

Highgate School - Richard's Music Centre

Stage 2/3 Whole-Life Cycle Carbon Assessment

Highgate School

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Executive Summary

Brief description of the development

The Applicant intends to seek planning permission for the following:

'Redevelopment of Richards Music Centre, including complete demolition of existing structure and development of a replacement building of two and a half storeys plus basement, and associated landscaping with improved provision for emergency services, servicing and disabled parking. Scope of the assessment.'

Scope of the assessment

The Whole Life-Cycle Carbon (WLC) Assessment has been conducted in accordance with BS EN 15978: 2011: (Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method) using the RICS Professional Statement: Whole Life Carbon assessment for the built environment, over a 60-year study period, covering the entirety of the life-cycle modules A, B, C and D. The Greater London Authority (GLA) Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022) states that the reference study period for the WLC Assessment should be 60 years, even in instances where the design life of a building exceeds or is less than 60 years.

The embodied carbon calculation for the WLC Assessment has been conducted using the LCA software One Click LCA. One Click LCA is an industry-recognised tool and is third-party verified for EN 15978, ISO 21931-1, ISO 21929-1 and for input data ISO 14040/44 and EN 15804 standards. For this assessment the "Whole life carbon assessment, Greater London Authority" tool was used to prepare the baseline and option studies, aligned with the RICS Professional Statement "Whole Life Carbon Assessment for the Built Environment" (2017), for service life of materials and transport distances.

The scope of the operational carbon emissions in the WLC Assessment therefore includes regulated energy consumption (heating, cooling, auxiliary, lighting and hot water) and unregulated energy consumption. Renewable electricity generated on-site from solar photovoltaics (PV) is also accounted for in the calculations. The operational energy consumption of the development has been calculated for a life cycle of 60 years based on the assumption that the annual operation energy consumption will remain the same throughout the life cycle of the project, as per the Building Regulations Part L modelling.]

Whole life-cycle carbon assessment results

The overall WLC carbon (A-C including sequestration) of the Proposed Development over its 60-year life cycle is approximately **3,575 tCO₂e** or **2,004 kgCO₂e/m² GIA**. The total embodied carbon (A-C excluding B6 & B7 and including sequestration) of the Proposed Development is **2,839 tCO₂e** or **1,591 kgCO₂e/m² GIA**.

Seventy-nine percent of the whole life carbon is attributed to the embodied carbon (A, B1-B5, C) and twenty-one percent to the operational carbon (B6-B7). The largest share of embodied carbon (i.e., excluding operational carbon B6-B7) emissions is approximately 54% can be attributed to the product stage (life cycle stages A1-A3, also known as the cradle to gate stage). Transport and construction stages (A4 – A5) contribute approximately 19% of the total embodied carbon. Recurring and end of life stages are responsible for the remaining 27% of embodied carbon.

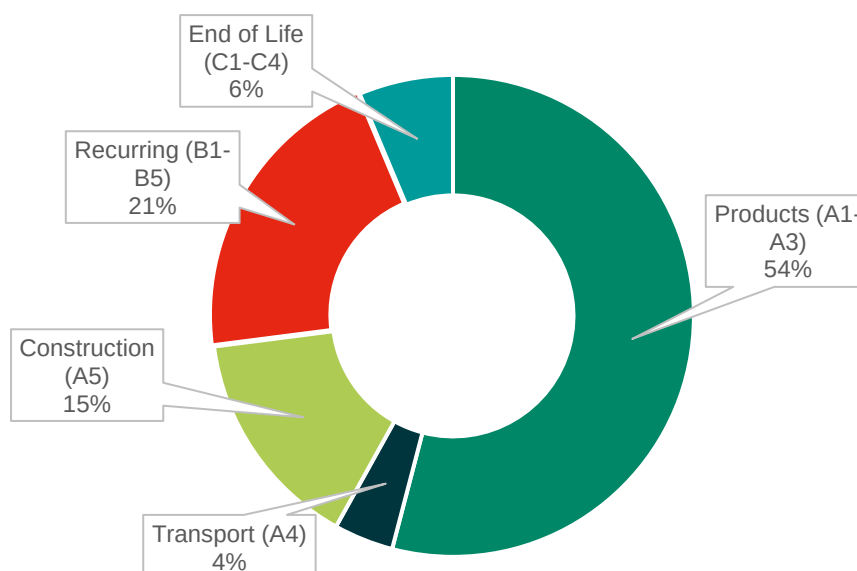


Figure 1 – Breakdown of embodied carbon emissions by life-cycle module

Comparison benchmarks

According to the GLA's Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022) requires that the results of the WLC Assessment of the Proposed Development are compared to the benchmarks provided in the same document (GLA, 2022). The GLA provides a WLC Benchmark, based on WLC analysis gathered from multiple projects within London and an Aspirational WLC Benchmark based on a 40% reduction on the WLC Benchmark. The embodied carbon results of the Proposed Development are compared to the GLA benchmarks for school buildings.

Based on the current assumptions, the Proposed Development **does not meet** the GLA embodied carbon benchmarks and aspirational benchmarks (Table 1).

Table 1 - Proposed Development WLC Assessment results compared to the WLC Benchmarks for Schools

Modules	WLC Benchmark (kgCO ₂ e/m ²)	Aspirational WLC Benchmark (kgCO ₂ e/m ²)	Proposed Development (kgCO ₂ e/m ²)
A1 – A5 (excluding sequestration)	<750	<500	1,208
B – C (excluding B6, B7 and sequestration)	<250	<175	448
A – C (excluding B6 and B7 and including sequestration)	<1000	<675	1,591*

*Please note that the results of A1 – A5 and B – C do not equal the result for A – C because this includes the benefits of sequestration.

The basement aspect of the Proposed Development is contributing to a significant share of the embodied carbon, particularly the sheet piling which accounts for around 20%.

Opportunities

This study utilised the typical UK construction products as advised by the RICS PS and by the Institution of Structural Engineers. The design team has identified an opportunity to increase the quantity of cement replacements in the structural concrete throughout the Proposed Development from 20% to 50%.

The use of a higher percentage of cement replacement across all structural concrete elements within the Proposed Development will reduce the embodied carbon by 91 kgCO₂e/m².

Similarly, there is a significant opportunity to incorporate recycled steel within the sheet piling as this is responsible for around 25% of the total impact. Alternatively, a review of the material options could be undertaken.

