



Ministry of Housing, Communities & Local
Government

THE UNITED KINGDOM HOLOCAUST MEMORIAL AND LEARNING CENTRE

Whole Life Carbon Assessment





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CONTENTS

1	EXECUTIVE SUMMARY	1
1.1	CARBON REDUCTIONS	1
1.2	RESULTS	2
1.3	COMPARISON AGAINST BENCHMARK	3
1.4	POST-CONSTRUCTION WLCA	3
2	INTRODUCTION	4
2.1	PURPOSE OF REPORT	4
2.2	THE DEVELOPMENT DESCRIPTION	4
2.3	BUILDING	6
2.4	WHOLE LIFE CARBON REQUIREMENTS	8
3	WHOLE LIFE CARBON ASSESSMENT METHODOLOGY	10
3.1	INTRODUCTION TO WHOLE LIFE CARBON ASSESSMENTS	10
3.2	METHODOLOGY STATEMENT	11
3.3	SOFTWARE	13
3.4	REFERENCE STUDY PERIOD	13
3.5	WHOLE LIFE CARBON UNCERTAINTY FACTOR	13
4	WHOLE LIFE CARBON ASSESSMENT SCOPE	14
5	RESULTS	17
5.1	KEY FIGURES	18
5.2	STANDARD (BUSINESS-AS-USUAL) SCENARIO	19
5.3	DECARBONISED SCENARIO	23
5.4	COMPARISON OF RESULTS (NON-DECARBONISED SCENARIO)	25
5.5	RESULTS SPLIT BY DISCIPLINE	27
6	CARBON REDUCTION OPPORTUNITIES	36

6.1	DESIGNING FOR LONGEVITY, ADAPTABILITY & FLEXIBILITY	36
6.2	DESIGNING FOR MATERIAL EFFICIENCY & MAXIMISING RECYCLED CONTENT	36
6.3	FURTHER OPTIONS FOR THE MOST CONTRIBUTING MATERIALS	36
6.4	RESPONSIBLE SOURCING & SPECIFICATION OF MATERIALS	39
6.5	DESIGNING FOR RE-USE & RECOVERY	40
6.6	REDUCE/REUSE/RECYCLING OF MATERIALS	40
6.7	OPERATIONAL ENERGY (MODULE B6)	40
6.8	MINIMISING ON-SITE ENERGY	40
6.9	SUMMARY	40
7	CONCLUSION	42

TABLES

Table 0-1- Carbon Summary of UKHMLC WLC Results (Non-decarbonised)	3
Table 4-1 – Review of Information Provided by Element Scope	14
Table 4-2 – Review of Information Provided by Lifecycle Module	16
Table 5-1 – WLCA Summary Results (Non-decarbonised)	18
Table 5-2 – Elements included in each category for WLC assessment	18
Table 5-3 – Comparison Project Summaries	25
Table 5-4 - Comparison of Features of Each Development	26
Table 5-5 - Architectural Whole Life Carbon Summary Results	27
Table 5-6 - Structural Whole Life Carbon Summary Results	29
Table 5-7 – Building Services Summary Results	31
Table 5-8 - Comparison of Annual Energy Intensity	33
Table 5-9 - Carbon Emissions of Operational Energy Over 60 Year Lifespan	34
Table 6-1 - UKHMLC carbon reduction strategies	41

