to Oxford Parkway with vehicle access from A4165 and A4260. There are no existing buildings or evidence of previously demolished buildings on site. The site comprises of two fields and are split by an area of woodland.

The topography of the proposed site is generally flat with a small gradient of 1:150 to 1:200 falling East to West.

Figure 2 Proposed Site Location

Source: AFL Architects

2.2 Building Layout

The ground floor of the development consists of commercial spaces in the North, GA/Premium GA entrances and Player's and Officials area (also the "Main Stand") in the Northwest. The ground floor will also house concessions and toilets lining the perimeter of the stadium which leads onto the pitch. The concessions and toilets will neighbour circulation spaces that provide floor to ceiling openings to allow spectators onto the rakers which line the outer perimeter of the stadium. The rakers will continue to form along the inside of the stadium in a tiered manner where the South and Southeast rakers portion of the stadium will continue until the fourth floor to maximise seating. The Northern section of the building will continue to house ensuite hotel rooms from the first floor until the fourth floor.

The first floor of the Main Stand will house the Gold and Silver Lounge as a part of the stadium's premium hospitality package. The Silver Lounge is also a double height space where the third floor of the Main Stand houses 20 no. sky boxes and a Director's Lounge.

2.3 Building Form

The building form maximises stadium occupancy while allowing for commercial/hotel spaces in the North of the stadium development. To maximise the functionality of the building, the stadium will be of circular shape to maximise circulation, access, and future stadium growth/increased capacity.

2.4 Building Orientation

The stadium is rotated -35 degrees from the North to optimise the amount of land around the stadium and to keep the tree band relatively untouched. When situation the stadium centrally on site in a North-South orientation, the location of the main stand to the West turns its back onto arriving fans and site visitors from the East.

2.5 Building Fabric

A high-performance envelope has been specified with insulation values having around a 10% improvement on the notional specification as defined in Part L 2021, Volume 2 of the Building Regulations. The following Table gives the envelope thermal properties specified at RIBA Stage 2.

Table 1 Building Performance Table

Element	Part L 2021 Limiting Value	Part L 2021 Notional Building	Stadium Development Proposed U-Values
External Wall	0.26	0.18	0.17
Ground/Exposed Floor	0.18	0.15	0.12
Roof	0.18	0.15	0.12
Window, rooflights, doors	1.60	1.40 g-value: 0.28, VLT: 60%	1.30 g-value: 0.34, VLT: 50%

Element	Part L 2021 Limiting Value	Part L 2021 Notional Building	Stadium Development Proposed U-Values
External Door	1.60	1.60	1.20

2.6 Thermal Mass

Within the General Access (GA) concourse area, the exposure of the concrete building elements, which offers high thermal mass, shall be combined with night-time purge ventilation to dissipate heat absorbed throughout the day during the night-time while the building is unoccupied.

2.7 Local Microclimate

A microclimate is the local ambient weather and climatic conditions for a given location. The local microclimate at OUFC has been discussed in the following section to determine whether these local conditions lend themselves to different LZC technologies and passive design measures or not.

To ensure the development does not overheat in the summer, the following design changes were implemented:

- Low energy and highly efficient lighting design
- Improved building fabric
- Louvres to reduce the workload of air conditioning units and provide natural ventilation to purge heat accumulated throughout the day.

2.7.1 External Conditions

External design conditions for the site have been taken from CIBSE Guide A, Environmental Design. Due to the increase in summertime temperatures the CIBSE projected weather files have been used for the summertime external design temperature.

Table 2: External Design Criteria

Season	External Design Conditions
Winter	-4.6 °C db[1]
Summer	30.40 °C db, 19.30 °C

Source: CIBSE Guide A: Environmental Design

[1] CIBSE Guide A, Table 2.5. Dry bulb temperature exceeds for 99.6% of the hours in the year, Swindon.

2.7.2 Wind

Table 3 highlights the average wind speeds on site for the potential of wind turbines and passive ventilation.

Table 3: Average wind speed for Oxford United Football Club

Height Above Ground Level (m)	Average Wind Speed (m/s)
10	4.7 m/s
25	5.7 m/s
45	6.0 m/s

Source: RenSMART Wind Report: https://www.rensmart.com/RenSMARTWindReport

CIBSE Guide AM10 states that a wind speed in excess of 3.5m/s is required to ensure the internal temperature is not exceeded for 99.6% of the time for all UK locations. Wind speeds of around 3.5-5m/s is required for most turbines to produce electricity; therefore, the wind profile of the site suggests wind turbines are viable LZC options.

2.7.3 Summary

The proposed stadium is surrounded by existing greenery. The local climate lends itself to LZC solutions for instance passive cooling and wind power generation, however, due to site constraints, these are unlikely to be feasible options for this project. Alternative LZC technologies such as PV (photovoltaic) panels, heat pumps and LED lighting would be more suitable given the site constrictions.

