Whole Life-Cycle Carbon Assessment

RIBA Stage 2

Stoney Wood Property Developments Ltd

Stoney Wood Quarter

The Fairway
London
NW7
London Borough of Barnet

Version	Revision	Date	Author	Reviewer	Project Manager
1	A	21.05.2025	Samantha May	Lamya Salem	Lamya Salem
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Executive Summary

This Whole Life Carbon Assessment (WLCA) has been prepared by SRE Ltd on behalf of Stoney Wood Property Developments Ltd (The Client) in support of an application for full planning permission for Stoney Wood Quarter, Barnet (The Proposed Development), within the system boundary.

The Proposed Development is for *"Redevelopment of the site for use as residential (Class C3), in new buildings up to ground plus 5 storeys. Ancillary flexible (Class E) uses at ground floor level. Together with plant, play space, car and cycle parking, hard and soft landscaping and all other works associated with the development".*

This WLCA has been conducted in accordance with the BS EN 15978: 2011 'Sustainability of Construction Works' principles[1], which is the standard UK framework for appraising the environmental impacts of the built environment. This assessment has also followed the methodology outlined in the London Plan Whole Life-Cycle Carbon Assessments Guidance (March 2022)[2] and RICS Professional Standard, Whole Life Carbon Assessment for the Built Environment (2nd edition)[3]. The embodied carbon footprint has been calculated using the One Click LCA tool, while energy consumption and related carbon emissions during operation for the Proposed Development has been predicted.

The assessment comprehensively evaluates the entire life cycle of the Proposed Development, covering Modules A, B, C, and D as defined by BS EN 15978. Over the 60-year Reference Study Period (RSP), the total life-cycle carbon impact of the development is projected to be 1,737 $kgCO_2e/m^2$, as detailed in Table 1.

The key findings include:

- Operational carbon emissions, encompassing both regulated and unregulated energy use, amount to 38,188,890 $kgCO_2e$, equivalent to 970 $kgCO_2e/m^2$ over the life cycle of the project.
- Embodied carbon emissions are estimated at 472 $kgCO_2e/m^2$.

Life-cycle Modules (BS EN 15978)			Global warming potential - non-decarbonised scenario	
			$kgCO_2e$	$kgCO_2e/m^2$
Product Sourcing and Construction Stage	A1-A3	Product Stage	15,870,697	403
	A1-A3 Biogenic Carbon	Product Stage - Carbon Sequestration	-7,444,748	-189
	A4	Transport to Project Site	1,477,171	38
	A5	Construction and Installation Process	1,232,039	31
Use Stage	B1	Use	1,476	0.04
	B2	Maintenance	393,630	10

[1] BS EN 15978: 2011 'Sustainability of Construction Works' principles
[2] London Plan Whole Life-Cycle Carbon Assessments Guidance (March 2022)
[3] RICS Professional Standards – Whole life carbon assessment for the built environment (2nd Edition, Version 2, November 2023)

Life-cycle Modules (BS EN 15978)			Global warming potential - non-decarbonised scenario	
			kgCO_2e	kgCO_2e/m^2
	B3	Repair	1,685,477	43
	B4	Replacement	11,167,426	284
	B5	Refurbishment	0	0
Use Stage - Operational Carbon	B6	Operational Energy Use	37,235,174	946
	B7	Operational Water Use	953,716	24
End-of-Life Stage	C1	Deconstruction/Demolition	133,834	3
	C2	Transport to Disposal Facility	341,326	9
	C3	Waste Processing	8,127,868	206
	C4	Disposal	1,089	0
Upfront Carbon	A1-A5		18,579,906	472
Life-cycle Embodied Carbon	A-C (excl B6 & B7)		32,987,284	838
Life-cycle Operational Carbon	B6 & B7		38,188,890	970
Benefits and Loads Beyond the System Boundary	D	Reuse, Recovery, Recycling Potential	-2,789,746	-71
Whole Life-cycle Carbon	A-C		68,386,428	1,737

Table 1 - Carbon Emissions per Life-cycle Stage of the Proposed Development

Module	WLC benchmark (kg CO_2e/ m^2 GIA)	Aspirational WLC benchmark (kg CO_2e/ m^2 GIA)	Result for this development
A1-A5 (excluding sequestration/ biogenic carbon)	<850	<500	472
B1-B5, C1-C4 (excluding B6 & B7)	<350	<300	555
A-C (excluding B6 & B7, including sequestration)	<1200	<800	838

Table 2 - Comparison of results with the GLA WLCA benchmarks

Introduction

1.0 Introduction

This Whole Life Carbon Assessment (WLCA) has been prepared by SRE Ltd on behalf of Stoney Wood Property Developments Ltd (The Client) during RIBA Stage 2, to quantify and report the anticipated carbon emissions across all life cycle stages of Stoney Wood Quarter, Barnet (The Proposed Development), within the system boundary.

The WLCA has been undertaken in accordance with the London Plan Whole Life-Cycle Carbon Assessments Guidance (March 2022) which outlines calculation of the Whole Life-Cycle Carbon (WLC) emissions in line with Policy SI 2 F of the 2021 London Plan[4]. The assessment has followed the methodology outlined in RICS Professional Standard, Whole life carbon assessment for the Built Environment (2nd edition, November 2023), which provides technical detail and calculation requirements on the practical implementation of the BS EN 15978: 2011 'Sustainability of Construction Works' principles.

The assessment involves the input of information detailed within drawings and Revit model received from the Design Team into the OneClick LCA tool to evaluate the associated embodied carbon impacts with the Proposed Development. To evaluate the development's operational energy demand, the assessment employs the industry-recognized SAP energy modelling software, following the methodology outlined in the Standard Assessment Procedure and Part L procedure.

A 60-year Reference Study Period (RSP) has been applied to calculate the whole life-cycle carbon emissions of the Proposed Development. The assessment identifies key carbon hotspots and outlines targeted mitigation strategies to reduce carbon emissions, with a particular focus on minimizing embodied carbon.

The figures within this report may be based on indicative modelling and an assumed specification outlined within the relevant sections. Therefore, this modelling may not represent the as built emission or energy use of the Proposed Development and further modelling may need to be undertaken at detailed design stage to confirm precise performance figures.

1.1 The Site and Proposed Development

The Proposed Development includes *"Redevelopment of the site for use as residential (Class C3), in new buildings up to ground plus 5 storeys. Ancillary flexible (Class E) uses at ground floor level. Together with plant, play space, car and cycle parking, hard and soft landscaping and all other works associated with the development".*

The Site is located on the northern side of the Fairway in the north of the London Borough of Barnet. It is to the east of the M1 and west of Barnet Way.

The Site is approximately 23,000 sqm in size and has no prevailing or dominant architectural style north of the Fairway, typology or local context. It is highly varied and the housing development which surrounds it is wedged between the M1 and Thameslink/Midland Mainline to the west and the A1 Barnet Way to the east. The south is dominated by a variety of interwar "metroland" semi-detached houses. There are flats and maisonettes located within the area in addition to larger family homes.

[4] The London Plan, March 2021

The site is bounded by Fairway and Northway School to the east and Stoney Wood woodland to the west which merges into Mill Hill Golf Course north and northeast of the Site. To the south of the Site is residential, with detached and semi-attached dwellings situated on large plots with front and rear gardens.

Figure 1 demonstrates the location of the Proposed Development.

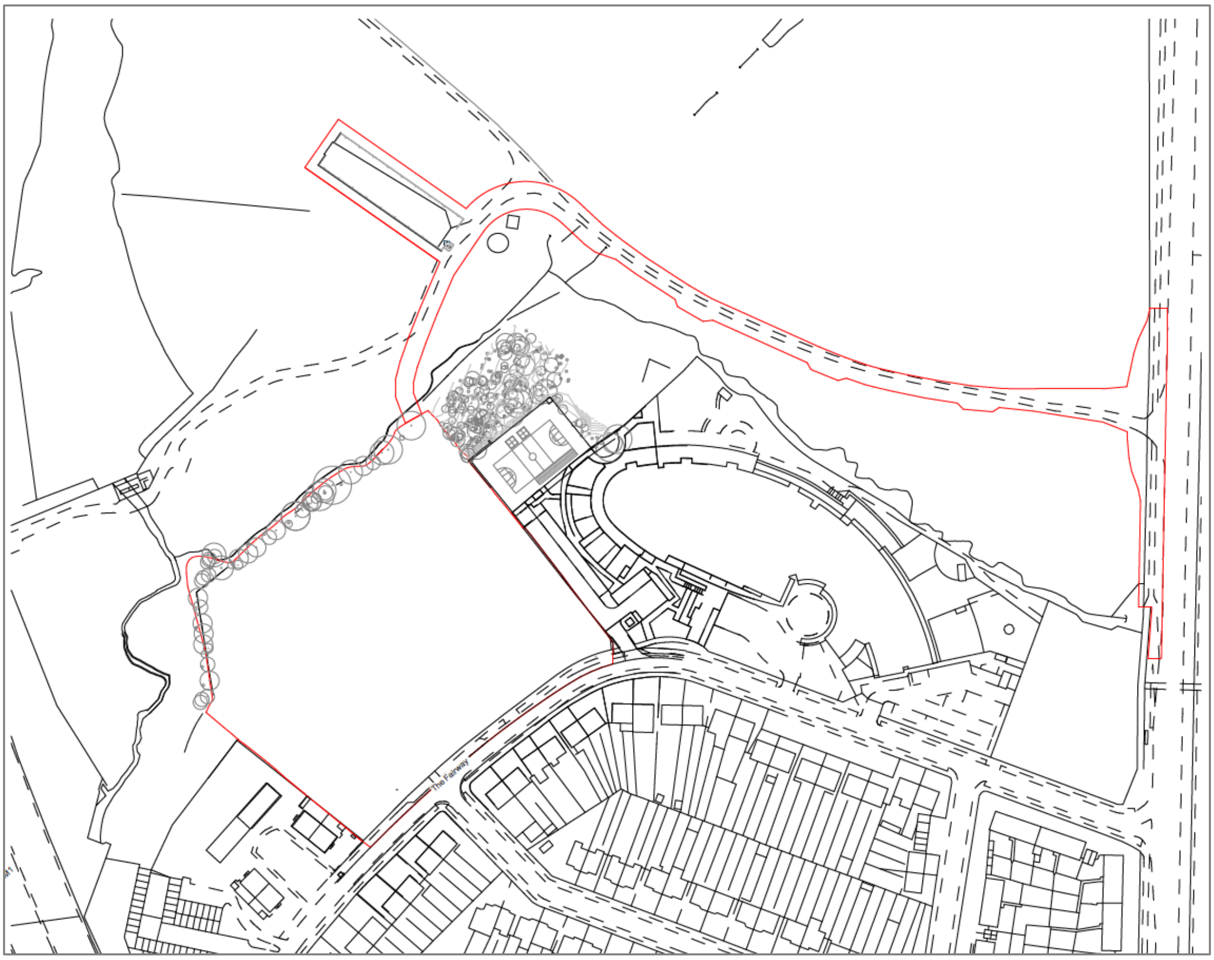

Figure 1 - Location of the Proposed Development

Figure 2 – Proposed Site Plan

1.2 Existing Developments

The site has a limited planning history, an application is currently pending consideration (ref. 24/1308/FUL) for "Retrospective temporary change of use of land to B8 storage and distribution for 2 years". A similar application was withdrawn in 2024 for a similar proposal.