FIGURES

Figure 2-1 –View of the Buxton and Holocaust Memorials together with the Houses of Parliament	4
Figure 2-2 – Site Location	5
Figure 2-3 – UK Holocaust Memorial and Learning Centre Site Plan	5
Figure 2-4 –Structural section of the building	6
Figure 2-5 –View of proposed Cafe/ Kiosk	7
Figure 2-6 –View of the entrance stairs between memorial fins	8
Figure 3-1 – Life Cycle Modules of Whole Life Carbon Assessments based on RICS 2.0	10
Figure 3-2 – Methodology summary of the WLC assessment for UKHMLC	12
Figure 5-1 – Most contributing materials to UKHMLC upfront carbon product stage (A1-A3)	19
Figure 5-2 - Upfront Carbon (A1-A5) per Building Element with Uncertainty Factor	19
Figure 5-3 - Embodied Carbon Split Non-Decarbonised scenario (A-C)	20
Figure 5-4 - Embodied Carbon Emissions per GIA with Uncertainty Factor (kgCO _{2e} /m ²)	20
Figure 5-5 – Whole Life Carbon breakdown by lifecycle stage and component, non-decarbonised scenario (kgCO _{2e} /m ²)	22
Figure 5-6 - Embodied Carbon Split Decarbonised scenario (A-C)	23
Figure 5-7 - Embodied Carbon Emissions per GIA with Uncertainty Factor (kgCO _{2e} /m ²)	23
Figure 5-8 – Whole Life Carbon breakdown by lifecycle stage and component, non-decarbonised scenario (kgCO _{2e} /m ²)	24
Figure 5-9 – Top 10 highest contributing architectural materials (A1-A3)	28
Figure 5-10 – Upfront Carbon (A1-A5) by building category (Structural)	29
Figure 5-11 – Top 10 highest contributing structural materials (A1-A3)	30
Figure 5-12 – MEP Embodied Carbon of by Lifecycle Stage [kgCO _{2e} /m ²] (non-decarbonised)	32
Figure 5-13 – Whole Building Energy Breakdown	34
Figure 6-1 – Most contributing material to UKHMLC embodied carbon	37
Figure 6-2 – The embodied carbon for main constituents of reinforced concrete, by The Concrete Centre	37
Figure 6-3 – UKHMLC carbon reduction strategies impact on Upfront Carbon	41

APPENDICES

APPENDIX A

TM65 ASSESSMENT

APPENDIX B

TM54 ASSESSMENT

APPENDIX C

POLICIES

APPENDIX D

COMPARISON BUILDINGS

APPENDIX E

ASSUMPTIONS

APPENDIX F

RESULTS



1 EXECUTIVE SUMMARY

This Whole Life Carbon Assessment has been prepared by WSP on behalf of Ministry of Housing, Communities & Local Government ('the Applicant') in support of an application for a planning permission for the development of the United Kingdom Holocaust Memorial and Learning Centre (UKHMLC) ('the Site') within Victoria Tower Gardens in Westminster. The description of the development is as follows:

Installation of the United Kingdom Holocaust Memorial and Learning Centre including excavation to provide a basement and basement mezzanine for the learning centre (Class D1); erection of a single storey entrance pavilion; re-provision of the Horseferry Playground and refreshments kiosk (Class A1); repositioning of the Spicer Memorial; new hard and soft landscaping and lighting around the site; and all ancillary and associated works.

The Applicant's approach to sustainable development is underpinned by policies from the London Plan and the Westminster Local Plan. Together these documents provide spatial policies, development management policies and site allocations to guide and manage development in the City of Westminster (CoW).

The building is comprised of two basement levels providing exhibition and educational space, carefully integrated into a constrained and historically sensitive site. and includes a sculptural bronze entrance, indicative of the building's cultural significance. The project objectives include:

- Becoming a landmark of national significance, highlighting the importance and relevance of the Holocaust to the United Kingdom's history.
- Combining design, landscaping and placemaking to enhance Victoria Tower Gardens – improving the visual and sensory experience of the green space and giving it focus and civic presence, both for visitors and existing users.
- Being an outstanding, ambitious, sensitive design that creates an emotionally powerful place for reflection and learning.
- Addressing the sensitivities of the historic, political and national importance of the exceptional setting, adjacent to the Palace of Westminster, a UNESCO World Heritage Site, and the River Thames – and in one of the most visited, and recognisable, parts of London.

1.1 CARBON REDUCTIONS

The priority for sustainability on this project has been incorporating strategies to ensure the building has a long life – remaining adaptable to promote its longevity as a cultural landmark that will serve as an enduring reminder of the need for our democracy to stand up against intolerance, injustice and hatred for generations to come. as well as a useful multi-functional space in a unique location. Further explanation of the incorporation of circular principles is provided in the Circular Economy Statement.