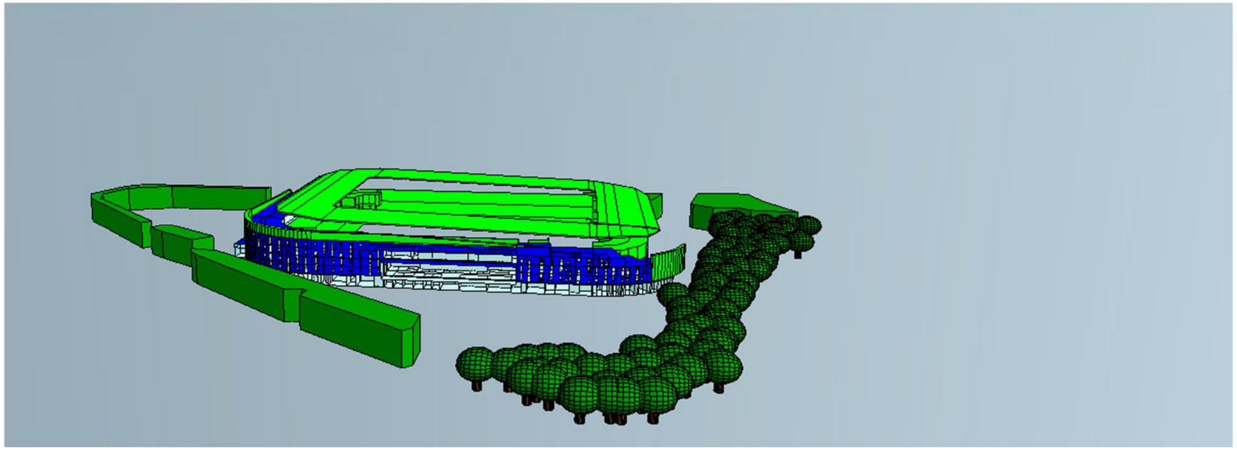
2.8 Dynamic Simulation model

In order to demonstrate the recommended reduction in CO_2 emissions on a Notional Building, a Dynamic Simulation Model has been created to undertake appropriate assessments on the proposed design.

Integrated Environmental Solutions Virtual Environment (IES-VE) is a Dynamic Simulations Modelling (DSM) leading software package that allows users run accurate whole building performance simulations.

The IES Virtual Environments (VE) 2023.1.0.0 software has been utilised for this assessment, which is an approved building energy calculation software listed by UK NCM. The image below shows the IES-VE DSM. The surrounding buildings have been simplified as appropriate for this modelling exercise.

Figure 3 IES-VE Model of the proposed OUFC



Source: IES-VE

2.8.1 Geometry

The model geometry has been created using the Revit model received from AFL Architects.

Table 4: IES-VE Model Architectural Information

Uploaded	Source	Data Type	Description
08.2023	AFL Architects	Revit Model	2022.1 – OUFC-MMD-ZZ-XX-M3-N-00001.rvt

2.8.2 Site Location and Weather Data

A building's external environmental conditions will affect the thermal performance of the building. The use of external weather information becomes more important the more dependant a building is on passive features to achieve acceptable internal comfort. Climate data is assigned to the virtual environment of the dynamic model to simulate external weather conditions that are likely to occur.

The UK Meteorological Office (MO) collects weather data at stations across the UK. The weather variables are synthesised into 2 types of CIBSE weather file type both current and future: Design Summer Year (DSY) and Test Reference Year (TRY) 2006 and 2016. The TRY weather files are composed of 12 separate months of data each chosen to be the most average month from the collected data. The TRY is used for operational energy analysis and for compliance with the UK Building Regulations (Part L).

Following the standardised methodology behind the Part L requirements, the closest CIBSE weather file location for the proposed development is London has been utilised for the purposes of these calculations.

2.8.3 Modelling Assumptions

The IES Virtual Environments (VE) 2023.1.0.0 software has been utilised for this assessment, which is an approved building energy calculation software package compliant with the Guidance of CIBSE AM11. It should be remembered that this is a theoretical analysis and actual conditions are subject to a wide range of variables. This analysis should be taken as an indication of performance under conservative conditions rather than necessarily what will take place in practice.

2.9 Quantification of Savings due to Passive Design Measures

To quantity the energy savings and reduction in carbon dioxide emissions due to passive design measures, a 'standard building' was modelled with fabric performance equivalent to that of a local building regulations notional buildings without any of the passive design measures.

The modelled building followed the BREEAM NC V6 methodology based on notional values defined by Part L 2021, Volume 2.

The following table presents the input from a standard and proposed buildings with the calculated.

Table 5 Savings from Passive Design Measure

Element	Standard Building Notional Values	Stadium Development Proposed U-Values
External Wall	0.18	0.17
Ground/Exposed Floor	0.15	0.12
Roof	0.15	0.12
Window	1.40 g-value: 0.28, VLT: 50%	1.30 g-value: 0.34, VLT: 50%
External Door	1.6	1.20
Metric	Standard Building	Proposed Building
Carbon emissions (kgCo2/m2year)	8.56	8.52
Savings (%)		**0.47**
Energy Consumption (kWh/m2/year)	92.83	92.48
Savings (%)		**0.38**

The implemented passive design measures have resulted into 0.47% reduction in carbon emissions and 0.38% reduction in energy consumption.