Post construction WLC assessment

An additional WLC Assessment should be completed at the Post-Construction Stage, as per the GLA's Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022). The post-construction WLC assessment will require an update of the information provided at the planning submission stage (RIBA Stage 2/3) and for the actual WLC carbon emission figures to be reported. The WLC calculation results should be updated for all modules, based on the actual materials, products and systems used for the construction of the Proposed Development. The evidence listed below should be provided as a minimum to support the updated results:

- Site energy (including fuel) use record; and
- Contractor confirmation of as-built material quantities and specifications per building element category; and
- Record of material delivery including distance travelled and transportation mode (including materials for temporary works); and
- Waste transportation record including waste quantity, distance travelled and transportation mode (inclusive of materials used for temporary works).

According to the guidance, the post-construction results will need to be compared with the planning submission stage results and the WLC benchmarks, accompanied with an explanation for the difference. The post-construction results should also be compared with the WLC Benchmarks, and the difference explained.

1. Introduction

1.1 Background

AECOM's Sustainable Development Group has been commissioned by Highgate School (hereafter referred to as the 'Applicant') to prepare a Whole Life-Cycle Carbon (WLC) assessment, to accompany a full planning application for the Richard's Music Centre (RMC) development (hereafter referred to as the 'Proposed Development'). The location of the Proposed Development is hereafter referred to as the 'Site'.

The Greater London Authority (GLA) Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022) states "National Building Regulations and the Mayor's net zero-carbon target for new development currently only account for a building's operational carbon emissions. As methods and approaches for reducing operational emissions have become better understood, and as targets have become more stringent, these emissions are now beginning to make up a declining proportion of a development's carbon emissions. Attention now needs to turn to WLC to incorporate embodied carbon emissions."

The GLA guidance also states "WLC emissions are those carbon emissions resulting from the construction and the use of a building over its entire life, including its demolition and disposal. They capture a building's operational carbon emissions from both regulated and unregulated energy use, as well as its embodied carbon emissions, i.e., those associated with raw material extraction, manufacture and transport of building materials, construction and the emissions associated with maintenance, repair and replacement as well as dismantling, demolition and eventual material disposal. A WLC Assessment also includes an assessment of the potential carbon emissions 'benefits' from the reuse or recycling of components after the end of a building's useful life. It provides a true picture of a building's carbon impact on the environment."

This document accompanies the GLA WLC Assessment Templates, which have been developed to meet the relevant planning Policy SI 2 of the London Plan, March 2021 (GLA, 2021).

The scope of this report is to:

- Outline the scope of the Whole Life-Cycle Carbon Assessment.
- Outline the methodology that was followed to complete the GLA WLC Assessment Templates.
- Present and analyse the results of the WLC Assessment of the Proposed Development.
- Compare the results of the WLC Assessment with the corresponding Benchmarks that are provided in the GLA's Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022)
- Provide recommendations for carbon optimisation of the design of the Proposed Development

This document has been produced in accordance with the GLA's Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022).

1.2 Policy

1.2.1 London Plan

The London Plan is the statutory Spatial Development Strategy for Greater London prepared by the Mayor of London ("the Mayor"). The new London Plan was adopted on 2 March 2021 and includes the following policy in relation to the Whole Life Carbon (WLC) Assessment:

1.2.1.1 Policy SI 2 Minimising greenhouse gas emissions

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.

1.2.2 London Borough of Haringey Local Plan: Strategic Policies DPD

The London Borough of Haringey adopted their Local Plan: Strategic Policies in 2013 and adopted alterations in July 2017. The document sets out Haringey's long-term development vision, up to 2026, and outlines the council's strategy for achieving that vision, including the high-level strategic policies to be used in determining planning applications.

This document is applied in conjunction with Haringey Council's Development Management Plan DPD, covered below in section 1.2.3, in addition to Site Allocation and Action Plan documents.

It is worth noting however, that work on a new Local Plan intended to run from 2022 to 2037 has already begun, with a Draft Local Plan expected to be published for consultation in Summer 2022. A New Local Plan: First Steps Engagement Document has already published.

1.2.2.1 Strategic Policy: SP4 Working Towards a Low Carbon Haringey

Over the lifetime of the Local Plan, reducing energy use in buildings and working towards a low carbon borough will be one of the key challenges facing Haringey. The Council will promote the measures outlined below to reduce carbon emissions from new and existing buildings.

- From 2011 onwards 100% of new non-residential development to be built to at least BREEAM “very good” standard and should aim at achieving BREEAM “excellent” or the current nationally agreed standard.
- 100% of new residential development to be zero carbon from 2016 onwards; 100% of new non-residential development to be zero carbon from 2019.

1.2.3 London Borough of Haringey Local Plan: Development Management DPD

The London Borough of Haringey adopted their Local Plan: Development Management in July 2017, this will remain effective until 2026, setting out planning policies to help determine which developments are granted planning permission. The spatial strategy provides a positive framework for managing development, growth and ensuring that housing, employment, infrastructure, and other needs are met in a way that contributes to the delivery of sustainable development, both in the Borough and Greater London.

This document is applied in conjunction with Haringey Council's Strategic Policies DPD, covered above in section 1.2.2, in addition to Site Allocation and Action Plan documents.

1.2.4 Highgate School Supplementary Planning Document (SPD)

The Council has developed this SPD in partnership with Highgate School, to help give more certainty to the local community about future development in the School's estate. The document does not currently reference WLC.

1.3 Description of development

1.3.1 Location

The Proposed Development site is south of the School's adjacent Junior Field and has a site area of approximately 0.565 hectares (ha) onto which 1,784 m² gross internal area (GIA) is intended to be delivered. This site forms part of Highgate School's Bishopswood Road Campus within the London Borough of Haringey and partially occupies Metropolitan Open Land. Additionally, the site is situated at the southern edge of the Highgate Conservation Area, in the Bishops Area. The Bishops Area lies between the west of the historic town centre and the boundary of the London Borough of Haringey and London Borough of Camden, with Hampstead Lane to the South and Aylmer Road to the North.

The area to the south and south-east of the site is not owned by the School and predominantly consists of residential land use. No. 2 Bishopswood is a Victorian Villa converted into flats and adjoins the southern boundary of the Proposed Development. The east of the site borders two 3-storey townhouse (Highgate Close) gardens. The area to the east of Junior Field is owned by C of E St Michael's Primary School with a path through this School providing safe access for Highgate pupils moving to/from the Senior School. This path continues along the front of the Proposed Development before running on the west side of the synthetic pitch up to the Mallinson Sports Centre and road crossing on Bishopswood Road.