It is currently in use as a car impound yard and is hoarded on all sides. It is bounded by Stoney Wood itself to the north, the Fairway and Northway Schools to the east and residential accommodation and a car scrap yard to the west. The site appears to have contained education buildings until the early 2010's which were demolished until the new school was provided adjacent with the land then vacant until the car impound yard was instated in 2023.

The site currently has no existing development. Hence, no major demolition activities will occur on site.

For the purpose of whole life-cycle carbon, pre-construction stage carbon emissions will be estimated based on the assumptions outlined in section 3.5.

1.3 Policy & Regulations

Table 3 below summarises the relevant planning requirements with regard to whole-life cycle carbon strategies.

Planning Policy	Requirement
The London Plan 2021	<u>Policy SI 2 Minimising greenhouse gas emissions</u> F. Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions. <u>Policy SI 7 Reducing waste and supporting the circular economy</u> A. Resource conservation, waste reduction, increases in material re-use and recycling, and reductions in waste going for disposal will be achieved by the Mayor, waste planning authorities and industry working in collaboration to: 1) promote a more circular economy that improves resource efficiency and innovation to keep products and materials at their highest use for as long as possible 2) encourage waste minimisation and waste prevention through the reuse of materials and using fewer resources in the production and distribution of products 3) ensure that there is zero biodegradable or recyclable waste to landfill by 2026 4) meet or exceed the municipal waste recycling target of 65 per cent by 2030 5) meet or exceed the targets for each of the following waste and material streams:

Planning Policy	Requirement
	a) construction and demolition – 95 per cent reuse/recycling/recovery b) excavation – 95 per cent beneficial use 6) design developments with adequate, flexible, and easily accessible storage space and collection systems that support, as a minimum, the separate collection of dry recyclables (at least card, paper, mixed plastics, metals, glass) and food
Barnet Local Plan 2021 - 2036[5]	Chapter 6 Character, Design and Heritage 6.4 Promoting High Quality Design 6.4.5 Reducing carbon dioxide (CO_2) emissions and adapting to future climate change are priorities for the Local Plan. All developments need to aim for zero carbon and should represent good quality design that demonstrates high levels of environmental awareness contributing to climate change mitigation and adaptation. Chapter 10 Environment and Climate Change 10.5 Carbon Reduction 10.5.4 In accordance with London Plan Policy SI 2F, development proposals referrable to the Mayor of London are required to calculate whole life cycle carbon emissions and demonstrate actions taken to reduce life-cycle carbon emissions. A whole life-cycle approach is needed to capture: i. unregulated emissions (i.e. those associated with cooking and small appliances), ii. embodied emissions (i.e. those associated with raw material extraction, manufacture and transport of building materials and construction), and iii. emissions associated with maintenance, repair and replacement as well as dismantling, demolition and eventual material disposal.
Barnet - Zero	Our Vision As we move forward, we will take action that will: • champion zero carbon development and affordable homes • build a local green economy with sustainable jobs and suppliers • support residents, communities and businesses in making sustainable choices • foster a sustainable and inclusive future for all generations Our commitment to net zero We are: • committed to reduce the amount of carbon we emit as an organisation

[5] Barnet Local Plan 2021-2036 (Adopted March 2025)

Planning Policy	Requirement
	• committed to supporting residents, communities and businesses reduce the carbon they emit across the borough • moving towards our ambitions through the delivery of our sustainability action plan • proud of the accelerated pace of change and the progress we have made since May 2022. Whilst putting residents, communities and businesses at the heart of our delivery we have: • championed sustainability • reduced our carbon emissions • raised awareness of the impact of a changing climate on our environment

Table 3 - Summary of Planning Policy requirements

Technical Guidance

2.0 Technical Guidance

This WLCA has been carried out in line with the BS EN 15978: 2011 (Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method). This is the standard UK framework for appraising the environmental impacts of the built environment. It sets out the principles and calculation method for the whole-life assessment of the environmental impacts from built projects. The following are the industry-wide methodology and standards that comply with BS EN 15978:2011.

2.1 Whole Life Carbon Assessment for the Built Environment, RICS Professional Standard 2nd Edition

RICS Professional Standard (PS) 2nd edition addresses all element and component categories making up a built asset, during every stage: from extracting raw materials and manufacturing constituent construction products, through operation, to recovery or disposal at end of life. It also assesses the potential loads and benefits of recovery beyond the system boundary in the next life cycle. All aspects of WLCAs covered by this document are explained and put into context.

This document can be applied to any type of construction or civil engineering project, including building and/or infrastructure assets involving any of the following:

- New construction/new-build assets
- Demolition of existing and construction of new assets
- Retrofit/refurbishment of existing assets
- Masterplans with multiple built assets, including associated project infrastructure, and
- Fit-out of built assets.

2.2 Whole Life-cycle Carbon Assessments Guidance – Greater London Authority (2022)

The GLA guidance explains how to prepare Whole Life-cycle Carbon (WLC) assessment in line with Policy SI2 F of the London Plan (2021) using the WLC assessment template. Policy SI 2 F applies to planning applications that are referred to the Mayor of London. However, WLC assessments are also supported and encouraged on major applications that are not referable.

This guidance explains how to calculate WLC emissions, and the information required to be submitted to comply with the policy. It also includes information on design principles and WLC benchmarks to aid planning applicants in designing buildings that have low operational carbon and low embodied carbon.

2.3 TM65 Embodied Carbon in Building Services: A Calculation Methodology (2021)

TM65 outlines the need for assessments of embodied carbon of products linked to MEP systems, to increase knowledge and facilitate WLC research in these areas. In this technical manual, embodied carbon is understood as the greenhouse gas emissions (GHG) associated with the making of a product, its installation, maintenance, repair and replacement, and its end of life. It covers the whole life cycle, excluding operational aspects and the potential recovery, reuse or recycling of materials. The embodied carbon associated with MEP design can be significant in a building's lifetime due to the materials that MEP equipment are made of and high replacement rates.

This guidance provides a consistent approach for:

- The data required from manufacturers
- An embodied carbon calculation methodology for MEP products, depending on how much information from manufacturers is available
- The way in which embodied carbon assessments are reported.

2.4 Standard Assessment Procedure (SAP)

The Standard Assessment Procedure (SAP) for the energy rating of dwellings is the methodology currently used by the government to estimate the energy performance of homes. The methodology has 2 main uses:

- To demonstrate compliance of new homes with Part L of the Building regulations
- To generate Energy Performance Certificates (EPCs) for all homes, which advise occupants, prospective buyers, landlords, and renters of the energy performance of a property

SAP plays a key role in developing, implementing, and monitoring government policies on energy efficiency, fuel poverty and heat decarbonisation, and is used across the whole building industry.

Methodology

3.0 Methodology

This section outlines the WLC assessment process, including life-cycle modules, WLC principles, data sources, the model inputs for each building elements and modules, and key assumptions.

3.1 Life-cycle Modules

There are four stages in the life of a typical project, described as life-cycle modules, set out by BS EN 15978 and RICS Professional Standards.

- Module A1-A5: Product Sourcing and Construction Stage
- Module B1-B7: Use Stage
- Module C1-C4: End-of-Life Stage
- Module D: Benefits and Loads Beyond the System Boundary

This WLC assessment has covered the entirety of Modules A, B, C and D. As shown in Figure 3, these modules are further broken down into sub-modules, summarised as follows:

- **Product Stage (A1-A3)**: Emissions associated with the extraction (A1), transporting (A2) and manufacturing processes (A3) necessary to produce the construction products, components and technical equipment required to construct the asset.

- **Construction Stage (A4-A5)**: Emissions arising from the transportation of construction products and the construction process, up to project completion. Module A5 also includes any on-site demolition or strip-out works required at the beginning of the project.

- **In Use Stage (B1-B7)**: Emissions generated during the operation of the building. This covers the impact of the use (B1), maintenance (B2), repair (B3), replacement (B4) and refurbishment (B5) of the building as well as energy and water use (B6-B7).

- **End-of-Life Stage (C1-C4)**: Emissions addressing the deconstruction, demolition (C1), transport (C2), waste processing (C3) and disposal (C4) of materials.

- **Benefits and Loads beyond the System Boundary (D)**: Covers any potential benefit from the reuse, recovery and recycling potential of the building materials or products.

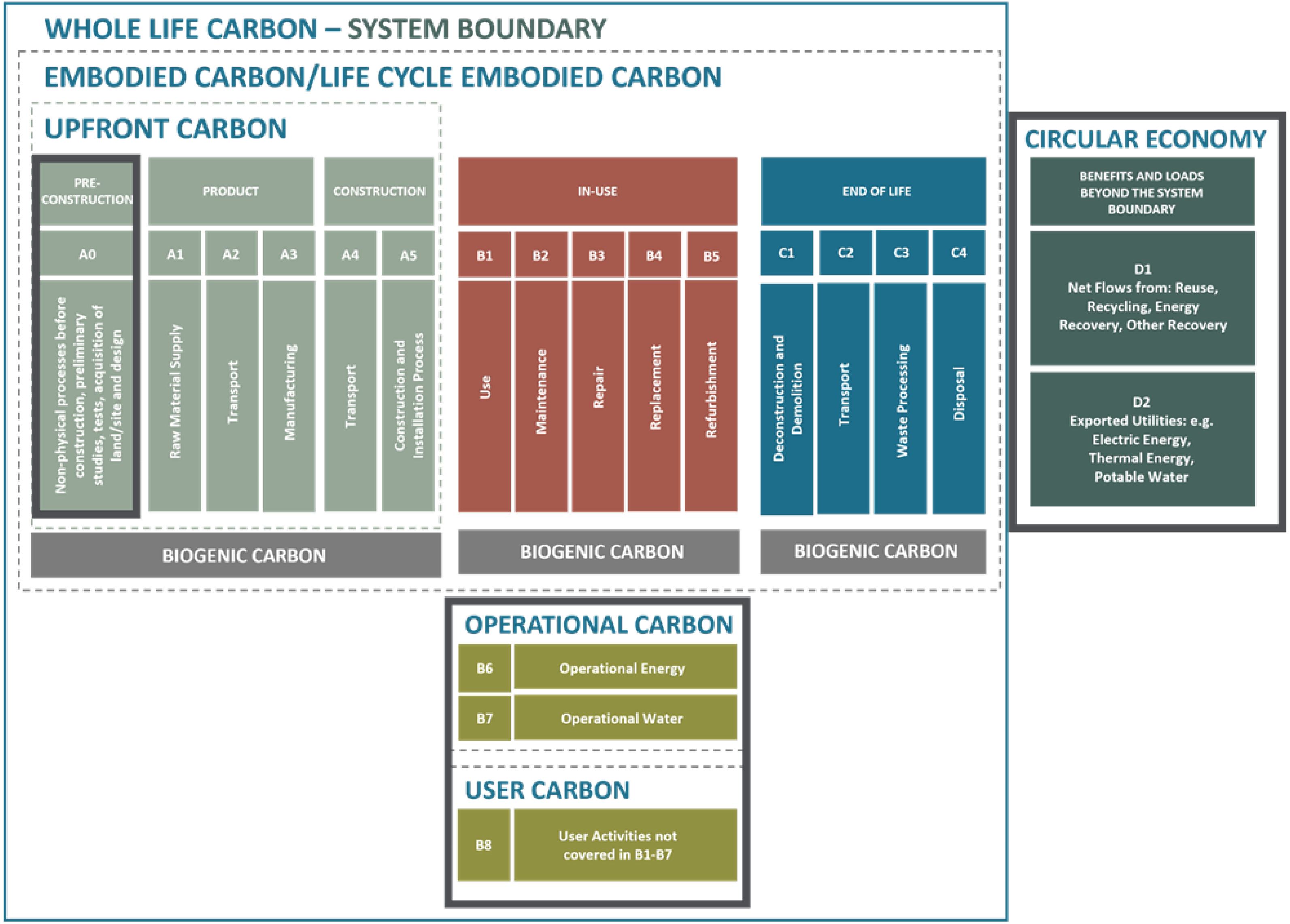

Figure 3 – Building life cycle stages and information modules (RICS WLCA Professional Standard)

3.2 Project Phases

A compliant WLC assessment should be undertaken at the following key project phases.