2.10 Adaptation to Climate Change

An overheating assessment which considers future weather (2020 high carbon emissions and 2050 medium carbon emissions) has been undertaken to predict the risk of the building overheating with the rise of temperature due to climate change. This assessment will determine the size and configuration of the natural ventilation openings in the concourse area which is updated to adapt to the increase in temperature caused by climate change. This will in turn inform the size of cooling systems where areas are cooled. The MEP spatial design and Electrical Infrastructure shall allow for incorporation of additional fans within the concourse area to increase the ventilation rate if required due to excessive future increase in temperature arising from global warming.

3 Low and Zero Carbon Technologies

3.1 Introduction

This section of the report covers the feasibility of incorporating LZC technologies within the proposed development. The suitability of multiple LZC technologies will be assessed on site suitability, the scope of potential energy production, the resultant decrease in CO_2 emissions and viable costs and payback.

The production of an LZC study is part of the BREEAM UK New Construction 2018 3.0: Non-domestic Buildings scheme under energy credit Ene 04. The aim of Ene 04 is to encourage design measures which reduce building energy consumption and associated carbon emissions to minimise the use of active building services systems. The LZC study identifies available opportunities to utilise renewable energy and/or low and zero carbon technologies to reduce building associated carbon emission.

This report is limited to a qualitative assessment of LZC technologies to establish the most appropriate for the new stadium development. This report will determine which LZC technologies should be given further analysis at future design stages of the project.

3.1.1 Planning Requirements

For commercial buildings over 2,000sqm, Oxford City Council require for 20% of total energy requirements, both unregulated and regulated to be met from on-site LZC or low carbon technologies[2].

3.1.2 Available Grants

There are no known grants for incorporation of LZC technologies on this project.

3.1.3 Technologies Considered

The following LZC technologies have been considered for use within the proposed development:

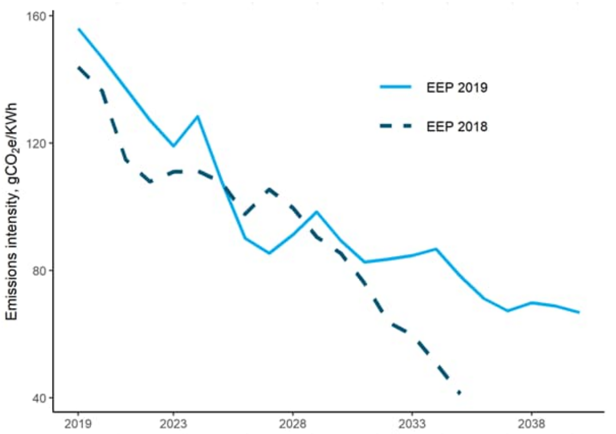
- Air Source Heat Pumps (ASHP)
- District Heating Networks
- Combined Heat and Power (CHP)
- Photovoltaic (PV) systems
- Wind power
- Solar Thermal

[2] Oxfordshire Energy Strategy, section 4.1.4.

3.1.4 Grid Decarbonisation

The national grid is continually decarbonising making the use of gas systems less preferential over electrically fuelled systems as the carbon factor of grid electricity is predicted to continue to decrease over time. Given that a proportion of the proposed development's heating and cooling demands are to be met via electricity, the building will produce fewer emissions in operation over time in line with the decarbonisation of the grid electrical network. The Chart 1 below shows the predicted grid decarbonisation trajectory.

Chart 1: Grid Carbon Factor Projection



Source: Department for Business, Energy & Industrial Strategy BEIS – 2020

3.2 LZC Technologies

Each LZCT (Low or Zero Carbon Technology) is examined within this section of the report to establish which systems are both technically viable and functionally viable for inclusion within the proposed development.

3.3 Air Source Heat Pumps

3.3.1 System Overview

ASHPs work by extracting heat from the air for space heating and domestic hot water provision and can also be used to provide cooling. The systems are easier and cheaper to install than GSHPs, however ASHPs are slightly less efficient. ASHPs supply more useful energy than they consume by extracting heat from the surrounding air. The heat energy released to energy required to power the equipment is known as the coefficient of performance (CoP). Most ASHPs have a CoP between 2 to 3 where 3 is achieved with favourable conditions.

There are two main types of ASHP: air to water and air to air.

- *Air to water systems* are used with a wet central heating system and can provide domestic hot water. The delivery temperature is lower than traditionally used making it particularly suitable to underfloor heating installations, also it is possible to serve radiators off the system. ASHPs can also be used to provide cooling. Where an ASHP system is used to produce domestic hot water a storage tank with electric immersion heaters to boost and pasteurise the stored Domestic Hot Water may be required. This will not be required if a high temperature ASHP or a low temperature Water-to-Water Source Heat Pump (WWHP) is used.

- *Air to air systems* produce warm air that is circulated through the building by fans and can therefore be used to directly heat or cool the building depending on requirements. An air-to-air system cannot be used to provide hot water.