Additionally, to this overarching strategy, specific strategies to reduce the embodied carbon have been incorporated throughout the design, including the following (further details are noted in later sections of this report):

- Structural optimisation to avoid over-specification and minimise concrete used.
- Raft foundation to reduce pile numbers and eliminate pile caps.
- 100% recycled-content bronze (including fins); 30–40% fins prefabricated.
- Mineral-wool insulation rather than oil-based
- Dual-purpose smoke extract/ventilation to cut ductwork; plant sized efficiently to reduce material quantities.
- Efficient heating, cooling and ventilation plant is specified to minimise energy demand; the preferred solution is an open-loop ground-source heat pump system (subject to detailed design and approvals).
- Heating, hot water and cooling are provided via heat-pump technology on a central loop serving the development. This delivers high seasonal efficiency and positions the scheme to benefit from ongoing grid decarbonisation (assessed on a conservative basis).
- Use of local suppliers/subcontractors where practicable.
- Structural finishes to be exposed, limiting additional finishes/materials required
- Superstructure elements in hard-to-access locations receive enhanced corrosion protection to minimise maintenance required

Design optioneering has also been undertaken as part of the BREEAM Mat 01 assessment. As the design progresses, the feasibility of specifying alternative low carbon concrete mixes (e.g. calcined clays, limestone fines) will be investigated further to minimise the impact of the elements that currently form the largest proportion of the total carbon.

A series of additional carbon-saving opportunities, not accounted for in the Whole Life Carbon assessment (WLCA), will be integrated into the design at later stages as it progresses., including:

- Subject to testing and suitability, crushed and graded demolition arisings will be prioritised for the temporary piling mat and for backfill where specification allows, reusing existing materials
- Opportunity to use recycled fill to form landscaping levels
- Potential for re-use of existing topsoil onsite

The Whole Life Carbon of the development will continue to be monitored throughout design stages.

1.2 RESULTS

The WLCA was conducted in accordance with the RICS Whole Life Carbon Assessment for the Built Environment, 2nd Edition published in 2023. A summary of the Whole Life Carbon results in *non-decarbonised scenario* is presented below:

- **Upfront carbon** (A1–A5): 7,243 tCO₂e, equivalent to 1,928 kgCO₂e/m².
- **Use + end-of-life** (B1–B5, C1–C4; excl. sequestered): 3,139 tCO₂e, equivalent to 836 kgCO₂e/m².
- **Total embodied carbon** (A1–A5, B1–B5, C1–C4; incl. sequestered): 10,219 tCO₂e, equivalent to 2,720 kgCO₂e/m².
- **Operational carbon** over 60 years (B6–B7):
 - Operational energy (regulated and unregulated): 5,581 tCO₂e
 - Water use (operational water energy): 55 tCO₂e
- **Whole-life carbon** over 60 years (incl. B6–B7, excl. sequestered): 15,856 tCO₂e, equivalent to 4,220 kgCO₂e/m².

1.3 COMPARISON AGAINST BENCHMARK

Due to the unique nature of the building use, site and massing, it is difficult to identify comparable industry benchmarks or targets for embodied carbon for this type of cultural and commemorative infrastructure, especially when compared on results normalised per m² of GIA. The closest typical benchmark would be the GLA commercial target, although the building and use are not similar to a typical Westminster office at all. It should also be noted that comparing on a per m² basis does not account for the double height space that aids future flexibility or the external area created above the building. While adding external areas has a detrimental impact on carbon numbers, these areas greatly improve health & wellbeing, biodiversity, and the urban greening factor creating enhanced public open space that connects the new memorial with both the adjacent Palace of Westminster and existing memorials, as well as improving the vantage from the park to the River Thames.