1.3.2 Existing site

The existing site includes a single storey, red brick building with mansard roof, and UPVC windows. This is also called Richard's Music Centre. Originally built as a sports pavilion, it has undergone several changes of use, functioning as the Junior School's music centre before subsequently being converted for IT Data Centre and Sports and Exercise (SpEx) department use. The building no longer supports modern requirements or meets Building Regulations and suffers foundation and drainage issues.

1.3.3 Proposed Development

The Applicant intends to seek planning permission for the following:

Redevelopment of Richard's Music Centre, including complete demolition of existing structure and development of a replacement building of two and a half storeys plus basement, and associated landscaping with improved provision for emergency services, servicing and disabled parking. Figure 2 shows the red line boundary for the planning application.

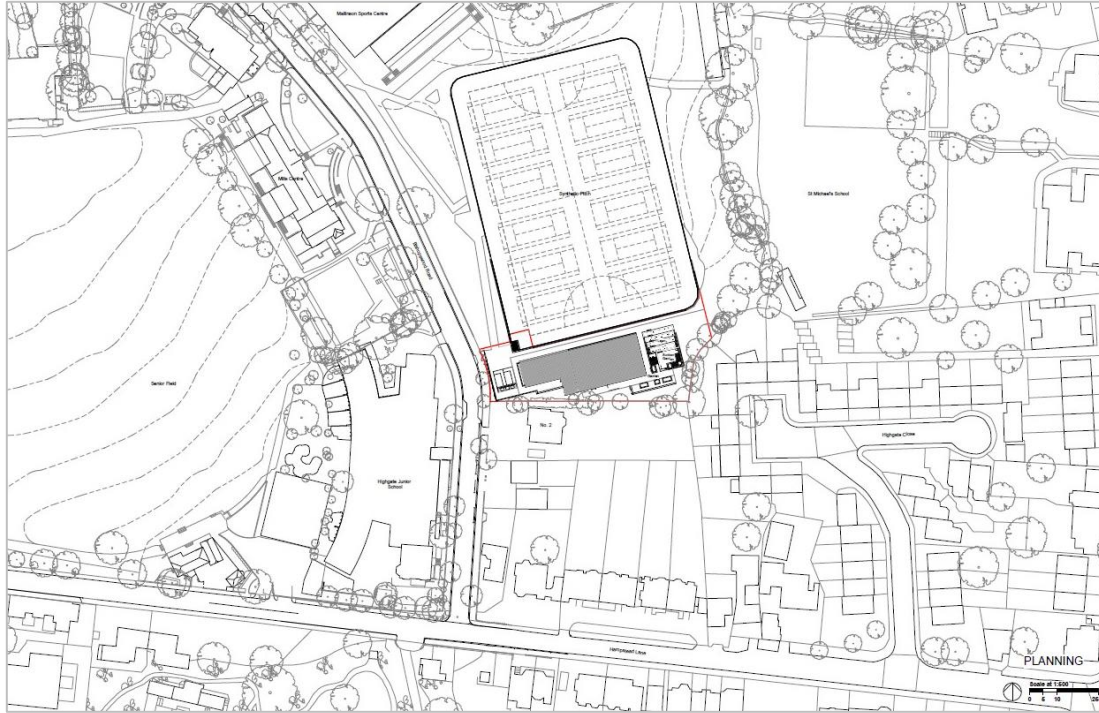


Figure 2 – Proposed Development red line boundary (Source: Hopkins Architects)

1.3.4 Background and Reasoning for Demolition

Following selection of the Proposed Development site, design proposals were developed, and extensive consultations were carried out. Please refer to the Statement of Community Involvement for further information.

The Design and Access Statement details how the existing building does not meet modern requirements both in terms of its construction and energy efficiency. In addition, there are structural problems with the building's foundations due to drainage issues. Furthermore, the current building does not meet modern accessibility standards required for the school.

2. Methodology

The calculation of the embodied carbon of the Proposed Development was based on the RIBA Stage 2 cost plan provided by the project team. An excel spreadsheet was also populated with information about the quantities and types of materials per building component and specifications such as thickness, concrete strength, weight of reinforcement per cubic metre etc.

The embodied carbon of the materials was calculated in One Click LCA, in accordance with the RICS PS. The operational carbon over a 60-year study period was added to the total embodied carbon to calculate the whole life carbon of the Proposed Development.

2.1 Proposed elements and materials

A high-level summary of the proposed materials and elements is outlined in Table 2. A detailed bill of materials is provided within the GLA reporting spreadsheet output.

Table 2 - Proposed Materials

Building Component	Description
Substructure	- Reinforced concrete, CFA piles, pile caps, capping beams, retaining walls, shear walls, columns and lowest floor slab (concrete typically C30/37 with 50% recycled content and rebar with 97% recycled content UK CARES) - Structural steel for sheet piles and shear studs (20% recycled content)
Frame	- Reinforced concrete walls, beams and columns (concrete typically C30/37 with 50% recycled content and rebar with 97% recycled content UK CARES) - Glulam Columns
Stairs	- Reinforced precast concrete (concrete assumed to be C30/37 with 10% recycled content and rebar 90% recycled content) - Steel handrails and Glass balustrades
Upper Floors	Reinforced concrete floor slab (concrete assumed to be C30/37 with 50% recycled content and rebar with 97% recycled content UK CARES)
Roof	- CLT roof slab (assumed mineral wool insulation, membranes, CLT panels) - Timber joists - Zinc roof covering
External Walls	Brickwork façade including facing bricks, cavity insulation and Metsec system (assumed steel framing system for dry lining)
Windows	- Plasterboard stud partition system (including insulation) - Blockwork Partitions - Glazed Partitions - Plasterboard lining to external walls
Finishes	- Aluminium framed, double glazed windows - Steel external doors - Wooden internal doors
Fitting, furnishings and equipment (FFE)	No specific materials have been modelled due to lack of information at Stage 2 so an overall contribution of 2% of the total A-C (exc. B6 & B7) has been applied to represent the FFE emissions. The 2% contribution is based on extrapolating the percentage contributions as detailed within GLA WLC Guidance 2022.
Building Services	- WC and showers - Sanitaryware - Blinds and blackout shutters - Cold water - Hot water - Space heating and air treatment

Building Component	Description
	• Air extract systems • Lifts • Lighting and electrical installations (HV, LV, LSS) • PV
Hard Landscaping	• Asphalt • Yorkstone paving

2.2 Scope

The WLC Assessment has been conducted in accordance with BS EN 15978: 2001: (Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method) using the RICS Professional Statement: Whole Life Carbon assessment for the built environment (hereafter referred to as the 'RICS PS').