An ASHP system requires an external collector, similar in appearance to an air handling unit (AHU). The technology can be operational at temperatures as low as -10ºC, which will be suitable for this site. There is potential for these units to be placed on top of the roof.

3.3.2 System Viability

Benefits:

- ✓ Cooling output is increased.
- ✓ Can be used for both space heating and domestic hot water.
- ✓ Does not require fuel to be delivered to site.
- ✓ Installation is easier compared to ground and water source heat pumps.
- ✓ There is no need for combustion and no potentially dangerous gases are produced.
- ✓ Low payback period

Limitations:

- ✗ Use of refrigerant gas is increased.
- ✗ Requires increased plant space.
- ✗ Medium running and maintenance costs.

3.3.3 ASHP Summary

ASHPs will be considered for inclusion to the proposed development. ASHPs have been selected for use with the new AHUs due to their very high efficiency, low payback period and suitability for a fully electric design. Additionally, with the projected decarbonisation of the grid, heat pumps will result in ongoing reductions in carbon emissions to the proposed development as the grid electrical energy emissions reduce.

Air Source Heat Pumps	
Suitability/system viability	This is a very efficient system providing heating which can be utilised within the building and can be accommodated within the building design.
Lifetime	Lifetime: 15-20 years
Land Use	None – Air source heat pumps would be installed at roof level within external plant enclosure.
Local Planning Requirements	For commercial buildings over 2,000sqm, Oxford City Council require for 20% of total energy requirements, both unregulated and regulated to be met from on-site LZC or low carbon technologies. Details of the external plant enclosure required to house the heat pumps would need to be submitted as part of the planning application.

Noise	Plant noise attenuation requirements to be reviewed by the acoustic consultant and attenuation included within the design and installation as necessary to prevent noise egress.
Carbon Saving	Due to the limitations of IES this could not be quantified, grid electricity 0. 207074 $kgCO_2/kWh$.
Conclusion	Viable – included in design

3.4 Solar Thermal Water Heating

3.4.1 System Overview

Solar thermal panels use radiation energy from the sun to heat water to provide hot water for domestic uses within a building. Heat from the sun is used to warm up an energy absorbing media pumped through a solar absorbing panel usually situated on the roof of the building served. The heated media is then pumped through a heat exchanger typically to heat hot water within a storage cylinder. Additionally, solar water heating is more efficient at yielding energy from the sun than photovoltaics.

There are two main options when considering solar thermal panels:

- Evacuated tube collectors uses a transfer fluid as the transfer media. They are the more efficient system, requiring less roof space, however, are more fragile and have a higher capital cost.
- Flat plate collectors use a transfer fluid (usually non-toxic propylene glycol), to transfer heat from the collector to a Heat Exchanger through a pressurised closed loop.

Installing a solar thermal system does not allow a conventional hot water heating system to be replaced but will provide a supplement to reduce the energy required for domestic hot water provision.

To ensure maximum efficiency, as with Photovoltaic (PV) panels, the system should be situated within 30˚ of south, at 45˚ inclination, and should remain unshaded throughout hours of operation.

Solar thermal hot water generation is not a preferred technology for the stadium due to potential legionella risks and maintaining the required temperatures for water heating and distribution. However, the high Domestic Hot Water (DHW) demand of a stadium building does increase the viability of a solar water heating system.

3.4.2 System Viability

Benefits:

- ✓ Operational noise from solar thermal panels is virtually silent and therefore unlikely to cause any disturbance to any neighbouring buildings.
- ✓ For buildings with a higher Domestic Hot Water demand, it is a more efficient system.

Limitations:

- × Requires large external area for solar panels – this space could potentially be better utilised by PV arrays.
- × Visual impact that requires planning approval.
- × Requires hot water storage plant space local to the panels.
- × Maintenance costs are high in comparison to PV.
- × Roof access required for maintenance and cleaning.

3.4.3 Solar Thermal Water Heating Summary

Solar thermal water heating systems are suited for buildings requiring a large quantity of hot water. There is limited roof area available due to utilisation of the roof canopy for PV arrays which will contribute to the reduction of the overall building net energy.

Solar Thermal Water Heating	
Suitability/system viability	The hot water generated by solar collectors could be utilised for domestic hot water usage within the building. The stadium will have a high DHW demand and therefore the technology would have an impact in reducing CO_2 emissions.
Lifetime	Lifetime: 25 years
Land Use	Solar collectors generally installed at roof level, south facing at an incline of 30 - 45°.
Local Planning Requirements	For commercial buildings over 2,000sqm, Oxford City Council require for 20% of total energy requirements, both unregulated and regulated to be met from on-site LZC or low carbon technologies. Planning permission would be required, and details of the solar collectors would have to be included within the planning submission.
Noise	Not an issue with this type of system.
Carbon Saving	Due to the limitations of IES this could not be quantified, grid electricity 0.207074 $kgCO_2/kWh$.
Conclusion	Not viable – limited roof area available.

3.5 Photovoltaics

3.5.1 System Overview

Photovoltaic (PV) cells convert light energy from the sun into electricity that can be utilised on-site reducing the amount of grid electricity required, reducing building running costs.