- **Concept design phase:** Pre-construction forecasts should be used as the project baseline for ongoing carbon reporting and progress tracking throughout the project.
- **Technical design phase:** Pre-construction forecasts should be used to evaluate the evolving design, and at-tender assessments should be used to evaluate tenders.
- **Construction phase:** As specific products are chosen or the design is adjusted, pre-construction forecasts should be reviewed and updated to monitor construction variations.
- **Post-completion phase:** A post-completion assessment should be used to check the carbon reductions predicted in the pre-construction and at-tender forecasts have been achieved.

As the project proceeds, carbon reduction opportunities become fewer, have reduced impact and are potentially more expensive to implement. This is illustrated in Figure 4.

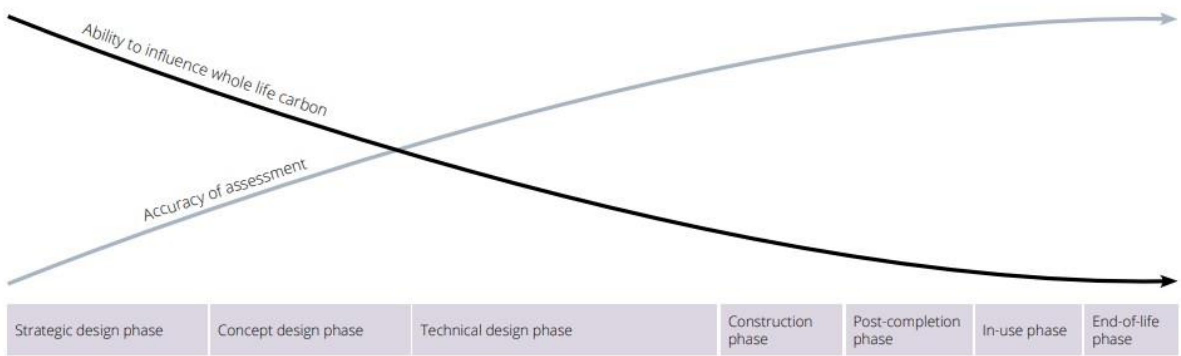

Figure 4 - The ability to influence whole life carbon decreases but the accuracy of assessment increases as the project progresses

The assessment is conducted during RIBA Stage 2 to establish the baseline carbon emissions of the Proposed Development and explore opportunities for reduction. This is achieved by applying the WLC principles outlined in Section 3.3 and developing alternative scenarios to minimize embodied carbon emissions through strategic material selection, as detailed in Section 0.

3.3 Whole Life-cycle Carbon Principles

Table 4 below outlines the WLC principles from the London Plan Guidance (Whole Life-cycle Carbon Assessments). Each principle has been considered in relation to the unique characteristics of the development, as detailed below.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
1	Reuse and retrofit of existing built structures	Retaining existing built structures for reuse and retrofit, in part or as a whole, should be prioritised before considering substantial demolition, as this is typically the lowest-carbon option. Significant retention and reuse of structures also reduces construction costs and can contribute to a smoother planning process.	A1-A5, B1-B6, C1-C4, D	There are no buildings on the current site and is currently used as a car impound yard.
2	Use repurposed or recycled materials	Using repurposed or recycled or materials, as opposed to newly sourced materials, typically reduces the carbon emissions from constructing a new building and reduces waste. This process would start by reviewing the materials already on site for their potential for inclusion into the proposed scheme. Many of the currently available standard products already include a degree of recycled content.	A1-A5, B1-B5, C1-C4, D	As above
3	Material selection	Appropriate low-carbon material choices are key to carbon reduction. Ensuring that materials are selected with consideration of the planned life expectancy of the building reduces waste, the need for replacements, and the in-use costs.	A1-A5, B1-B5, C1-C4, D	The building will be built with concrete structure, brick cladding, internal stud wall etc. Low-carbon materials with long service lifespan are considered and proposed.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
		It is important to note that the overall lifetime carbon emissions of a product can be as much down to its durability as to what it is made of. For example, bricks may have high carbon emissions in terms of their manufacture, but they have an exceptionally long and durable life expectancy. The selection of reused or recycled materials and products, plus products made from renewable sources, will also help reduce the carbon emissions of a project.		
4	Minimise operational energy use	A ‘fabric first’ approach should be prioritised to minimise the heating and cooling requirement of a building and the associated systems. Naturally ventilated buildings avoid the initial carbon and financial costs of a ventilation system installation, and the repeat carbon and financial costs of its regular replacement.	A1-A5, B1-B4, B6	It will feature high-efficiency systems such as mechanical ventilation with heat recovery (MVHR), energy-efficient lighting, and renewable technologies including air source heat pumps and rooftop photovoltaic panels.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
5	Minimise the carbon emissions associated with operational water use	Carbon emissions from water use are largely due to the materials and systems used for its storage and distribution, the energy required to transfer it around the building, and the energy required to treat any wastewater. The choice of materials used and the durability of the systems, which help avoid leakage and resulting damage to building fabric, are therefore key aspects of reducing the carbon emissions of water use. On-site water collection, recycling and treatment, and storage can have additional positive environmental impacts as well as reducing in-use costs.	A1-A5, B1-B7, C1-C4, D	As the Proposed Development is a residential scheme, water usage is expected to be high due to the large number of occupants. To reduce domestic water consumption, the installation of water-efficient fittings, in line with the requirements of Part G, is essential. Operational water uses on-site, including for cleaning, maintenance, and landscaping should also be taken into consideration. In line with Building Regulation Part G, a water consumption of 110 l/p/d will be used to calculate the overall water consumption of the developments.
6	Disassembly and reuse	Designing for future disassembly ensures that products do not become future waste, and that they maintain their environmental and economic value. A simple example is using lime rather than cement mortar - the former being removable at the end of a building's life, the latter not. This enables the building's components (e.g. bricks) to have a future economic value as they can be reused for their original purpose rather than becoming waste or recycled at a lower level (e.g. hardcore in foundations). Designing building systems (e.g. cladding or structure) for disassembly and dismantling has	A1-A5, B1-B5, C1-C4, D	Disassembly and reuse have been considered through flexible design of building layouts. Internal partition walls will be design separately from the structural elements and can be removed or reconfigured easily. Demountable walls, movable panels, or lightweight partitions are considered. Standardized Components will be considered when selecting materials and composite materials will be avoided. Modular bathrooms and kitchens have been considered to streamline the construction and disassembly process.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
		similar and even broader benefits. Ease of disassembly facilitates easy access for maintenance and replacement leading to reduced maintenance carbon emissions and reduced material waste during the in-use and end-of-life phases. This leads to the potential for material and product reuse which also reduces waste and contributes to the circular economy principle.		
7	Building shape and form	Compact efficient shapes help minimise both operational and embodied carbon emissions from repair and replacement for a given floor area. This leads to a more efficient building overall, resulting in lower construction and in-use costs. A complex building shape with a large external surface area in relation to the floor area requires a larger envelope than a more compact building. This measure of efficiency can be referred to as the 'wall to floor ratio', or the 'heat loss form factor'. This requires a greater use of materials to create the envelope, and a potentially greater heating and/or cooling load to manage the internal environment.	A1-A5, B1-B6	The building has been designed to maximise daylight in all rooms.
8	Regenerative design	Removing carbon from the atmosphere through materials and systems absorbing it makes a direct contribution to carbon reduction. Examples include unfinished concrete, some carpet products and maximising the amount of vegetation.	A1, B1, D	Regenerative Design has been considered. The building will be constructed using concrete.

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No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
9	Designing for durability and flexibility	Durability means that repair and replacement is reduced which in turn helps reduce lifetime building costs. A building designed for flexibility can respond with minimum environmental impact to future changing requirements and a changing climate, thus avoiding obsolescence which also underwrites future building value. Buildings designed with this principle in mind will be less likely to be demolished at their end-of-life as they lend themselves to future refurbishment. Examples include buildings being designed with 'soft spots' in floors to allow for future modification and design, as well as non-structural internal partitions to allow layout change.	A1-A5, B1-B5, C1-C4, D	Materials with long lifespan are considered when selecting materials.
10	Optimisation of the relationship between operational and embodied carbon	Optimising the relationship between operational and embodied emissions contributes directly to resource efficiency and overall cost reduction. For example, the use of insulation has a clear carbon benefit whereas its fabrication will generate carbon emissions. This means that it is important to look not only at the U-value of insulation, but also the carbon emissions from the manufacture and installation of different product options. Avoiding fully glazed façades will reduce cooling demand and limits the need for high-carbon materials (glass units, metal frame, shading device etc) at both the construction and in-use stages through wholesale replacements.	A1-A5, B1-B6	Optimisation of the relationship between operational and embodied carbon. Fully glazed facades are avoided for the developments. Facades are designed to achieve lower U-value with less materials used.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
11	Building life expectancy	Defining building life expectancy gives guidance to project teams as to the most efficient choices for materials and products. This aids overall resource efficiency, including cost efficiency and helps future-proof asset value.	A1-A5, B1-B5, C1-C4, D	Building life expectancy is considered 60 years.
12	Local sourcing	Sourcing local materials reduces transport distances and therefore supply chain lengths; and has associated local social and economic benefits, e.g. employment opportunities. It also has benefits for occupiers as replacement materials are easier to source. Transport type is also highly relevant. A product transported by ship will have significantly lower carbon emissions per mile than one sent by HGV. A close understanding of the supply chain and its transport processes is therefore essential when selecting materials and products.	A1-A5, B3-B5	Local sourcing of materials will be implemented to the Proposed Development.
13	Minimising waste	Waste represents unnecessary and avoidable carbon emissions. Buildings should be designed to minimise fabrication and construction waste, and to ease repair and replacement with minimum waste, which helps reduce initial and in-use costs. This can be achieved through the use of standard sizes of components and specification and by using modern methods of construction (MMC). Where waste is unavoidable, the designers should establish the suppliers' processes for disposal or preferably reuse or recycling of waste.	A1-A5, B1-B7, C1-C4, D	Modern construction methods will be employed, and the design has been developed in mind with disassembly and reuse in the future.

No.	Principle	Description	Relevant life-cycle modules	WLC principles considered for the Proposed Development
14	Efficient construction	Efficient construction methods (e.g. modular systems, precision manufacturing and MMC) can contribute to better build quality, reduce construction-phase waste and reduce the need for repairs in the post-completion and defects period (snagging). These methods can also enable future disassembly and reuse with associated future carbon savings.	A1-A5, B1-B7, C1-C4, D	Modular bathrooms and kitchens have been considered to streamline the construction and disassembly process.
15	Lightweight construction	Lightweight construction uses less material, which reduces the emissions of the building as there is less material to source, fabricate and deliver to site. Foundations can then also be reduced with parallel savings. Lightweight construction can also be easier to design for future disassembly and reuse. The benefits of lighter construction should be seen in the context of other principles such as durability.	A1-A5, C1-C4, D	Lightweight construction will be considered in the design process when calculating the load capacity.
16	Circular economy	The circular economy principle focuses on a more efficient use of materials which in turn leads to financial efficiency. Optimising recycled content, reuse and retrofit of existing buildings; and designing new buildings for easy disassembly, reuse and retrofit, and recycling as equivalent components for future reuse are essential. The use of composite materials and products can make future recycling difficult. Where such products are proposed, the supplier should be asked for a method statement for future disposal and recycling.	A1-A5, B1-B5, C1-C4, D	Future disassembly and materials with high potential for reuse and recycling have been considered, promoting a circular economy.