The WLC Assessment covers the carbon emissions of the Proposed Development over its lifetime, accounting for:

1. Embodied carbon emissions
2. The operational carbon emissions (regulated and unregulated)
3. Future potential carbon emission 'benefits', post 'end of life', including benefits from reuse and recycling of building structures and materials (lifecycle module D).

2.3 Life-cycle modules

This WLC Assessment has followed the BS EN 15978 standard over a 60-year study period, covering the entirety of modules A, B, C and D:

1. Module A1 – A5 (Product sourcing and construction stage)
2. Module B1 – B7 (Use stage)
3. Module C1 – C4 (End of life stage)
4. Module D (Benefits and loads beyond the system boundary)

Figure 3 demonstrates the different life-cycle modules included in the WLC Assessment as well as the difference between embodied carbon and whole life-cycle carbon.

The GLA Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022) states that the reference study period for the WLC Assessment should be 60 years, even in instances that the design life of a building exceeds or is less than 60 years.

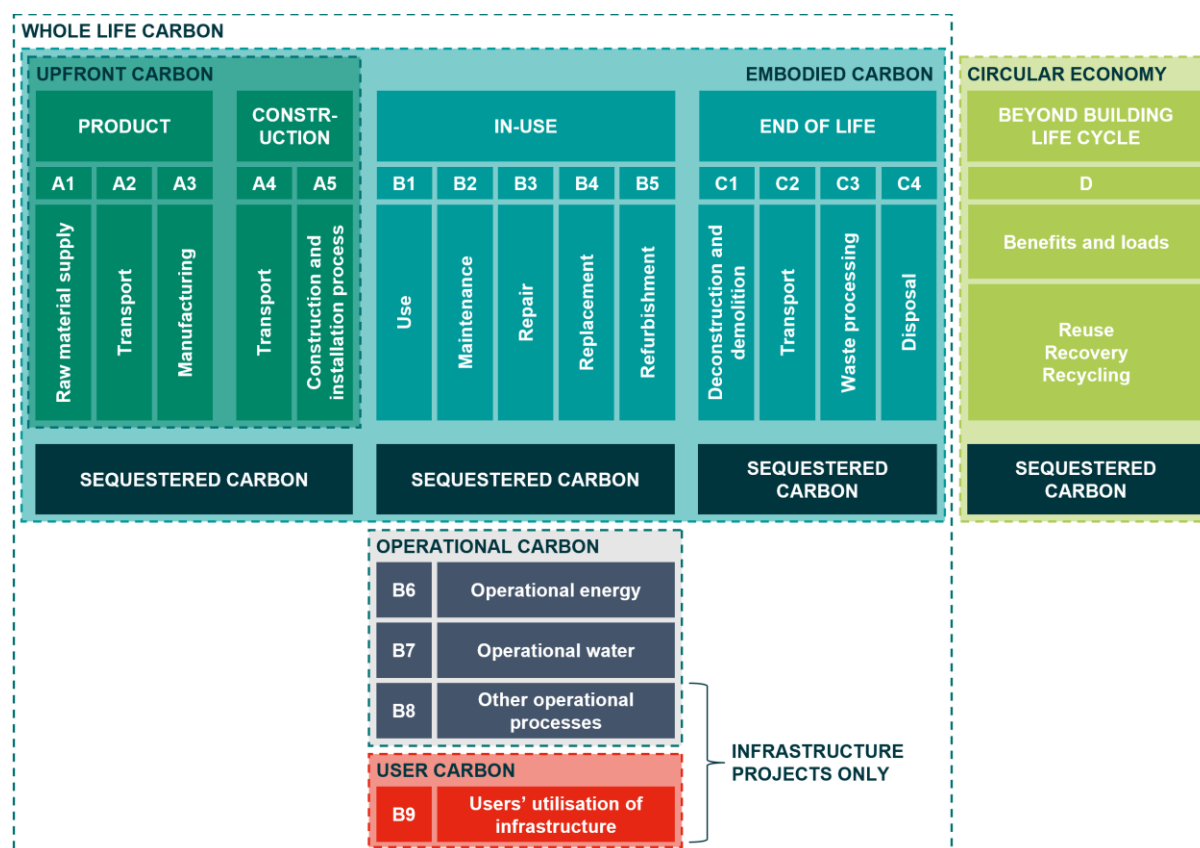


Figure 3 - Whole life carbon and life-cycle modules: EN 15978:2011 Modular display of the building assessment stages

The embodied carbon estimates from construction and materials for applicable life-cycle stages A – C, otherwise known as a cradle-to-grave study, are estimated for a life cycle of 60 years. This includes embodied emissions related to the raw extraction of materials, their processing in a factory or equivalent, transport and construction on site, any replacements assumed over the study period and finally end of life disposal. Benefits and loads beyond the building life cycle, Module D, are shown in the GLA WLCA template.

The operational carbon estimate includes the carbon emissions associated with the operational energy consumption of the development. This has been calculated for a life cycle of 60 years based on the assumption that the annual operation energy consumption will remain the same throughout the life cycle of the project, as per the Building Regulations Part L modelling.

The operational carbon estimate also includes the carbon emissions associated with water use during the operation of the building, related to water supply and wastewater treatment. This has been calculated for a life cycle of 60 years based on the Energy Saving Trust's Water Energy Calculator values regarding the litres/person/day assumptions.

2.4 Building elements

All the applicable building elements listed in, where included within the Stage 2 cost plan, have been included in the WLC Assessment in accordance with the RICS PS. The building elements are broken down according to the RICS New Rules of Measurement (NRM) classification system level 2 sub-elements.

Table 3 - Building elements (RICS PS) included in the WLC Assessment

Building Element Group	Building Element (NRM level 2)	
Demolition	0.1 Toxic/hazardous/contaminated material treatment	N/A
	0.2 Major demolition works	Yes
0 Facilitating works	0.3 & 0.5 Temporary/enabling works	Yes
	0.4 Specialist groundworks	Yes
1.1 Substructure	1.1 Substructure	Yes
2 Superstructure	2.1 Frame	Yes
	2.2 Upper floors incl. balconies	Yes
	2.3 Roof	Yes
	2.4 Stairs and ramps	Yes
	2.5 External walls	Yes
	2.6 Windows and external doors	Yes
	2.7 Internal walls and partitions	Yes
	2.8 Internal doors	Yes
3 Finishes	3.1 Wall finishes	Yes
	3.2 Floor finishes	Yes
	3.3 Ceiling finishes	Yes
4 Fittings, furnishings and equipment (FF&E)	4.1 Fittings, furnishings & equipment incl. building related and non-building-related	Partially*
5 Building services/MEP	5.1–5.14 Services incl. building-related and non-building-related	Partially†
8 External works	8.1 Site preparation works	Partially‡
	8.2 Roads, paths, paving and surfacing	Yes
	8.3 Soft landscaping, planting and irrigation systems	No§
	8.4 Fencing, railings and walls	N/A
	8.5-8.7 External fixtures, drainage, services	Partially†
	8.8 Minor building works and ancillary buildings	N/A

Building element 6, Prefabricated Buildings and Building Units, and 7, Work to Existing Building, are not applicable to this WLC assessment and are excluded.