A PV cell consists of two or more thin layers of semi-conducting material, most commonly silicon. When the silicon is exposed to light, electrical charges are generated, these can be conducted away by metal contacts as a direct electrical current (DC). The electrical output from a single cell is small, so multiple cells are connected together and encapsulated to form a module ("panel"). The PV module is the principle building block of a PV system and any number of modules can be connected together to give the desired electrical output.

PV systems can be integrated into the structure of a building, installed on a roof or façade or as a free-standing array. To ensure maximum efficiency the panels need to be situated between South-East and South-West and remain predominantly unshaded throughout the hours of operation. The panels should be placed at an angle of 30-45° to the horizontal to be most effective. Although most efficient in direct sunlight, the PV cells do still generate electricity in overcast weather.

The stadium has been designed to provide a 2° incline roof with significant potential for arrays directly orientated south, providing the ideal positioning for PV panels. PV panels operate silently; however, the visual impact of the system should be considered. The panels can be deemed unsightly and can also cause reflections and glare within the surrounding area however as there are no adjacent buildings, this is not of concern.

3.5.2 System Viability

Benefits:

- ✓ On-site electricity is generated (reducing carbon emissions). The electricity can also be sold back to the grid during periods of low demand within the building.
- ✓ Established and mature technology.
- ✓ Low maintenance costs.

Limitations:

- × Requires large external area for solar panels – roof space is already limited.
- × Feed in Tariffs are no longer available for projects.
- × Visual impact that requires planning approval.
- × Roof access required for cleaning and maintenance.

3.5.3 PV Summary

Given the proposed building systems approach is a fully electric solution, PV panels would be an efficient means of reducing the operational energy and associated carbon emissions. They are therefore included in the use on the development.

Photovoltaics	
Suitability/system viability	Electricity generated by the PV array could be utilised within the building to reduce the consumption of grid electricity. The system can be easily integrated into the project and used as a bolt on technology, alongside other LZCs. It is also not influenced by the building services strategy.
Payback	Payback: 3 years as per calculations done by the MM Electrical Team.
Land Use	Usually installed at roof level at an incline of 30 - 45° and south facing. Plant is to be located in a roof top plant room therefore there is roof space for PV.
Local Planning Requirements	For commercial buildings over 2,000sqm, Oxford City Council require for 20% of total energy requirements, both unregulated and regulated to be met from on-site LZC or low carbon technologies. Planning permission would be required for the photovoltaic array but would be applied for at same time as the proposed development.
Noise	Not an issue with this type of system.
Carbon Saving	2.6% CO_2 reduction on top of the already proposed measures. This equates to 3,000m^2 of PV. Grid electricity 0. 207074 $kgCO_2/kWh$.
Conclusion	Viable

3.6 Wind Turbines

3.6.1 System Overview

Wind power can be harnessed to generate electricity using turbines, which can be used in parallel to a mains supply or with a battery backup system. Turbines can either be building mounted or free standing depending on the development requirements and the site conditions.

The two basic types of wind turbines are horizontal axis and vertical axis, with the horizontal axis type being the more efficient type in most applications. Horizontal axis turbines have a central hub with evenly spaced blades that rotate at an almost constant rate regardless of wind speed. Whereas, vertical axis turbines can be installed without a tower, making them easier to integrate with the building's structure.

Minimum wind speeds of 3.5-5 m/s are required for most turbines to produce electricity and regulators are included that operate when the wind speed exceeds the safe limit. To operate efficiently, wind turbines need to be facing towards the oncoming wind, with as little obstructions to the wind path as possible.

3.6.2 System Viability

Benefits:

- ✓ On-site electricity is generated (reducing carbon emissions). The electricity can also be sold back to the grid during periods of low demand.
- ✓ Established and mature technology.
- ✓ Low maintenance costs.
- ✓ Completely renewable source of energy as it is generated from wind.

Limitations:

- × Requires large external area for wind turbines – roof space is already limited.
- × Feed in Tariffs are no longer available for projects.
- × There is a high visual impact by using wind turbines, in addition to proximity to trees to the south and green borders to the surrounding areas.

Table 6: Wind Speeds of the Existing Site

Location	Wind Speeds
Latitude: 51.80461598527921	At 10m above ground level: 4.7 m/s
Longitude: -1.2781498917234915	At 25m above ground level: 5.7 m/s
Height above sea level: 65 m	At 45m above ground level: 6.0 m/s

Source: https://www.rensmart.com/Maps?postcode=ch495pec

3.6.3 Wind Turbines Summary

Roof mounted wind turbines are require a large external area for operation. As the roof space is limited and is being used for the PV arrays and ASHPs, this is not viable. Freestanding roof turbines also require a lot of land where most of the existing natural topography is currently being used as natural shading. Wind turbines further injure and kill birds which are prevalent in the area due to large greenery space.