Table 4 - WLC Principles (Whole Life-cycle Carbon Assessments – London Plan Guidance)

3.4 Data Sources

The accuracy of the data used in the assessment is essential. Table 5 below summaries the data sources for the assessment.

- During the early design stage, when specific manufacturers have not yet been identified, appropriate generic carbon data from verified Type III Environmental Product Declarations (EPDs) should be applied as specified in WLC-LPG and RICS PS, Table 16.
- The material quantities are taken from the Revit model which was provided by the design team.
- As a structural engineer has not yet been appointed, the quantities for the substructure and framework have been estimated using the Revit model which was provided.
- For MEP equipment, quantity estimations follow the RICS MEP supplementary table and CIBSE TM65, as the project is still in early design and the specifications for MEP services have not yet been finalised.
- The energy consumption and associated energy carbon emissions are derived from the SAP report.

Further details can be found in Section 3.4 regarding model Inputs and Section 3.5 for assumptions applied.

Data Source	Discipline/Company	Description
Generic Materials	OneClick - LCA Software	OneClick generic database & EPD database
Cost Plan	N/A	N/A
Architectural Plans	London Placemaking	Architectural drawings, Revit model
Structural Engineering drawings	N/A	N/A
M&E drawings	N/A	N/A
Energy Strategy	N/A	N/A
Pre-Demolition audit	N/A	N/A

Table 5 - Data Sources for the WLCA

3.5 Modelling Inputs

The section elaborates on the building element categories, in line with 'RICS Whole Life Carbon Assessment for the Built Environment' (2nd Edition, November 2023). The building elements are based on the RICS NRM classification system level 3 sub-elements.

Building element group	Building element (NRM Level 3)	Scope notes
Demolition	0.1 Toxic/hazardous/contaminated material treatment	The information is not available at the early design stage. More information will be added to the assessment at a later stage.
	0.2 Major demolition works	There is no demolition on the site.
0 Facilitating works	0.3 and 0.5 Temporary/enabling works	It is assumed there are no facilitating works. The construction site impacts are included under A5 site operations.
	0.4 Specialist groundworks	As above.
1 Substructure	1.1 Foundations and piling	Pile foundation with footing foundation will be implemented for developments with heavy loads.
	1.2 Basement retaining walls and lowest slab	Basement retaining walls. Lowest floor slab: Concrete slab will be installed with reinforcement, insulation, vapour barrier membrane.
2 Superstructure	2.1 Frame	The frame will be concrete columns and beams.
	2.2 Upper floors	Concrete masonry units and precast concrete, PUR rigid insulation, concrete screed, sand, timber joists, metal decking, chipboard, vapour barrier membrane
	2.3 Roof	Aluminium standing seam roof cladding, Ready-mix concrete RC25/30 with CEM I cement, reinforcement steel 97% recycled content, polyethylene vapour barrier membrane, Kingspan Kooltherm K5 insulation, roof felt
	2.4 Stairs and ramps	Hardwood stairs, concrete stairs

Building element group	Building element (NRM Level 3)	Scope notes
	2.5 External envelope including roof finishes	Aluminium framed curtain wall system with 50% recycled aluminium, Brick wall (clay brick) and mortar with fibreglass insulation, cavity and concrete masonry blockwork. Retaining walls – precast concrete. Screed – on window areas. Balconies – aluminium railings and balconies, glass panels. Aluminium standing seam roof cladding, Kingspan Kooltherm K5 insulation, Ready-mix concrete C30/37 10% recycled binder, reinforcement steel 97% recycled content, waterproofing membrane.
	2.6 Windows and external doors	Timber framed windows, Aluminium framed windows, Aluminium skylights. Timber front doors.
	2.7 Internal walls	Concrete masonry units, gypsum plaster boards, internal timber joists.
	2.8 Internal doors	Wooden interior doors.
3 Finishes	3.1 Wall finishes 3.2 Floor finishes 3.3 Ceiling finishes	Floor – engineered wood flooring. Walls – plaster, plasterboard, paint finish. Ceiling – emulsion paint.
4 Fittings, Furnishings & Equipment (FF&E)	4 FFE – Building/Non-building related	Sofas, chairs, cabinets, bed frames, tables, drawers, kitchen units, WCs, washbasin, bath and shower units and waste bins have been included.
5 Mechanical, Electrical & Plumbing (MEP)	5.1 - 5.5 – MEP services building/Building related	ASHP
6 Prefabricated Buildings and Units	6 Prefabricated buildings and units	Nothing has been proposed for the current design.

Building element group	Building element (NRM Level 3)	Scope notes
7 Works to existing building	7.1 Works to existing building or alterations	There are no existing buildings on the site.
8 External Works	8.1 Roads, paths, pavings, surfaces fencing, railings, walls, external fixtures 8.2 Soft Landscape planting, irrigation 8.3 External drainage, external services, minor building works	External hard landscaping has been included.

Table 6 - RICS WLC Building Element Categories for the Proposed Development

Table 7 below provides detailed information for each lifecycle module and a description of the source of the information or the assumption made for each stage, as per RICS PS and LPG-WLCA.

Module	Description	Data Source/ Assumption
A1-A3 Product Stage	A1 – Raw material supply: This Stage considers the environmental impact of raw materials which includes, extraction from their natural source, transporting to factories, energy used and emissions released during both extraction and transportation. A2 – Transport: This stage focuses on the environmental impact associated with transporting raw materials from suppliers to the manufacturing facility. This impact arises from the emissions generated by the fuels consumed by the transportation vehicles.	At early design stage, the material quantities are measured based on the architecture's drawings and Revit models. Generic carbon data will be used based on RICS PS default specifications for main building materials, when manufacturer's data is unavailable.

Module	Description	Data Source/ Assumption
	A3 – Manufacturing: This stage captures the environmental impact of manufacturing, which includes the fuels/materials used by machines, as well as disposal of any waste generated during the production process.	
A4 Transport to Site	Captures the impacts associated with the transportation of the materials and components from the factory gate to and from the project site.	Due to the project being in the early design stage, transport scenarios outlined by RICS guidance have been utilised (0).
A5 Construction & Installation Process	A5.1 – Pre-construction demolition: Carbon impacts resulting from deconstruction/ demolition, transporting and disposal of waste as part of the main works to the existing scheme. A5.2 – Construction activities: Carbon impacts from any construction activities and installation processes on-site, including temporary works, energy consumption for site accommodation and use of plant, machinery and equipment. A5.3 – Waste & waste management: Carbon impacts from the production and transport of products that will be wasted, as well as any impacts associated with waste treatment	There is no pre-construction demolition on the site. Construction - emissions will be captured at the post-construction stage. However, to include at the early design stage, construction site emissions have been accounted for using the floor area of the proposed development. Waste figures are to be captured at the post-construction stage. However, RICS-assigned waste rates for typical materials are used to calculate the carbon impact.
B1 In-use emissions	B1.1 – Material emissions & removals: Non-energy related carbon removals/emissions arising from component during. B1.2 – Fugitive emissions: Accidental release of refrigerants from MEP equipment	The refrigerant leakage rate is based on CIBSE TM65 for VRF system Annual Leakage Rate – 9%, End of Life Recovery Rate – 97%

Module	Description	Data Source/ Assumption
B2 Maintenance	Accounts for the carbon impacts from any activities relating to maintenance processes, including cleaning, as well as any relevant products used and waste produced	Following the RICS and GLA WLCA guidance, B2 impacts can be assumed to be 10 $kgCO_2e/m^2$ or 1% of modules A1-A5 to cover all building element categories, whichever is greater.
B3 Repair	Captures carbon impacts from all activities that relate to repair processes, and any products used and waste produced including impacts from production, transportation to and from site, and installation of the repaired items	The B3 impacts have been calculated using the software and can be assumed to be equivalent to 25% of B2 maintenance impacts and 10% of A1-A3 impacts of MEP equipment.
B4 Replacement	Accounts for any carbon impacts associated with the anticipated replacement of built asset components, including any impacts from the replacement including the production, transportation to site and installation of the replacement items as well as any losses during these processes, as well as any impacts associated with the removal and end-of-life treatment of replaced items	The carbon impacts have been determined using the software which utilises the expected lifespans for typical building elements/components as per the RICS (Appendix C).
B5 Refurbishment	Captures impacts from production, transport to site and installation of the components used for a change or refurbishment planned prior to project completion during in-use stage	There is no planned refurbishment during the study period.
B6 Operational Energy	Captures carbon emissions from all operational energy use by a building over its lifecycle	The unregulated and regulated energy is based on the SAP modelling results. The carbon emissions from the operational energy will directly come from the energy assessment. The carbon emission factors used align with those used in the energy strategy for the development.
B7 Operational Water	Capture carbon impacts related to water supply and wastewater treatment, as measured and/or predicted over the life cycle	The estimated water consumption has been taken from the Revit model. At this stage, assumed to be 110 Liters/person per day based on the Building regulations Part G.

Module	Description	Data Source/ Assumption
C1-C4 End-of-Life	C1 – Deconstruction/demolition impacts: The impacts arising from any on- or offsite deconstruction and demolition activities at the end of life of the asset, including any energy consumption for site accommodation and plant use C2 – Transport Impacts: carbon impacts associated with the transportation of material from deconstruction and demolition to the appropriate final location. C3 – Waste processing: Impacts associated with their preparation for reuse, waste treatment and recovery prior to reaching the end-of-waste state. C4 – Disposal: Impact of elements not expected to be reused, recycled or recovered, but intended for final disposal either in landfill or incineration.	All the end-of-life scenario are based on the default values and scenarios modelled within the OneClick to divert at least 95% of the waste away from landfill/incineration and achieve circularity.
D Benefits and loads beyond the system boundary	D1 - Net output flows from reuse recycling energy recovery other recovery D2 - Exported utilities, e.g. electric energy thermal energy potable water	D stage carbon emissions are based on the default values and scenarios modelled within the OneClick

Table 7 - RICS WLCA life cycle modules for the Proposed Development

3.6 Modelling Assumptions

Table 8 below outlines the assumptions that have been incorporated into the design.