* Applied 2% overall contribution based on GLA WLC Guidance, see Section 2.1 for more information.

† Similar to FF&E, embodied carbon data are not readily available for MEP services and associated equipment, this is an industry-wide issue but the impact is captured as much as possible for these elements.

‡ At this stage, site operations are captured in accordance with the RICS PS. This is described in Section 2.6.2.

§ Soft landscaping is not typically accounted for within the assessment and any impact would be negligible.

2.5 LCA software and database

The embodied carbon calculation for the WLC Assessment have been conducted using the LCA software 'One Click LCA'. It is an industry-recognised tool and is third-party verified for EN 15978, ISO 21931–1, ISO 21929–1 standards and for input data ISO 14040/44 and EN 15804. For this assessment the "Whole life carbon assessment, Greater London Authority" tool was used to prepare the baseline and option studies, aligned with the RICS Professional Statement 'Whole Life Carbon Assessment for the Built Environment' (2017) for service life of materials and transport distances.

2.6 Operational energy analysis

AECOM has been commissioned by Highgate School ('the Applicant') to produce an energy statement in support of a detailed planning application for the redevelopment of their Richards Music Centre (RMC) site at Bishopswood Road ('the Site') in the London Borough of Haringey.

The energy strategy for the proposed development is:

1. Energy efficient fabric and buildings services design;
2. A GSHP system to provide space heating and cooling to the building and hot water to changing room areas;
3. A PV array on the roof of the building.

The results of the energy statement are incorporated into this WLC assessment.

2.7 Assumptions

A number of assumptions have been made at this early stage of design. These broadly align with the RICS PS and GLA WLC guidance.

2.7.1 Product stage (A1 - A3)

Recycled content for the steel and aluminium elements are as per RICS methodology default recommendations (Table 4).

Table 4 - Overview of the proposed recycled content and recycle rates at end of life for the metal elements of the Proposed Development

Material	Recycled Content	
	Details	Specification
Steel	Reinforcement bars	97% Recycled Content
	Structural steel sections	20% Recycled Content
	Studwork/Support frames	Galvanised steel, 15% Recycled Content
Aluminium	Cladding panels	Aluminium sheet, 35% Recycled Content
	Glazing frames	Aluminium extrusions, 35% Recycled Content

2.7.2 Construction process stages (A4 – A5)

Waste factors for the materials based on traditional build types have been taken from the default values provided within the software tool.

Transport distances are as per RICS PS methodology default figures where applicable (Table 5).

Table 5 - Overview of the proposed transport distances as per RICS methodology default figures

Transport scenario	Distance	
	km by Road	km by Sea
Locally manufactured	50	-
Nationally manufactured	300	-
European manufactured	1,500	-
Globally manufactured	200	10,000

Construction emissions have been based on the carbon emissions within the LCA tool with default processes for each material/building element.

2.7.3 Use stage (B1 – B5)

The in-use life stages mainly comprise of replacements to materials/building components over the 60-year study period. This is defined by the expected lifespan of each building element. Material lifespans are as per RICS methodology default figures (Table 6).

Table 6 - Indicative component lifespans as per RICS professional statement and guidance document

Building Part	Building Element/ components	Expected Lifespan
Roof	Roof coverings	30 years
Superstructure	Internal partitioning and dry lining	30 years
Finishes	Wall finishes: Render/Paint	30/10 years respectively
	Floor finishes, Raised Access Floor (RAF)/Finish layers	30/10 years respectively
	Ceiling finishes Substrate/Paint	20/10 years respectively
	Ductwork	20 years
	Electrical installations	30 years
	Lighting fittings	15 years
	Communications installations and controls	15 years
	Water and disposal installations	25 years
	Sanitaryware	20 years
	Lift and conveyor installations	20 years
	Glazed cladding/Curtain walling	35 years
	Windows and external doors	30 years

In accordance with the GLA's WLC guidance document, B2 emissions are calculated by multiplying the GIA by 10 kg/CO₂e. This value is distributed across element categories based on the amount of maintenance anticipated.

B3 emissions are based on 25% of the B2 emissions, as per the GLA's WLC guidance document recommendation.

2.7.4 End of Life (C1 – C4)

Table 7 provides an overview of the assumption for the end-of-life scenario for different types of materials based on default values from the One Click LCA dataset used. It is important to note that One Click LCA's capability is limited to modelling either 0% or 100% recycled rates only. These end of life impacts typically only account for 1-5% of the total emissions and reducing these values to smaller percentages to align with industry actuals would have a negligible effect on the overall results. Therefore, these default values were retained within the modelling calculations.

Table 7 - End of life scenarios for different types of materials within the Proposed Development

Material	End of Life Scenario	Recycling Rate
Structural concrete	Crushed and recycled	100%
Steel (structural, rebar, galvanised, zinc coated)	Recycled	100%
Insulation (Rockwool/ EPS)	Landfill/ Plastic-based incineration	0%
Polyurethane membranes	Plastic-based incineration	0%
Timber	Wood incineration	0%
Bricks and Mortar	Brick crushed to aggregate, Mortar used in a backfill	100%
Plasterboard	Recycled	100%
Paints	Landfill	0%
Glass	Recycled	100%
Ceramic Tiles	Crushed to aggregate	100%
Asphalt	Asphalt reuse via reprocessing	100% (reused rate)

2.7.5 Furniture, Fixtures and Fittings (FF&E)

The RIBA Stage 2 cost plan does not provide sufficient detail on the quantum of (FF&E) components and therefore this has only partially been addressed at this stage.

2.7.6 Building services

To accurately calculate the embodied carbon of the MEP Services, a detailed list with all the materials included in the proposed building services and their quantities is required. This was only partially feasible at this stage; therefore, reasonable assumptions have been made for the type of materials and their quantities of the proposed building services to provide a more accurate WLC result at this stage

There are pre-defined constructions, assemblies and systems within One Click LCA that can be used to make reasonable estimations of embodied carbon. The Proposed Development has been allocated the following systems based on the building floor area to estimate the embodied carbon:

1. Drinking water distribution.
2. Hot water distribution.
3. Heating distribution.
4. Sewerage connection.
5. Electrical cabling.
6. Ventilation system.