Wind Turbines	
Suitability/system viability	The electricity generated by wind turbines could be utilised within the building to reduce the consumption of grid electricity.
Lifetime	Lifetime: 20 years
Land Use	Wind turbine(s) would have to be roof mounted due to the restricted development site area.
Local Planning Requirements	No planning policy requirements for renewable energy systems. Planning permission would be required for the wind turbines.
Noise	Noise can be an issue.
Carbon Saving	Due to the limitations of IES and time constraints, this could not be quantified. Grid electricity 0. 207074 kgCO_2/kWh.
Conclusion	Not viable - Roof mounted wind turbines could be considered however there are limited roof space which is suitable for mounting the wind turbines due to utilising the space for the ASHPs which are main components of the building overall all-electric, low carbon, heating strategy.

3.7 Ground Source Heat Pumps (GSHPs)

GSHPs work by extracting heat from the ground for space heating and domestic hot water. A closed-loop system circulates a water and refrigerant solution through loops of pipework buried in the ground and the stable ground heat is absorbed by the refrigerant solution. The refrigerant solution is then passed through a highly efficient heat exchanger and the low-grade heat is extracted to be used in the building. Providing the system pipework is installed deep enough in the ground to avoid seasonal ground temperature fluctuations, the temperature of the GSHP system remains fairly constant.

GSHPs are particularly suitable for low temperature heating systems in larger buildings with good levels of thermal insulation and can also be used to provide limited cooling during summer months. When coupled with heat pumps the output of the heating and cooling are increased, with efficiencies that exceed conventional chillers and boilers.

To make the system feasible, there needs to be sufficient area for the pipework installation within the ground, either vertically or horizontally. GSHPs will not be considered for the proposed development due to the limited free space on site, which is confined by existing greenery. The area required from ground bore hole array is also not available to meet the building maximum heating demand.

3.8 Water Source Heat Pumps

Water source heat pumps take advantage of the relatively stable temperatures of the watercourse throughout the year. A closed loop system cycles water through the system to provide low grade heat in the winter or cooling in the summer. When coupled with heat pumps the output of the heating and cooling are increased, with efficiencies that exceed conventional chillers and boilers.

Water source heat pumps will not be considered as there is no suitable watercourse nearby.

3.9 Combined heat and power (CHP)

Combined Heat and Power (CHP) systems generate electricity and heat simultaneously. Heat is recovered from the exhaust gases from the engine or turbine electric generation. CHP systems are best suited to applications with a year-round demand for heating and hot water and are approximately 80% efficient. CHPs can achieve cost savings of up to 40% over electricity sourced from the grid and heat generated by on-site boilers. There is the potential for hydrogen fuelled CHP, however currently the technology is not sufficiently developed.

CHP plant is usually contained within the plant area and as a result have little aesthetic impact, other than a flue similar to a boiler installation. Noise and vibrations issues with the plant can be overcome using acoustic enclosures and anti-vibration mountings.

CHP however, will not be considered for inclusion to OUFC as there is insufficient space on site for CHP. The peak heating demands will be met by an alternative low carbon heat source (Air Source Heat Pump) which avoids the consumption of fossil fuels on site.

3.10 Hydroelectric Power

Turbines are placed within the flow of water to produce mechanical energy that causes the turbines to rotate at high speed. The turbines drive a generator that converts the mechanical energy into electrical energy. The amount of hydroelectric power that can be generated is related to the water flow and the vertical distance (known as head) through which the water has fallen. In the smallest hydroelectric schemes, the head of water can be a few meters, in the larger schemes the power station which houses the turbines is often hundreds of meters below the reservoir.

Hydroelectric power will not be considered as there is no nearby suitable watercourse with sufficient reliable flow and head which may be utilised.

3.11 Energy Storage

Energy storage is the capture of energy produced at one time for use at a later time. This can be useful in buildings occupied for specific hours each day- energy produced outside of these occupied hours can be stored and used at a later time when the building is again occupied.

During RIBA 2, the benefits of including a Battery Energy Storage System (BESS) to store electricity created via the roof mounted PV have been considered. This is to reduce the demand on the Distribution Network Operators (DNO) electricity connection and work towards achieving Net-Zero Carbon in operation.

However, the design proposal considers the development will be occupied 24hrs and the energy created via the PV array will not produce an excess, which could be stored. Therefore, the PV will feed directly into the LV infrastructure to supplement the primary DNO electricity supply and will be consumed by the connected equipment.

3.12 Biomass

Biomass boilers burn fuels such as virgin wood and energy crops in the form of chips or pellets to generate heat. Although carbon is released during fuel combustion it is equivalent to the approximate amount absorbed during the growth of the fuel, and on this basis the technology is carbon-neutral, excluding the treatment of fuel and transportation.

Due to the fuels used for biomass boilers, large storage areas are required. A dedicated area would be required, accessible for delivery purposes and in close proximity to the plant area. There is also a potential of high maintenance costs, particularly if woodchip is used.

Biomass will not be considered for inclusion due to the limited fuel storage and plant room facilities of the proposed design.