Assumptions		
Substructure	Foundations: Concrete	Ready-mix concrete, C40/50, 15% cement replacement with fly ash
	Foundations: Reinforcement	Reinforcement steel (rebar), generic, 97% recycled content (typical)
	Lowest floor	Ready-mix concrete, C40/50, CIII/B, 2413 kg/m3, Viaduct (Tarmac), Reinforcement steel (rebar), generic, 97% recycled content, Filter fabric, PUR rigid insulation panels, Polyethylene vapour barrier membrane, cementitious floor levelling screed
Superstructure	Concrete frame	Ready-mix concrete, C40/50, 25% cement replacement with GGBS Reinforcement steel (rebar), generic, 97% recycled content
	External Wall	Precast concrete retaining wall, incl. reinforcement, Aluminium frame window system with double glazing, per m^2, 128.77 kg/unit, Concrete masonry unit, Brick wall, incl. mortar, Fiberglass insulation in batts, Aluminium balcony system, aluminium railings
	Windows and external doors	Timber framed windows, Aluminium framed windows, Aluminium skylights Timber front doors
	Upper Floors	Precast dense masonry blocks and precast concrete slabs, cementitious floor levelling screed, PUR rigid insulation panels, vapour proof membrane, timber joists
	Roof	Aluminium standing seam roof cladding, Kingspan Kooltherm K5 insulation, Ready-mix concrete C30/37 15% Cement replacement with fly ash, reinforcement steel 97% recycled content, waterproofing membrane for roof
	Stairs and ramps	Hardwood stairs, concrete stairs
	Internal walls and partitions	Concrete masonry unit, red brick average production, gypsum plasterboard, emulsion paint

Assumptions		
	Internal doors	Wooden interior doors
	Fittings, furnishings and equipment (FF&E)	Sofas, chairs, cabinets, bed frames, tables, kitchen units, WCs, washbasin, bath and shower units have been included
	Services (MEP)	ASHP
External works	Hard landscaping	Concrete pavement
Building Services	Refrigerant	R290 refrigerant is proposed Annual Discharge – 1 kg; Annual Leakage Rate – 9%, End of Life Recovery Rate – 97%
In-Use Emissions	Operational emissions	In the absence of further information, we have assumed 1,600 kWh per flat per year which is roughly equivalent to £400/£500 per year/ flat
Operational Water	Water Consumption	Residential – 105 litres/person per day based on the proposed water fittings as listed here: • WC's: All dual flush capacity 3/6 Litres or less • Kitchen taps flow rate: 8 l/min or less • Bathroom taps flow rate: 6 l/min or less • Bath capacity to overflow: 140 l or less • Showers flow rate: 8 l/min or less • Dishwasher consumption: 0.5 Litres per place setting or less • Washing machine consumption: 6 litres per kg dry load or less

Table 8 - WLCA Assumptions

3.7 Completeness of Assessment

The WLC assessment accounts for all building-related cost items associated with each element. A minimum of 95% of the capital cost allocated to each building element category should be accounted for at each stage of the assessment. Items excluded should each account for less than 1% of the total capital cost of that building element category.

While the cost plan is currently unavailable, material quantities have been taken from the Revit model and drawings by the LCA consultant. Small material quantities for non-building-related elements are excluded, as their final specifications will be determined at a later stage. A contingency factor of 15% is applied to all elements and scenarios in the calculations.

The LCA model has been verified by a separate in-house LCA consultant, who reviewed the material quantities and selections.

All building elements set out in Table 9 below and all associated construction works are covered in the WLCA to ensure consistency of reporting, whatever the project phase. The elemental breakdown structure is derived from RICS' New rules of measurement (NRM), as discussed previously in section 3.5. Table 9 below summarise the coverage percentage of each element.

Building Element	Percentage Coverage
0 Facilitating works	100%
1 Substructure	100%
2 Superstructure	100%
3 Internal Finishes	100%
4 FFE	97%
5 Services	100%
6 Prefabricated buildings	100%
7 Work to existing buildings	N/A
8 External Works	97%
Average Coverage	**98%**

Table 9 - Building Element Coverage Percentage

Results

4.0 Results

The embodied carbon result encapsulates all lifecycle stages (A1-A5, B1-B5, C1-C4) excluding Modules B6-B7 (operational energy and water) and Module D (benefits beyond the proposed system). Operational carbon emissions are represented within Modules B6 (operational energy demand) and B7 (water demand). The total calculated WLCA result for the proposed development over the building's 60-year lifespan can be seen in Table 10 below.

Module	Lifecycle Embodied Carbon	Operational Carbon	Whole Lifecycle Carbon
A1-A5 Construction Process stage ($kgCO_2e$)	18,579,906		
B1-B5 Use Stage ($kgCO_2e$)	13,248,009		
B6-B7 Operational Demands ($kgCO_2e$)		38,188,890	
C1-C4 End of Life stage ($kgCO_2e$)	8,604,117		
Total Carbon Emissions ($kgCO_2e$) (excluding biogenic carbon)	32,987,284	38,188,890	
Biogenic Carbon ($kgCO_2e$)	-7,444,748		
Total Carbon Emissions ($kgCO_2e$) (including biogenic carbon)	40,432,032	38,188,890	

Table 10 - Whole Life Carbon result for the Proposed Development

Module	WLC benchmark (kg CO_2e/ m^2 GIA)	Aspirational WLC benchmark (kg CO_2e/ m^2 GIA)	Result for this development
A1-A5 (excluding sequestration/ biogenic carbon)	<850	<500	472
B1-B5, C1-C4 (excluding B6 & B7)	<350	<300	555
A-C (excluding B6 & B7, including sequestration)	<1200	<800	838

Table 11 - Comparison of results with the GLA WLCA benchmarks

It is worth noting that the emissions for stages B and C are slightly higher than the benchmark. However, the upfront carbon of the development is lower than both the WLC benchmark and the aspirational benchmark. Moreover, the overall WLC for Stages A-C is almost at the aspirational WLC level. The slightly high estimate for stages B and C is related to the uncertainty for these future stages.

4.1 Embodied Carbon

4.1.1 Contribution of CO_2e per lifecycle stage

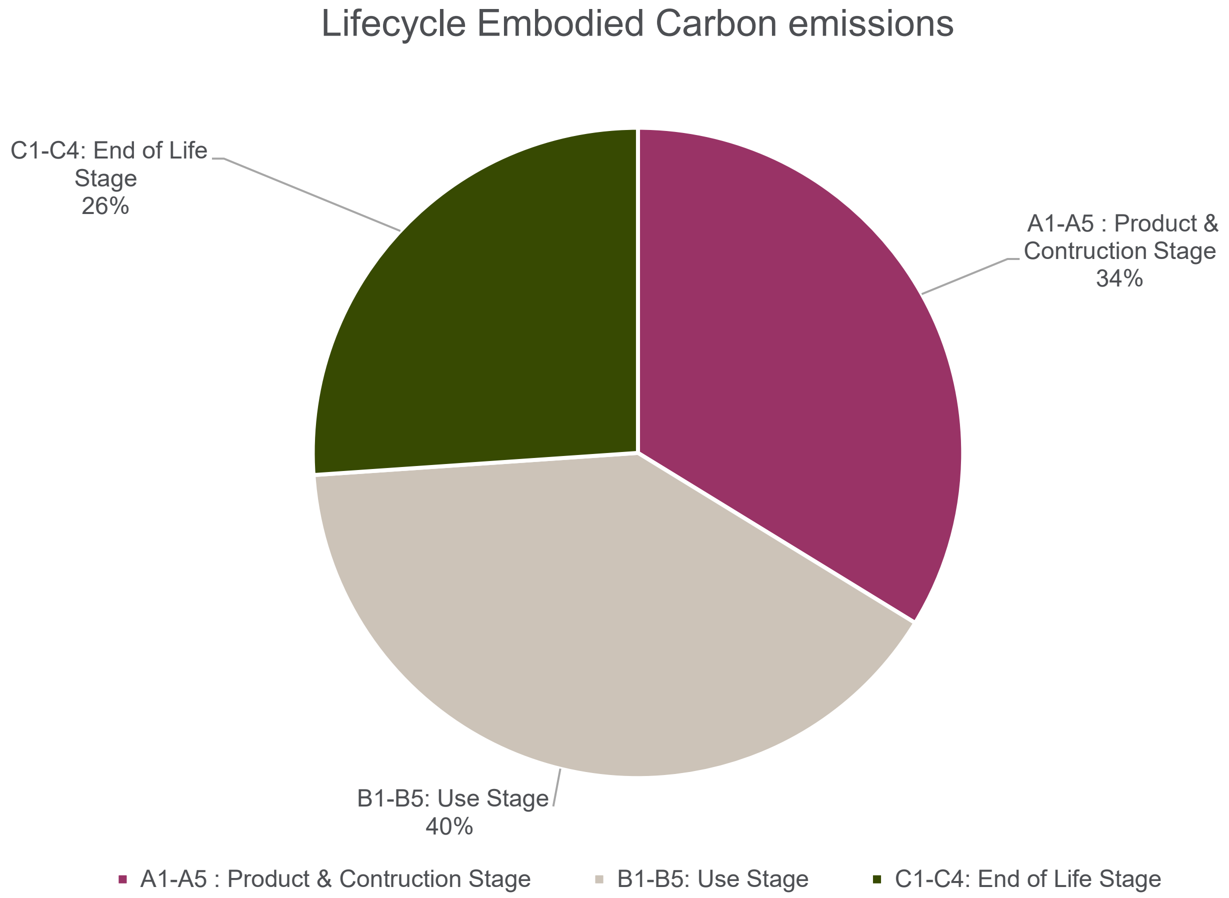

Figure 5 - Embodied Carbon emissions over lifecycle stages

Figure 5 above demonstrates that the carbon emissions associated with the use stage (B1-B5) is the highest followed by the product and construction stage (A1-A5). The emissions for lifecycle modules A1-A5 are based on the manufacture, transportation and installation of products on the site. The product and construction stages often have the highest carbon emissions associated with them.

Considering the above, the in-use phases for the proposed development provide significant room for improving the carbon performance of the building.

As the assessment has been undertaken early in the design stage, the project team can realign their detailed design and construction processes based on the carbon performance of the current design in order to deliver an even more sustainable development. This may include opting for more durable products which require less replacement and repair over the lifetime of the building to reduce the associated embodied carbon.

4.1.2 Contribution of carbon-intensive materials

In order to capture a more detailed picture of building material carbon emissions, a breakdown of the contribution of different building elements and materials to the overall carbon emissions for the proposed development is given below.

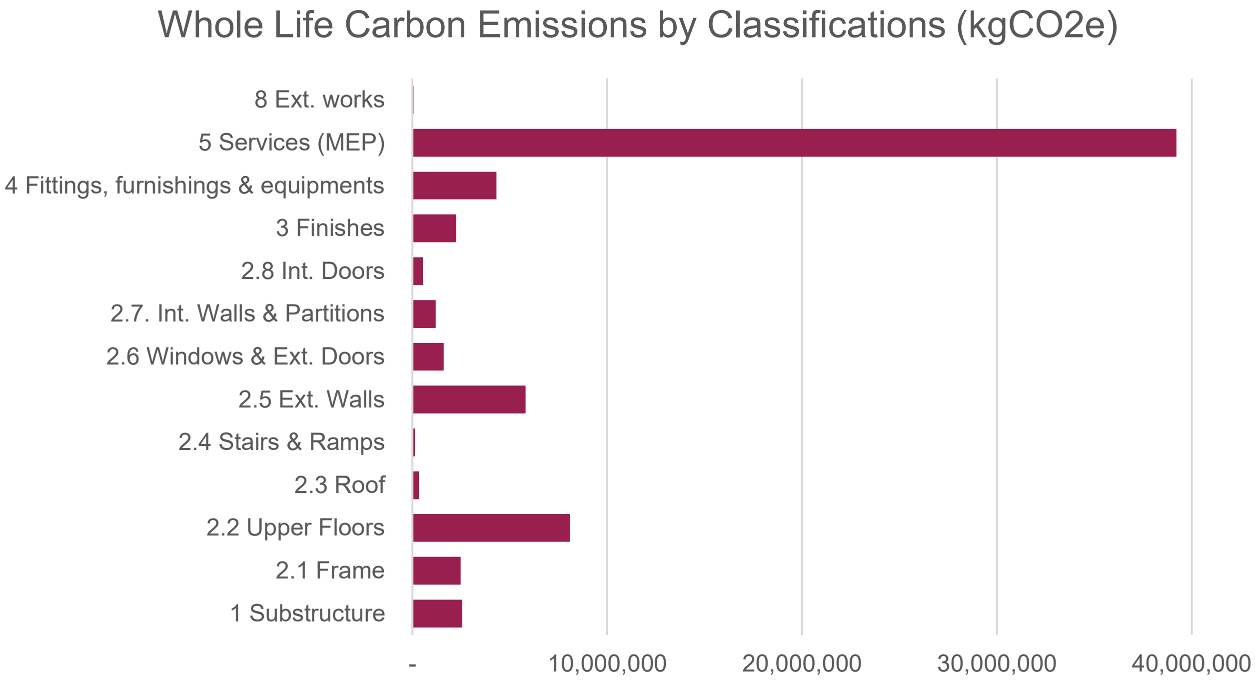

Figure 6 - Breakdown of the carbon emissions per building element

Figure 6 illustrates that the building element with the highest carbon emissions is the building services, which covers the operational energy of the building during its use. Since the assessment is conducted at the design stage, the actual carbon emissions from these activities depends on the assumptions discussed earlier in Section 3.5.