Embodied carbon related to and sanitary appliances (i.e., toilet, washbasin, shower) has also been considered in the assessment where possible.

2.8 Third Party Mechanisms for Verification

There are several mechanisms AECOM use to quality assure the submission. Firstly, the individuals who produced this study and report are not part of the project's design team and act as external consultants. No design option or solution modelled as part of this study was created by the AECOM WLC consultants and all information was provided by the design team and cost consultants. An exception may be where a potential carbon reduction solution is identified and communicated within the report to stimulate conversation. Secondly, all AECOM outputs undergo a quality assurance process. The report is written, checked, verified and approved by different people within the consultant team and no individual can undertake more than one of these roles. Finally, in terms of modelling, AECOM WLC consultants use the in-built completeness and plausibility checker within One Click LCA to ensure that the model quantities are consistent with the required standard and typical buildings of a similar nature.

3. Whole Life-Cycle Carbon Assessment Results

The overall WLC of the Proposed Development is **3,575 tCO₂e** (A-C including sequestration) or **2,004 kgCO₂e/m² GIA**, as indicated in Table 8. The total embodied carbon of the Proposed Development is **2,839 tCO₂e** (A-C excluding B6 & B7 and including sequestration) or **1,591 kgCO₂e/m² GIA**. Detailed results are presented in Table 8.

Table 8 - WLC carbon and total embodied carbon for the Proposed Development over its 60-year life-cycle

	GIA (m ²)	Total WLC (tCO ₂ e)	Normalised WLC (kgCO ₂ e/m ²)
WLC carbon (A-C)*		3,575	2,004
Embodied carbon only (A, B1-B5, C)	1,784	2,839	1,591

The results include sequestration

It should be noted that both the sheet piling, and photovoltaic panels (PV) are having a significant influence on the result. This is discussed in section 4.

Table 9 shows the breakdown of the overall WLC carbon of the Proposed Development by the main life-cycle stages, over the assumed 60-year life cycle. The total impact of the building does not include Module D. This follows the GLA benchmarks which exclude Module D.

Table 9 - Breakdown of the embodied carbon of the Proposed Development's life-cycle stages

Life-cycle Stage		Total WLC (tCO ₂ e)	Normalised WLC (kgCO ₂ e/m ²)
Products	A1-A3	1,597	895
Transport	A4	118	66
Construction	A5	440	247
Recurring	B1-B5	612	343
Energy & Water	B6- B7	737	413
End of Life	C1-C4	187	105
Product Reuse*	D	-926	-519
Biogenic Carbon	-	-116	-65
Total	A-C	3,575	2,004

*Excluded from totals.

As indicated in Figure 4, **79%** of the WLC carbon of the Proposed Development is attributed to the embodied carbon (A, B1-B5, C) and just **21%** to the operational carbon (B6-B7).

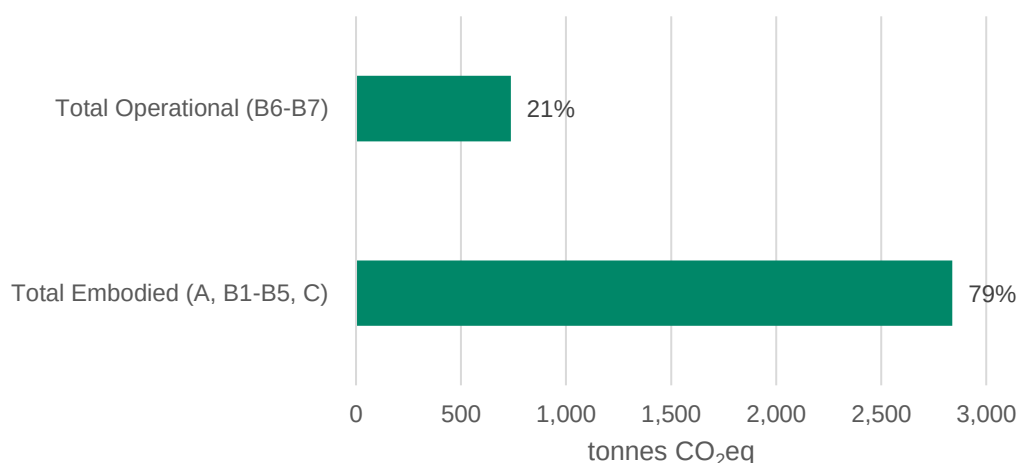


Figure 4 - Breakdown of the total emissions from operational and embodied carbon sources

Figure 5 shows the percentages of contribution of the different life-cycle stages to the total embodied carbon (A-C, excluding B6-B7). The product stage (A1 – A3) of the building life-cycle, otherwise known as the 'cradle to gate' stages, consists of raw material extraction, transport and processing within the manufacturing of the product is responsible for approximately 54% of the total embodied carbon of the Proposed Development. Transport and construction stages (Modules A4 – A5) contribute around 19% of the total embodied carbon. Therefore, life-cycle stages A1-A5 indicate that the embodied impact at completion of construction works accounts for 73% of the total impact over the building's 60-year life-cycle.

The embodied carbon from recurring building elements (Modules B1-B5) contributes approximately 21% of the total embodied carbon. This is due to elements that need replacing over the 60-year life-cycle of the building. The end of life and disposal (Module C) accounts for about 6% of the total embodied carbon.

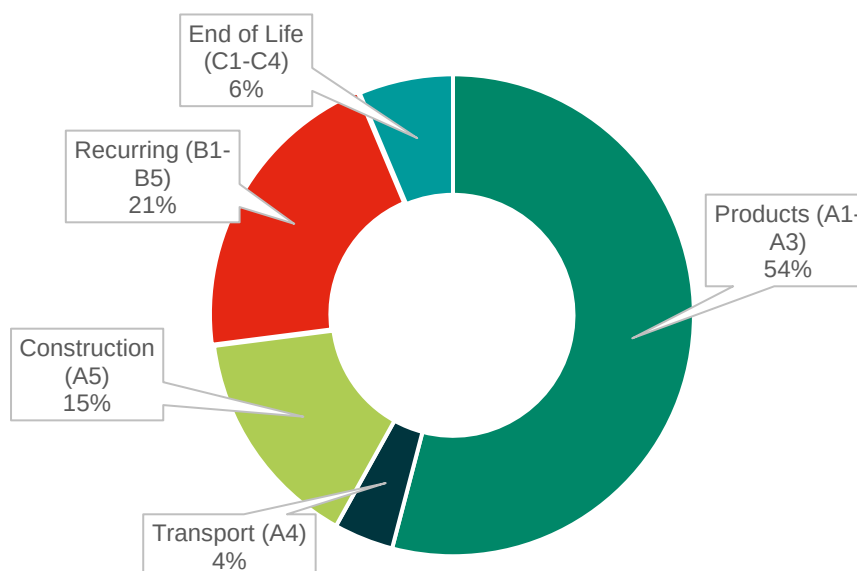


Figure 5 - Breakdown of embodied carbon emissions by life-cycle module

Figure 6 shows that 19% of the total embodied carbon of the Proposed Development is attributed to Superstructure and 45% to the Substructure. The rest of the building categories are responsible for around 36% of the overall embodied carbon. The contribution of embodied carbon from the substructure is high and is attributed to the basement, 20m long piles and sheet piling; this alone is responsible for more than 20% of all emissions. This is discussed in further detail in section 4.