3.13 BMS system

The building management system (BMS) will be used to control individual aspects of the building systems such as HVAC, ventilation etc, and will integrate with the sitewide BMS system. Data from the BMS system will demonstrate and quantify operation and energy consumption improvements across the spectrum of design, construction, and operational sustainability. The appropriate use of technology and more specifically connected information systems are required to; collect, measure, analyse and apply data. The following principals will apply:

- Controls, sensors, devices, and monitoring systems integrated with the BMS based on real conditions in the spaces. Variables such as light, noise, temperature, energy, occupation rates and movement can be easily monitored as necessary, through adoption of smart buildings principles to create healthy, functional spaces.
- Data should be created through open-source / open-protocol systems without proprietary systems.
- Automated controls are used where appropriate and are optimised, e.g., with Artificial Intelligence (AI), usage of occupancy detection techniques where appropriate.
- Using technology for scenario modelling during the design phase for future adaptability and future proofing.
- Design verification through POE, operational monitoring, and construction impacts, leading to improving benchmarking and best practice.

3.14 Lighting Strategy

High efficiency lighting systems and intelligent lighting controls can have a significant impact on the energy demand and subsequently the emissions of a building. Standalone daylight sensors for example apply a continuous process, adjusting lamp output throughout the day according to natural light available. This offers huge energy savings and corresponding carbon reductions as well as a much more pleasant environment for the users of the stadium.

In terms of the daylighting strategy for the proposed development, there are minimal opportunities for the use of natural light to be utilised due to the building's deep plan and limited rooms with access to an external wall/windows. Nevertheless, all rooms along the building perimeter with access to natural daylight will be provided with daylight linking controls.

Further lighting strategies have been proposed in all spaces to reduce the energy demand for artificial lighting, by monitoring occupancy presence and including occupant accessible switching.

3.15 Heating, Cooling and Ventilation Strategy

This section presents on overview of the proposed Heating, Cooling and Ventilation services for the new OUFC Stadium, Hotel and Mixed Use development.

Heating and Cooling

- Central Low Temperature Hot Water (LTHW) heating system with external air source heat pumps and internal fan coil units, radiators, radiant panels and overdoor heaters serving the stadium main stand which includes the players/officials area; stadium operations; and hospitality.
- Central Chilled Water (CHW) cooling system with an external chillers and internal fan coil units serving the stadium main stand which includes the players & officials area; stadium operations; and hospitality.
- Central LTHW and CHW heating and cooling system serving the Hotel including all bedrooms, common areas and Hotel Operations.
- Central Air Handling Unit's (AHU's) and Local Mechanical Ventilation Heat Recovery Units shall incorporate integral heating LTHW coils and cooling CHW coils.
- Standalone Local Direct Expansion (Dx) Split systems for the Comm's rooms.
- Frost protection electrical heating in where required in plant rooms.
- The General Access (GA) Concourse shall not be thermally conditioned.

- The stage 2 design allows for all electric heating and cooling systems in the commercial units. Space and distribution zones have been provided as dedicated zones for future tenant heating and cooling plant. The Energy analysis has been undertaken under the assumption that the tenant fit out will include individual central Variable Refrigerant Flow (VRF) for each commercial unit.
- Heat input to for Domestic Hot Water Services will be by standalone high temperature heat pumps.
- Heat input to Pitch Heating System shall be by standalone central air source heat pumps.
- Catering heat rejection plant
- Trace heating shall be provided to all pipework services in unheated or external spaces.

Ventilation

- Air Handling Units (AHUs) for the Stadium Operation, Hospitality and Player/Officials areas.
- Mechanical Ventilation Heat Recovery Units (MVHRs) in Hospitality Suites (Sky Boxes). Each room will have its own dedicated system
- MVHR serving a group of rooms at level 04 including Control room and TV broadcasting rooms.
- Mechanical extract ventilation in GA Concourse WCs and Concessions with make-up air via natural ventilation openings in the GA Concourse
- Mixed-mode ventilation in GA Concourse via natural ventilation louvres and WC/Concessions make-up air paths through the concourse.
- Commercial areas shall be tenant fit out with local ventilation plant.
- Kitchen Supply and Extract systems in the 2no. Main Kitchens with duct risers between the Kitchen and the roof fans.
- Naturally ventilated firefighting shafts (2no. Shafts on the main stadium stand)
- Smoke clearance via natural ventilation openings in the General and Premium Access concourse areas.
- Plant Rooms, Bin Stores and Cleaners Rooms within the Concourse zone shall be provided with standalone extract systems with exhaust to horizontal louvres and ducted air make up paths from the outside with 24 hour operations.

3.15.1 Building Change of Use

The following actions have been undertaken in the design to account for building change of use:

- The main distribution zones and systems for the mechanical ventilation (e.g., main ducts in the vertical risers) shall be oversized to accommodate increased airflow which may arise due to future increase in occupancy or a change of space use. This reduces the scope of future adaptation works which will be limited to amendment of final horizontal distributions and potentially prevents requirements for significant structural alterations to accommodate ventilation systems of increased capacity.
- The plant space and services distribution routes serving the commercial fitout spaces shall be designed to accommodate high density of occupation.
- The Electrical Infrastructure has been initially sized with 20% spare capacity to which can accommodate potential increase in mechanical ventilation requirements which may result in further increases in heating and cooling plant capacity, all of which utilise electrical power.
- Cold water storage shall be provided to ensure the assets (e.g., pitch) can be protected in the event of a mains water failure which may arise due to draughts or damage to the water infrastructure caused by extreme weather.