4.2 Operational Carbon – Energy

The energy consumptions and associated carbon emissions of the proposed development have been calculated based on each flat consuming approx. 1,600kWh per year.

4.3 Low-carbon options appraisal

The assessment has considered low-carbon alternatives for the options appraisal that might change the aspect of the design along with reduction of embodied carbon emissions. These options have been selected, taking into account the type of building and suitability of change, as shown in Table 12 below.

Option	Original design	tCO_2e	Actions included to reduce whole life-cycle carbon emissions	tCO_2e	% Improvement
1	Reinforcement steel (rebar), generic, 60% recycled content, A615 (One Click LCA)	58	Reinforcement steel (rebar), generic, 97% recycled content (typical)	33	43%

Option	Original design	tCO_2e	Actions included to reduce whole life-cycle carbon emissions	tCO_2e	% Improvement
2	Aluminium cladding	3,237	Brick wall, incl. mortar	821	74%
3	Ready-mix concrete, normal-strength, generic, C40/50 (5800/7300 PSI), S1 XC0/XC1, 0% recycled binders in cement	4,696	Ready-mix concrete, C40/50, CIII/B, 2413 kg/m3, with improved embodied carbon	528	89%

Table 12 - Improvements to the design

Option	Baseline	tCO_2e	Further potential opportunities	tCO_2e	% Improvement
1	PUR rigid insulation panels	3,873	EPS insulation panels	887	77%
2	Concrete beams	2390	Steel beams	2235	7%
3	Steel front doors	614	Timber front doors	574	6.5%

Table 13 - Further potential opportunities to reduce carbon

Actions have been considered to demonstrate a reduction in carbon emissions, and have been integrated into the design. It is important for the design team to thoroughly evaluate and incorporate the options that prove the most effective in significantly reducing carbon emissions.

Figure 7 shows how the options chosen have contributed to a reduction in carbon emissions. The design options provide further potential opportunities for carbon reduction. The results from each design option have been compared with the design baseline to depict the percentage improvement. These results can be seen in Figure 8.

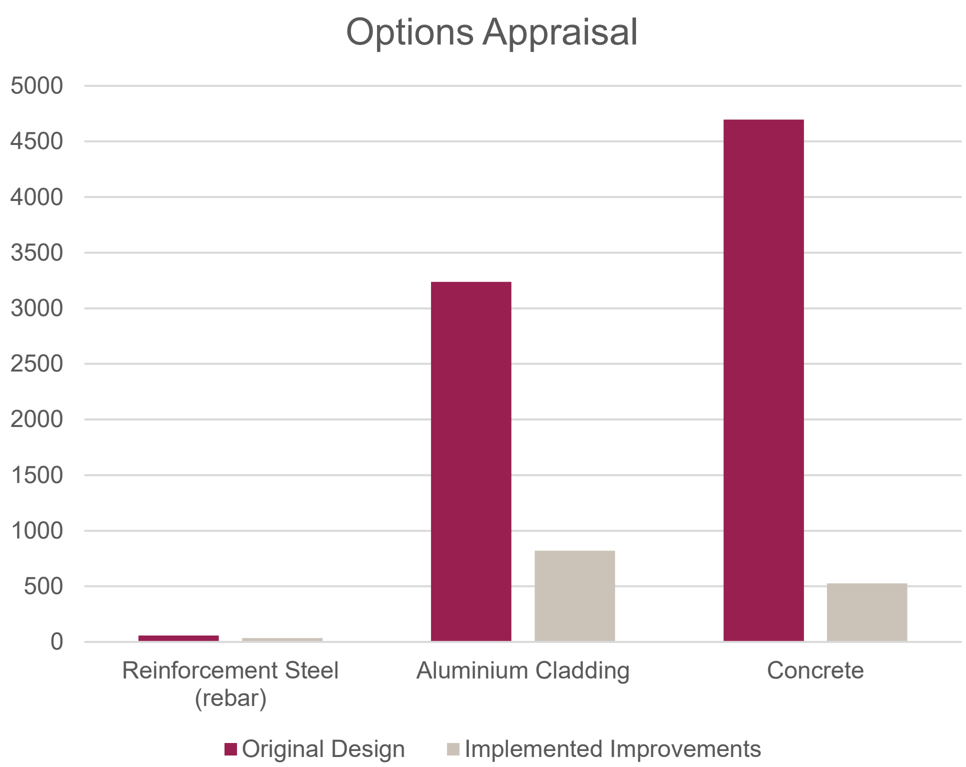

Figure 7 – Comparison of baseline vs Implemented options

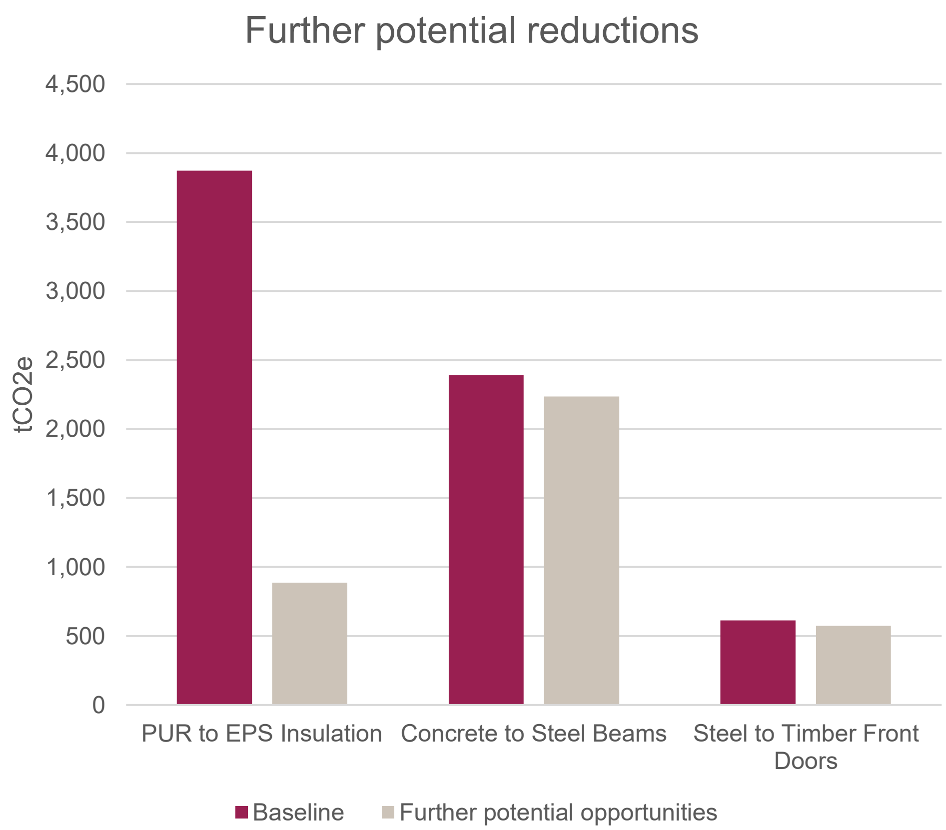

Figure 8 - Comparison of further potential opportunities

4.4 GLA Benchmarking

The WLC benchmarks specified are used as a guide when projects are urged to examine how they can reduce WLC emissions. A further set of aspirational WLC benchmarks have been developed which are based on a 40% reduction in WLC emissions compared to the first set of WLC benchmarks. This is founded on the World Green Building Council's target to achieve a 40% reduction in WLC emissions by 2030. As of now, modules B6, B7 and D have not been included in the benchmarks due to their variability in predicted and actual readings upon construction and use of the Proposed Development.

GLA benchmarks are calculated by assessing the carbon emissions the different lifecycle stages of a development against its gross internal floor area to highlight areas of carbon reduction/mitigation. The performance of the Proposed Development is displayed in Figure 99 below. The GLA benchmarks are achieved and the results are just slightly over the GLA aspirational benchmarks.

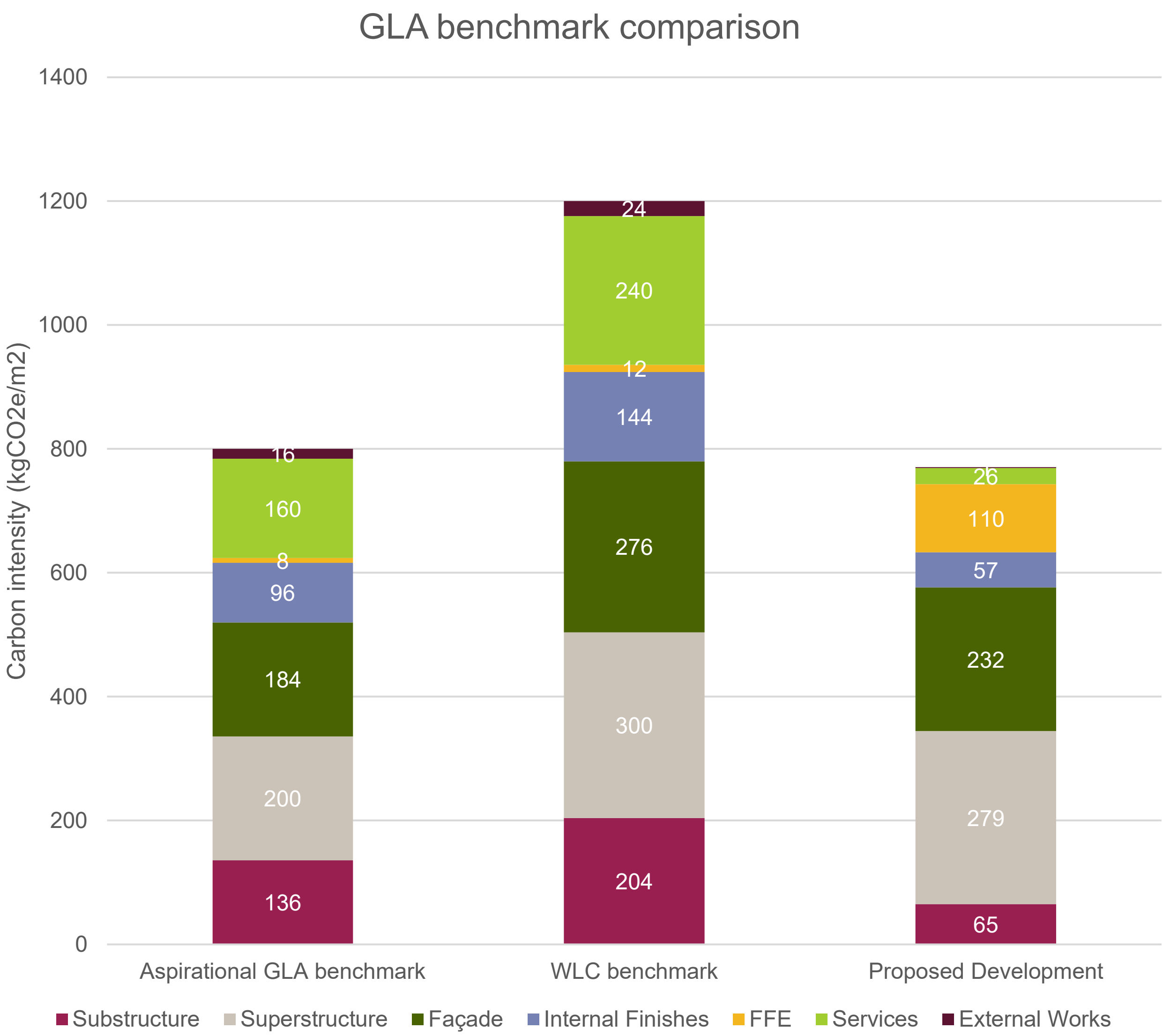

Figure 9 - Comparison of the Proposed Development's Carbon Emissions against GLA Residential Benchmarks