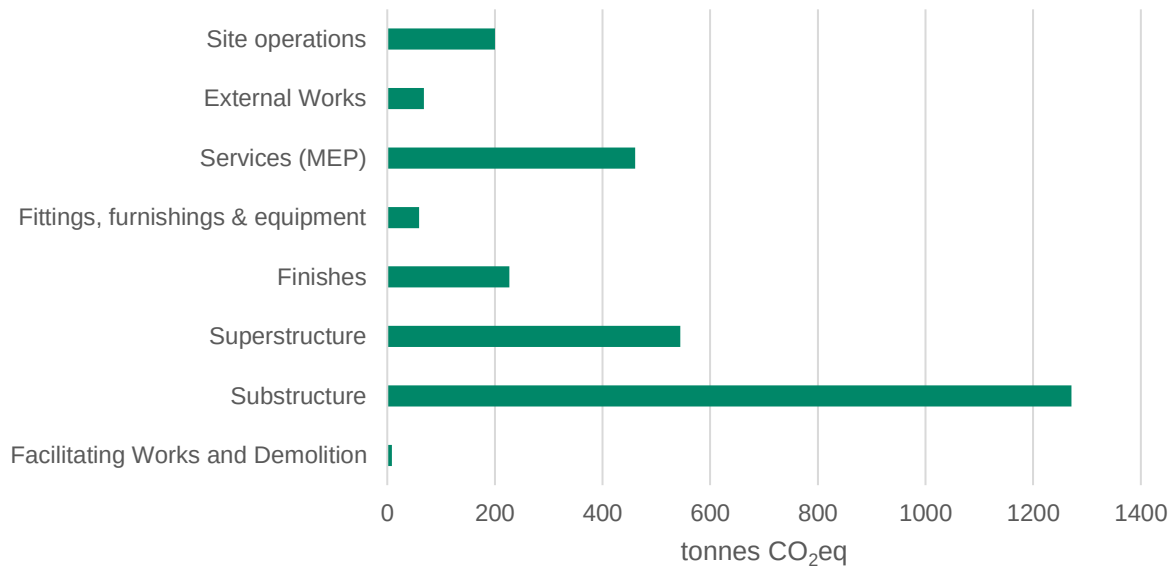


Figure 6 - Breakdown of the total embodied carbon by building element categories

Figure 7 shows that 38% of the total operational (B1-B5) and end of life (C1-C4) embodied carbon of the Proposed Development is attributed to the MEP equipment, 28% to the superstructure and 22% to the finishes.

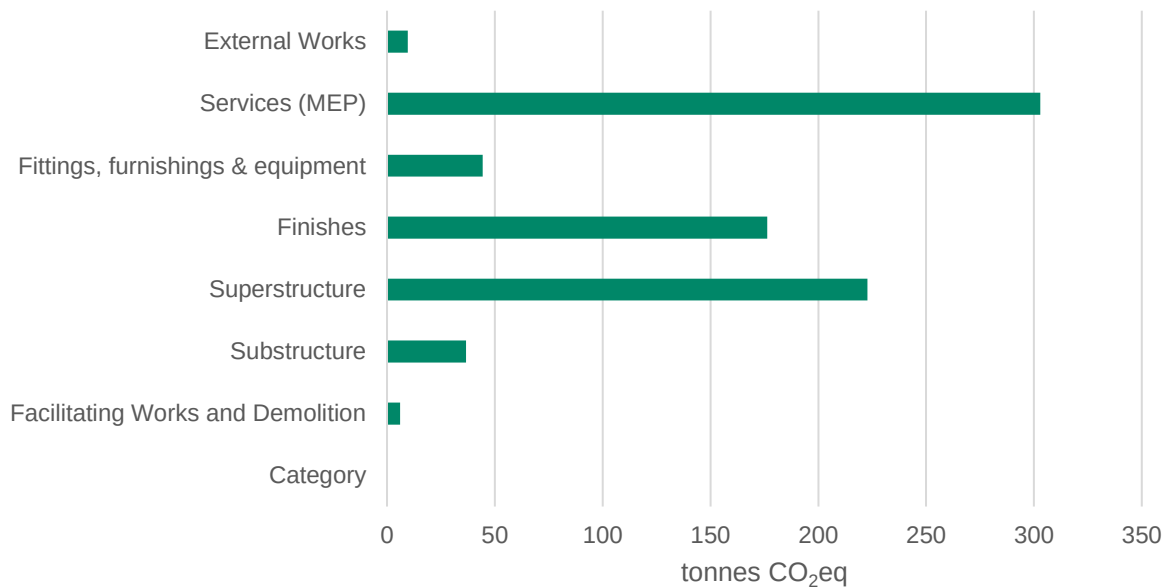


Figure 7 - In use and end of life embodied carbon breakdown (B-C excl. B6-B7) by building element category

Figure 8 provides an overview of the breakdown of the embodied carbon of the superstructure per building element. The study demonstrates that the largest share of the embodied carbon of the superstructure across the whole life of the Proposed Development is attributed to external walls, windows and external doors.