3.15.2 Ventilation

Energy Export Potential

PV has the potential for exporting electricity to the grid to further generate income. It is anticipated that due to the size and use of the proposed stadium and the profile nature of the other facilities such as the Hotel and commercial spaces, a constant electrical load will be required.

3.16 Sizing and Energy Generation

3.16.1 ASHP

The building services strategy developed assumes an all-electric system, with the ASHP being the primary energy system. HVRF, VRF systems and Mechanical Ventilation with Heat Recovery (AHUs) are envisaged to provide heating, cooling, and ventilation in occupied spaces. For the purposes of the Ene 04 credit, only the ASHP's heating mode operation and contribution to DHW has been considered.

To calculate the carbon emission savings associated with the use of an ASHP, a baseline energy model in line with Part L 2021 Volume 2 has been created, where the space heating and DHW demand has been served by low temperature hot water (LTHW) gas boilers.

The consumption in kWh per year and CO2 emissions for space heating and hot water in the case of the ASHP and in the case of gas boilers can be seen in the Table below.

Table 7 ASHP Scenario

Scenario	Space heating and DHW consumption	Space heating and DHW CO2 Emissions
Gas Boiler	102.27 kWh/m^2 per year	21.48[3]
ASHP	30.63 kWh/m^2 per year	4.25
Energy & Carbon dioxide savings	71.64 kWh/m^2 per year & 70% reduction in energy per year	17.22kgCo_2/m^2 which is 80% reduction in Co_2 emissions per year

3.16.2 PV Panel

As PV has been deemed appropriate for this development, the below table details the sizing of the PV system. The table below presents a minimum number of PV to achieve a pass in Part L Volume 2 (Building other than dwellings).

[3] SAP 10.2, the latest published figures have been assumed in calculation CO2 emissions; 0.210 for mains gas and 0.1388 for electricity. SAP10 - Standard Assessment Procedure - BRE Group.

Table 8 PV Scenario

Properties	PV Systems Value
Inclination of PV Panels (°)	2
Modelled areas (m^2)	3,000
Panel area (m^2)	2.37
Nominal Power (W)	500
Orientation of PV panels	South
Level of overshading	None of very little <20%
Ventilation Strategy	Moderately ventilated modules

The table below shows the annual energy production and CO_2 emissions savings for the proposed PV system.

Table 9 PV and ASHP Scenario

Scenario	Energy Production	Space Heating and DHW CO2 Emission Savings
3,000m^2 PV and ASHP	17.92 kWh/m^2 per year	17.22kgCo_2/m^2 per year

4 Conclusion

This passive design measures introduced and quantified along with the LZC Study has been developed by Mott MacDonald on behalf of OUFC, in line with BREEAM credit Ene 04. This study also contributes to the concept design achieving a BREEAM rating of ”Very Good.”

A standard building model with the notional values from Part L 2021 Volume 2 was simulated and the proposed building with improved values was modelled where the savings in energy consumption per year and carbon emissions per year was quantified. It was seen that there was a 0.47% reduction in carbon emission and 0.38% reduction in energy consumption.

The LZC technologies have been assessed against site suitability, building function, maintenance and the impacts associated with installation. The most viable LZC technology options for this scheme that satisfy all the energy requirements set by Building Regulations Part L Volume 2 (for buildings other than dwellings). and contribute towards achieving the “Very Good” BREEAM target, are:

- LED lighting
- Photovoltaics (PV) Panels
- Heat recovery systems
- Heat pumps

ASHP (Air Source Heat Pump).After consideration of the building system options and LZC technologies, ASHPs have been selected as the primary source of heating and cooling due to their very high efficiency, low payback period and fully electric system. Additionally, with the projected decarbonisation of the grid, heat pumps will result in ongoing reductions in carbon emissions to the development throughout its operation. The results also indicate there was a 70% CO2 reduction and 80% primary energy reduction when compared to the Part L 2021 TER and TPER.

It is recommended that PV panels are taken forward in the design, alongside ASHPs as an LZC solution for this building. However, it should be noted the potential effectiveness of the PV option is reduced as the roof is inclined to 2°. Due to the limited space on the roof and the large quantity of PV required, the optimal tilt angle of the PV is unable to be achieved. The simulation results also show that there was a 17.22kgCo_2/m^2 per year reduction in CO_2 and 81.4% primary energy reduction when compared to the Part L 2021 Building Primary Energy Rate.

The lack of suitable watercourses nearby results in hydroelectric power and water source heat pumps not being suitable. Further to this, due to the existing site constraints, a GSHP is also non-viable. Additional technologies including CHP and district heating were considered, however, these have been ruled out.

The showcased reduction in CO2 per year and energy reduction when introducing LZC technologies and when introducing passive design measures has demonstrated how Ene 04 is achieved.

5 Appendix

A.1 Gas Boiler BRUKL

A.2 ASHP BRUKL

A.3 ASHP and PV BRUKL

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