Improvement Options

5.0 Improvement Options

This section presents recommended opportunities on how to further reduce the proposed development's embodied carbon emissions. A series of improvement options have been identified during the current design stage which are subject to feasibility. The feasibility of the recommended improvement options should be analysed during the next design stages to assess implications on cost, programme as well as market availability and procurement options.

The following options are under consideration:

- Increasing the recycled content of the steel rebar in concrete elements of the building which would not compromise the structural integrity of the Proposed Development.
- Rebar specifications - As one of most contributing material, beyond quantity optimisation, low-carbon specification should be considered. Adopting a national EAF rebar manufactured with renewable energy could offer one of the biggest potential savings.
- Changing the door types from aluminium to wooden doors can bring down the carbon emissions associated with this building element.
- Changing the insulation type can reduce the carbon emissions associated with the proposed development.

To aid the tangibility of decarbonisation across the Proposed Development as it moves from design to construction, the following recommendations can be incorporated:

- The appointed Principal Contractor should endeavour to comply with the principles of a Sustainable Procurement Policy or provide their own similar policy, subject to review by the Applicant.
- The appointed Principal Contractor shall endeavour to source materials with valid EPDs and Responsible Sourcing Certification and gather documentation. The Principal Contractor shall endeavour to procure EPDs at the product level, or if unavailable, EPDs at the manufacturer/Organisational level, for all material types and categories.
- The Principal Contractor shall endeavour to procure materials with valid certification from BES 6001 (all), CARES (steel), FSC/PEFC/SFI (timber), or alternatively EMS (all), for all material types and categories.

Additionally, to support responsible sourcing of materials and services, the following websites can be extremely useful resources to gather organisational and product-level material EPD/Certification:

- ***Global product EPDs*** – EPD Library | EPD International (environdec.com)
- ***Global product/Organisation Responsible sourcing certificates*** – Responsible Sourcing League Tables - BRE Group
- ***Global PEFC timber products*** – PEFC - Programme for the Endorsement of Forest Certification
- ***Global FSC timber products*** – FSC Certificates Public Dashboard
- ***Global product/Organisation Responsible sourcing certificates – Greenbook Live: BES 6001 The Framework Standard for Responsible Sourcing***

Conclusion

6.0 Conclusion

The WLCA undertaken during the design stage has provided a baseline to establish a pathway to reduce the lifecycle emissions for Stoney Wood Quarter, Barnet. The assessment has identified carbon hotspots for the Proposed Development and suggested low carbon options that will help to reduce the embodied CO_2e emissions.

From Figure 9 above, the development passes the GLA's WLC guidelines established in the London Plan Guidance for WLCA. Residential benchmarks have been used to compare the carbon emissions, enabling the Proposed Development to pass the GLA's Baseline benchmark for lifecycle stage A-C.

The assessment determined the operational energy emissions based on the annual energy demand of the Proposed Development. The operational emissions have been considered for a non-decarbonised scenario as per the London Plan Guidance for WLCA.

As a result, the WLCA has been completed to support the 'London Plan Policy SI 2' and the planning application for the Proposed Development. In order to mitigate the CO_2e emissions, the Project team should consider the potential for materials with lower embodied carbon emissions and seek to incorporate sustainable construction practices.

Module	Lifecycle Embodied Carbon	Operational Carbon	Whole Lifecycle Carbon
A1-A5 Construction Process stage ($kgCO_2e$)	18,579,906		
B1-B5 Use Stage ($kgCO_2e$)	13,248,009		
B6-B7 Operational Demands ($kgCO_2e$)		38,188,890	
C1-C4 End of Life stage ($kgCO_2e$)	8,604,117		
Total Carbon Emissions ($kgCO_2e$) (excluding biogenic carbon)	40,432,032	38,188,890	
Biogenic Carbon ($kgCO_2e$)	-7,444,748		
Total Carbon Emissions ($kgCO_2e$) (including biogenic carbon)	32,987,284	38,188,890	71,176,174
D Benefits Beyond the System Boundary	-2,789,746		
Total Carbon Emissions ($kgCO_2e$) (including Module D)	30,197,538	38,188,890	68,386,428

Table 14 - Summary of the Whole Life cycle carbon emissions of the Proposed Development

Appendix

Appendix A - OneClick LCA Inputs

Class	Material	Quantity	Unit
Foundation	Ready-mix concrete, C40/50 XC2 XC4 XD2 XD3 XF3 XF4, CIII/B, 2413 kg/m3, Viaduct (Tarmac)	4803.56	m3
Foundation	Reinforcement steel (rebar), generic, 97% recycled content (typical), A615 (One Click LCA)	529214	kg
Foundation	Precast concrete retaining wall, incl. reinforcement, ep. 0.25m, C25/30 XC4 CEM II/A-S (SNBPE)	8535.46	m2
Beam	Polyethylene vapour barrier membrane, 0.15 mm, 0.14 kg/m2 (One Click LCA)	10704.67	m2
Beam	Rigid thermoset cellular insulation material faced on both sides with a glass tissue, L=0.21 W/mK, R=4.7619 m2K/W, 100 mm, 3.5 kg/m2, 35 kg/m3, Lambda=0.021 W/(m.K), Kooltherm K5 (Kingspan Insulation B.V.)	8553	m2
Beam	Aluminum standing seam roof and wall cladding with insulation, 0.19 W/mK, 1 mm aluminum plate, 200 mm stone wool 14.27 kg/m3 (Kalzip)	10357.1	m2
Beam	Ready-mix concrete, normal-strength, generic, C30/37 (4400/5400 PSI), 10% (typical) recycled binders in cement (300 kg/m3 / 18.72 lbs/ft3) (One Click LCA)	10010.84	m2
Beam	Reinforcement steel (rebar), generic, 90% recycled content, A615 (One Click LCA)	288360.4	kg
Beam	In-situ concrete slab assembly	9661	m2
Beam	Steel purlins and framing, 7850 kg/m3 (Voestalpine Metsec plc)	1451.1	kg
Beam	Membrane, waterproofing, for roofs, multilayer, 1.5-2.0 mm, 2x15/20 m, 2.35 kg/m2, Sarnafil TG 76 Felt PS (Sika)	10002.67	m2
Beam	Precast concrete floor slab, 117.63 kg/m2 (CENTRE D`ETUDES ET DE RECHERCHES DE L`INDUSTRIE DU BÉTON)	43873.4	m2
Beam	Sand (One Click LCA)	483631	kg

Class	Material	Quantity	Unit
Beam	Weber floor smoothing screed, 5-50mm layer thickness, 34 kg/m2, vetonit 130 Core (weber.)	18617.58	m2
Beam	Reinforcement mesh fabric (glass fibre), 0.16kg/m2, R131 (ADFORS)	9.7723	m3
Beam	Stone wool (mineral wool) insulation, unfaced, L = 0.0315 W/mK, R = 1 m2K/W, 31.5mm, 1.26 kg/m2, 40 kg/m3, (Range: 36-50kg/m3), 22% slag content (One Click LCA)	32580.75	m2
Beam	Plywood, generic, 4-50 mm (0.16-1.97 in), 620 kg/m3 (38.7 lbs/ft3) (One Click LCA)	18617.58	m2
Beam	Dried lumber from spruce or pine wood, 474 kg/m3, moisture content 18 % (Puutuoteteollisuus)	5015.983	m2
Beam	Planed timber, conifer (Treindustrien)	4654.393	m2
Beam	Gypsum plaster board, regular, generic, 6.5-25 mm (0.25-0.98 in), 10.725 kg/m2 (2.20 lbs/ft2) (for 12.5 mm/0.49 in), 858 kg/m3 (53.6 lbs/ft3), 0% recycled gypsum (One Click LCA)	18617.58	m2
Beam	Glass wool insulation in bats or rolls, unfaced, L = 0.035 W/mK, R = 2.86 m2K/W, 100 mm, 2.75 kg/m2, 27.5 kg/m3, (Range: 20-35kg/m3), 50% recycled glass content (One Click LCA)	9063.11	m2
Beam	Ready-mix concrete, normal-strength, generic, C30/37 (4400/5400 PSI), S1 XC0/XC1, 0% recycled binders in cement (min cem. content: 280 kg/m3 / 18.72 lbs/ft3), Portland cement CEM I 42.5 (One Click LCA (2024))	9063.11	m2
Beam	Reinforcement steel (rebar), generic, 80% recycled content, A615 (One Click LCA)	160508.1	kg
Beam	Finishing wall mortars, French average, 3 mm, 4.2 kg/m2, Mortiers de ragréage muraux (DONNEE ENVIRONNEMENTALE GENERIQUE PAR DEFAUT)	126883.96	kg
Beam	Steel sheets, generic, 90% recycled content (typical), S235, S275 and S355 (One Click LCA)	1687.07	kg
Beam	Chipboard, 690.85 kg/m3, thickness=8-38 mm, width=1830-2500 mm, length=1220-5600 mm (AB Klaipėdos mediena)	18617.58	m2
Beam	Vapour-proof membrane, 0.15 mm, 140 g/m2, Dampsperre 15 (Baca Plastindustri)	44725	m2