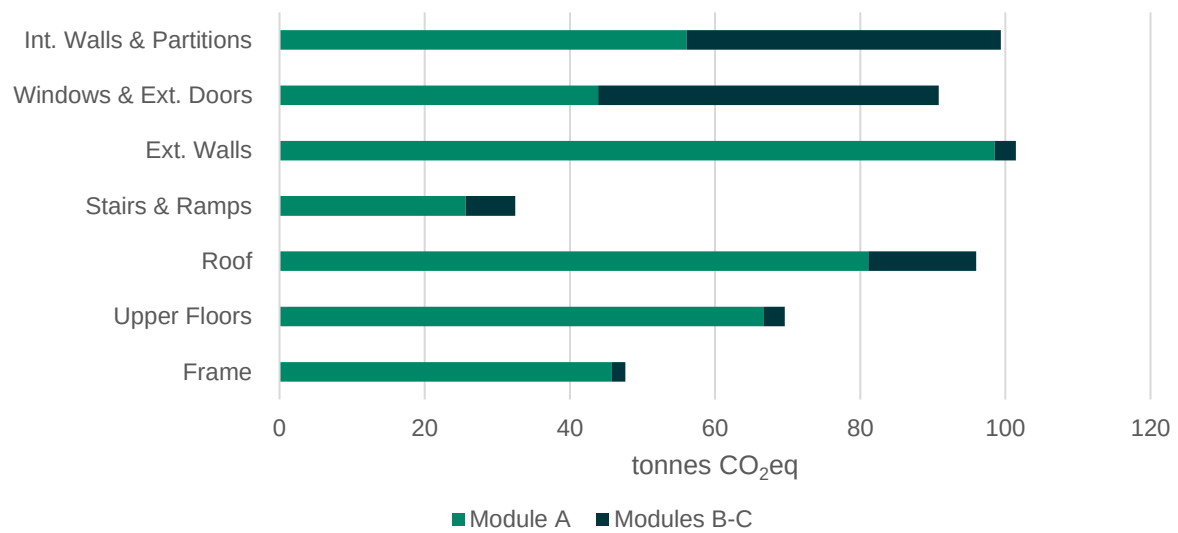


Figure 8 Breakdown of the embodied carbon of the Superstructure by the Building Element Subcategories

4. Comparisons of the Results with Benchmarks

4.1 GLA

According to the GLA's Whole Life-Cycle Carbon Assessment Guidance (GLA, 2022), it is required that the results of the WLC Assessment of the Proposed Development are compared to the benchmarks provided in the same document (GLA, 2022).

The embodied carbon results of the Proposed Development are compared to the GLA benchmarks for Schools (Table 10). Based on the current assumptions, the development **does not meet the GLA embodied carbon benchmark** for Modules A1-A5, B-C or A-C. The results also demonstrate that it also **does not meet** the aspirational targets for Schools under Modules A1-A5, B-C or A-C.

Table 10 - Comparison of the WLC Assessment results for the Proposed Development against the WLC Benchmarks for Schools

Modules	WLC Benchmark (kgCO ₂ e/m ²)	Aspirational WLC Benchmark (kgCO ₂ e/m ²)	Proposed Development (kgCO ₂ e/m ²)
A1 – A5 (excluding sequestration)	<750	<500	1,208
B – C (excluding B6, B7 and sequestration)	<250	<175	448
A – C (excluding B6 and B7 and including sequestration)	<1000	<675	1,591*

*Please note that the results of A1 – A5 and B – C do not equal the result for A – C because this includes the benefits of sequestration.

The basement aspect of the Proposed Development is contributing to a significant share of the embodied carbon, particularly the sheet piling which accounts for around 20% alone. The basement and relatively small overall GIA, therefore, is contributing a larger proportion of embodied carbon than a building with a larger GIA.

5. Carbon Reduction Opportunities

5.1 Key Opportunity

This study utilised the typical UK construction products and associated carbon factors as advised by the RICS PS and by the Institution of Structural Engineers. The design team has identified an opportunity to increase the quantity of cement replacements in the C30/37 structural concrete throughout the Proposed Development from 20% to 50%.

The use of a higher percentage of cement replacement across all structural concrete elements within the Proposed Development will reduce the embodied carbon by 91 kgCO₂e/m².

5.2 Further Opportunities

5.2.1 Sheet Piling

There is a significant opportunity to incorporate recycled steel within the sheet piling as this is responsible for around 20% of the total impact. Alternatively, a review of the material options could be undertaken. For example, concrete alternatives could be explored.

5.2.2 Design for disassembly

A key consideration for embodied carbon and circular economy is to ensure they can be easily dismantled and reused/recycled where possible. This is also important for interior finishes and building services which are likely to be replaced much more often in a building's lifespan than the structural elements. Adhesives and welding should therefore be avoided where possible.

5.2.3 Internal finishes

If possible, leaving structures exposed with bare finishes will result in a much lower life-cycle carbon impact through reduced material requirements (including less replacements).

5.2.4 Refrigerants for building services

There are a wide range of refrigerants, many of which have a global warming potential (GWP, kgCO₂e/kg) that is many times greater than CO₂. The carbon impact of such refrigerants released into the atmosphere, which can occur from leakages, can be significant. Therefore, refrigerants with lower GWP should be preferred where feasible, but this should be considered against the energy efficiency of the heat pump system to ensure the greatest reduction in WLC in the system. A refrigerant with a GWP of less than 150 kgCO₂e/kg refrigerant is recommended.

Table 11 - Global warming potential of different refrigerants for building services

Refrigerant Name	Trade or Common Name	High-GWP?	Global Warming Potential*
R-744	CO ₂	No	1
R-290	Propane	No	4
R-170	Ethane	No	6
R-152a	HFC-152a	No	124
R-32	HFC-32	Yes	675
R-134a	HFC-134a	Yes	1430
R-22	HCFC-22a, Freon	Yes	1810
R-410A	Puron, AZ-20	Yes	2088
R-125	HFC-125	Yes	3500
R-404A	HP-62	Yes	3900
R-502		Yes	4656.72
R-12	CFC-12	Yes	10900

6. Conclusions and Next Steps

This document accompanies the Greater London Authority (GLA) WLC Assessment Templates, which have been developed to meet the relevant planning Policy SI 2 of the Publication London Plan December 2020. The report outlines the Scope of the WLC Assessment, presents and analyses the results of the WLC Assessment of the Proposed Development and compares them with the corresponding benchmarks that are provided in the GLA's Whole Life-Cycle Carbon Assessment Guidance (2022).

The baseline WLC over the 60-year study period: **3,575 tCO₂e which corresponds to 2,004 kgCO₂e/m² GIA.**

The operational carbon is responsible for **21%** of the WLC of the Proposed Development, while **79%** is attributed to the embodied carbon of the building materials, facilitating works and external works.

6.1 Next Steps

A further WLC Assessment will be completed at post-construction stage, as per the GLA's Whole Life-Cycle Carbon Assessment Guidance. Accordingly, the post-construction results will be compared with planning submission stage results and GLA benchmarks, accompanied with an explanation for any significant differences

Appendix A GLA WLC Template