Class	Material	Quantity	Unit
Beam	Ready-mix concrete, RC 32/40 (32/40 MPa), 15% Cement replacement with fly ash	10357	m2
Beam	Self-levelling screed, 1 mm, 2.25 kg/m2, Gyvlon® EXCELIO (Anhydritec)	2754.1	m3
Column	Ready-mix concrete, C40/50 XC2 XC4 XD2 XD3 XF3 XF4, CIII/B, 2413 kg/m3, Viaduct (Tarmac)	9426648	kg
Column	Reinforcement steel (rebar), generic, 97% recycled content (typical), A615 (One Click LCA)	1195846.4	kg
Door	Aluminium framed fixed glass skylight, triple glazed, 0% recycled aluminium, 1.2 x 1.2 m, 59.7 kg/m2, 1.44 m2/unit (One Click LCA)	30.74	m2
Door	Stainless steel door handle, 1.69 kg/unit (ASSA ABLOY)	56.62	m2
Door	Grey cast iron part, EN15804+A1, ref. year 2018	0.93	m2
Door	Aluminium frame window double-glazed, operable(tilt and turn), 50% recycled aluminium, 1.48 m x 2.18 m, 25.3 kg/m2 (One Click LCA)	21151.488	m2
Door	Internal wooden doorleaf, fire resistant, 1.981x0.838 m, 17.9 kg/m2 (JELD-WEN)	880	m2
Door	External wood door (One Click LCA)	440	m2
External Wall	Aluminium frame window system with double glazing, per m2, 128.77 kg/unit, 2300 mm x 2180 mm, Coulissant Luméal PF 2 rails 2 vtx GA (Hydro Building Systems)	8489.8	m2
External Wall	Concrete masonry unit with cement-free binder, 100 mm, 153.8 kg/m2	56703.55	m2
External Wall	Fiberglass insulation in batts, faced, R-5.68 (Rsi=1 m2K/W), 1.416 kg/m2, Unfaced Fiberglass, Kraft Faced Fiberglass, Panel Deck FSK-25, FSK-25, ComfortTherm®, Cavity-SHIELD™ (Johns Manville)	56703.55	m2
External Wall	Aluminium balcony system, 3300 x 1800 mm, 595 kg/unit, Cobalt Hybrid Balcony (Blue Chyp Ltd, Cradley Heath plant)	0.88	kg

Class	Material	Quantity	Unit
External Wall	Free standing aluminium railing, 48 mm, 11 kg/m2 (GLASSLINE GmbH)	120.84	m3
External Wall	Cement mortar (One Click LCA)	2961210	kg
Finish	Clay plaster, gross density 900.0 kg/m3, dry density 1600 kg/m3, EN15804+A1, ref. year 2018	145573.67	m2
Finish	Rendering mortar – normal / finishing render, 1550 kg/m3 (quick-mix)	56703.55	m2
Finish	Weather resistant coating for exterior walls, 1.290 kg/l, 0.161 kg/m2 (AkzoNobel Decorative Paints)	350000	m2
Finish	Acrylic water-based decorative emulsions for interior wall or ceiling surface, 0.1184 kg/m2, Flat Matt XD (COAT paints)	59018.59	m2
Finish	Hardwood	110.81	m3
Finish	Multi-layered engineered wood flooring, 13 mm, 7.01 kg/m2, 539 kg/m3 (Parador)	24787	m2
Finish	Emulsion matt paint for allround interior use, Pigment: Lightfast Pigments, binder: PVA Copolymer emulsion , solvent: Water, 1.443 kg/l, 18m2/l, 0.16 kg/m2, Supermatt White, Almond White, Gardenia, Magnolia, Light Base, Medium Base (Dulux Trade)	55076	m2
Finish	Carpet tile, 0.23-0.28 in (5.85-7.15 mm), 0.5 x 0.5 m, 4.12 kg/m2, Inline (Forbo Flooring B.V.)	24787	m2
Finish	Single glass pane - no frame, 1 mm	0.31	m3
Internal Wall	Tile adhesive, all round, for ceramics, 1-5 mm, 1400 kg/m^3	24.55	m2
Internal Wall	Granite for interior and exterior coating of pavements, floors, walls and facades, 30 mm, 2671 kg/m^3	24.55	m2
Internal Wall	Finishing wall mortars, French average, 3 mm, 4.2 kg/m^2	28,052	m2
Internal Wall	Concrete masonry unit (CMU), 198 kg/m^2, Synerg·Eco	14026	m2

Class	Material	Quantity	Unit
Internal Wall	Planed timber, conifer	4164.40	m2
Internal Wall	Glass wool insulation in bats or rolls, unfaced, L = 0.035 W/mK, 100 mm, 2.75 kg/m^2, 50% recycled glass content	31735.6	m2
Internal Wall	Oriented strand board (OSB), 8-30 mm	181.42	m2
Internal Wall	Adaptable walls with fabric-coated panels, 5m x 2.9m, 27 kg/unit, Adaptable Walls	10	Units
Internal Wall	Gypsum plaster board, regular, 50% recycled gypsum, 6.5-25 mm	71800	m2
Staircase	Concrete staircase, U-shaped, with no flat landing, width 140cm, 1928.2kg (CERIB)	500	ton
Ff&E	Three-seat sofa without armrest, H: 790 mm, D: 680 mm, W: 1710 mm, 24 kg/unit (One Click LCA)	688	unit
Ff&E	Chair, 6.37 kg/unit, Alf chair (MARK Product)	2336	unit
Ff&E	Acrylic bath and shower tub, EN15804+A1, ref. year 2018	78000	kg
Ff&E	Wooden cabinet, 73.05 kg/unit, Cabinet, MFC, COMBO, 2 levels w/hinged doors + 1 level open room (Scan Sørlie)	1323	unit
Ff&E	Particleboard double bed frame, 1390 x 1950 mm, 77.8 kg/unit, DOUBLE BED FRAME (Bisley)	1097	unit
Ff&E	Oak table, 10 kg/unit, Arris table/oak (MARK Product)	1855	unit
Ff&E	Wooden chair, 8.64 kg/unit, OVO Chair (Benchmark)	632	unit
Roof	Rigid thermoset cellular insulation material faced on both sides with a glass tissue, L=0.21 W/mK, R=4.7619 m2K/W, 100 mm, 3.5 kg/m2, 35 kg/m3, Lambda=0.021 W/(m.K), Kooltherm K5 (Kingspan Insulation B.V.)	1798.77	m2
Roof	Pitched steel roof	6.34	m2

Class	Material	Quantity	Unit
Roof	Ready-mix concrete, RC25/30 with CEM I cement	347.67	m2
Roof	In-situ concrete slab assembly	347.67	m2
Site	Aggregate (crushed gravel), generic, dry bulk density, 1600 kg/m3 (One Click LCA)	6191	m2
Site	Galvanized steel bicycle shelters, 76.7 kg/unit, Abri-vélo [1 vélo] (DONNEE ENVIRONNEMENTALE GENERIQUE PAR DEFAUT)	8	unit
Site	Concrete stone pavement, stone thickness 50 mm (2 in)	6191	m2
Site	Ready-mix concrete, normal-strength, generic, C30/37 (4400/5400 PSI), 10% (typical) recycled binders in cement (300 kg/m3 / 18.72 lbs/ft3) (One Click LCA)	309.55	m3
Slab	Cementitious floor leveling screed, 10-250 mm, 1.8 kg/m2/mm, 1.6–1.8 kg/l, webervetonit 6000 Rapid Screed (Saint-Gobain Finland Oy)	64500.76	m2
Slab	Precast dense concrete masonry blocks, 190 kg/m2 (Mineral Products Association)	559.92	m2
Slab	Precast concrete beams and columns, steel reinforced	291.68	m2
Slab	Toughened glass - no frame, 1 mm, ex frame	49.92	m2
Slab	PUR rigid insulation panels with aluminium foil, paper and PET facing, R=7.4 m2K/W, L=0.022 W/mK, 160 mm, 5.73 kg/m2, Lambda=0.022 W/(m.K), EFITOIT® 160 mm (SOPREMA SAS)	63659	m2
Slab	Sand cleanliness per GFA, EN15804 A1/A2	7164.91	m2
Slab	Floor slab, timber joists, P2 R30 (1…2 krs.) (Large school), incl. One Click LCA generic data	18617.58	m2
Slab	Concrete in situ or Precast Concrete Assembly, incl. Glass Wool Insulation, for South Europe	9063.11	m2

Class	Material	Quantity	Unit
Slab	Metal-concrete composite decking, 130mm depth, C 30/37, included: sheet metal decking, rebar, steel beams and columns share per m2	22.14	m2
Systems	Wooden lockers and cupboards, 58.1 kg/unit (Bisley)	231	unit
Systems	Air/water heat pump for tertiary buildings for hot water production, reversible, 389 kg/unit, CAHV-R450YA-HPB (MITSUBISHI ELECTRIC B.V. FRANCE)	140	unit
Systems	Wooden wardrobe, 72.9 kg/unit (Bisley)	788	unit
Systems	TV socket, 0.05 kg/unit (One Click LCA)	523	unit
Systems	Ceramic toilet with flush tank (cistern), 34.8 kg/unit, 980 × 360 × 430 mm (One Click LCA)	578	unit
Systems	Waste container for commercial use, H:1340 mm, D:1090 mm, W:1200 mm, 50 kg/unit, 1000 L (One Click LCA)	144	unit
Systems	Ceramic bathroom washbasin, 16.7 kg/unit, 850 × 460 × 150 mm (One Click LCA)	574	ton

Appendix B - RICS Transportation Values

Transport Scenario (both road and sea to be used)	km by road*	km by sea**
Locally manufacturer (ready-mix concrete)	20	-
Locally manufactured (general) e.g. aggregate, earth, asphalt	50	-
Regionally manufactured e.g. plasterboard, blockwork, insulation, carpet, carpet, glass	80	-
Nationally manufactured e.g. structural timber, structural steelwork, reinforcement, precast concrete	120	
European manufacturers e.g. Cross Laminated Timber (CLT), façade modules	1,500	100
Globally manufactured e.g., specialist stone cladding	500	10,000

* Means of transport assumed as average of all average rigid HGVs or other road vehicles where details available (average laden)
** Means of transport assumed as average container ship

Appendix C - RICS Material Replacement Values

Building Part	Building Elements/Components	Expected Lifespan
Substructure	Piling and foundations	60 years (or building lifespan)
	Lowest ground floor	
Superstructure: frame, upper floor and roof structure	Structural elements, e.g. columns, walls, beams, upper floor and roof structure	60 years (or building lifespan)
Facade	**Opaque modular cladding**	
	Rains screens, timber panels	30 years
	Brick, stone, block and precast concrete panels	60 years
	Glazed cladded/ curtain walling	35 years
	Windows and external doors	30 years
	Hardwood/steel/aluminium windows	
	Doors	20 years
Roof	**Roof Covering**	
	Single-ply membrane	30 years
	Standing seam metal	30 years
	Tiles, clay and concrete	60 years
Superstructure	**Internal Partitioning and dry lining**	
	Stud work	30 years
	Blockwork	60 years
Finishes	**Wall Finishes**: Render/paint	30/5 years

Building Part	Building Elements/Components	Expected Lifespan
	Floor Finishes	
	Carpet/Vinyl	7 years
	Stone tiles	25 years
	Raised access floor (RAF) pedestal/tile	50/30 years
	Ceiling Finishes	
	Substrate/paint	10 years
	Suspended grid (ceiling system)	25 years
FF&E	Loose furniture and fittings	10 years
Services/MEP	Heat Source e.g. boilers, calorifiers	20 years
	Heat source, e.g. heat pumps (except ground surce)	15 years (20 years)
	Space heating and air treatment	20 years
	Central cooling systems (cooling only) e.g. fan coil systems, variable air volume, variable refrigerant volume	15 years
	Ductwork	
	Galvanised	40 years
	Plastic or flexible	15 years
	Electrical installations	30 years
	Lighting fittings	15 years
	Communications installations and controls	15 years
	Water and disposal installations	25 years
	Rainwater harvesting and grey water collection	30 years

Building Part	Building Elements/Components	Expected Lifespan
	Sanitaryware	20 years
	Lift and conveyor installations	20 years
Hard Landscaping	Asphalt	35 years
	Concrete and stone paving	60 years
	Timber decking	15 years

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