Therefore, the carbon footprint per visitor has also been calculated as an alternative metric. Based on an anticipated 500,000 visitors annually and an embodied carbon figure of **10,219tCO₂e**, the development equates to approximately **341grams** of CO₂e per visitor per year, which is roughly equivalent to a 3km drive in an average petrol car.

This figure remains reasonable when compared to similar cultural or public buildings—such as the London Tunnel, Lord’s Cricket Ground, and the Museum of London as can be seen in more detail in Section 4.

Table 0-1- Carbon Summary of UKHMLC WLC Results (Non-decarbonised)

	Upfront Carbon Module A1-A5 (Excluding sequestered carbon)	Embodied Carbon Modules A-C (Excluding B6 & B7; Including sequestered carbon)	Whole Life Carbon Modules A-C
Normalised by floor area <i>kgCO₂e / m²</i>	1,928	2,720	4,220
Normalised by visitor numbers <i>gCO₂e / visitor</i>	241	341	529

1.4 POST-CONSTRUCTION WLCA

In accordance with the GLA guidance, it is anticipated that an ‘As Built’ Assessment will be required at Post-Construction Stage after RIBA Stage 5 (upon commencement of RIBA Stage 6, prior to building handover).

2 INTRODUCTION

2.1 PURPOSE OF REPORT

WSP have been appointed by the Ministry of Housing, Communities & Local Government to undertake a Whole Life Carbon assessment to support the planning application for the United Kingdom Holocaust Memorial and Learning Centre, situated within Victoria Tower Gardens in Westminster.

2.2 THE DEVELOPMENT DESCRIPTION

The United Kingdom Holocaust Memorial and Learning Centre in Victoria Tower Gardens is conceived as an enduring reminder for generations, crafted as a landmark of national significance that highlights the importance and relevance of the Holocaust within UK history. The design is sensitive to the park and its world-heritage setting, guiding visitors through an entrance pavilion and contemplative courtyard, with Parliament present as a beacon of tolerance and democracy. The scheme unites the park's memorials into a coherent Garden of our Nation's Conscience, preserving green space and retaining and enhancing existing uses. In doing so, it provides a cultural monument and a powerful place for reflection and learning, strengthens the civic presence of Victoria Tower Gardens.

The development description is:

Installation of the United Kingdom Holocaust Memorial and Learning Centre including excavation to provide a basement and basement mezzanine for the learning centre (Class D1); erection of a single storey entrance pavilion; re-provision of the Horseferry Playground and refreshments kiosk (Class A1); repositioning of the Spicer Memorial; new hard and soft landscaping and lighting around the site; and all ancillary and associated works



Figure 2-1 –View of the Buxton and Holocaust Memorials together with the Houses of Parliament



Figure 2-2 – Site Location

The site is located in Victoria Tower Gardens, a public park situated beside the Houses of Parliament in Westminster, London. Victoria Tower Gardens is adjacent to the River Thames and sits directly to the south of the Palace of Westminster, a UNESCO World Heritage Site.



Figure 2-3 – UK Holocaust Memorial and Learning Centre Site Plan

2.3 BUILDING

The building is designed to be a memorial to those who lost their lives in the Holocaust, providing exhibition and educational space for this purpose, as well as supporting office and learning space. It is comprised of two basement levels, carefully integrated into a constrained and historically sensitive site, and includes a sculptural bronze entrance, indicative of the building's high-profile status and cultural significance.

The total Gross Internal Area (GIA) of the building is approximately 3,757m², with an additional external space created as part of the public realm, blending into the surrounding landscape of Victoria Tower Gardens. This is a highly bespoke building, both in use and in form and is tailored to accommodate a unique blend of memorial, educational, and contemplative spaces.

The development is predominantly subterranean, arranged as a two-storey concrete basement box formed using a boundary secant pile wall with central piles. Intermediate floors are reinforced-concrete slabs supported by RC walls, columns and beams, with precast hollow-core planks forming the B3 slab. Various structural typologies, including in situ flat slabs, precast slabs and metal deck slabs, have been used for most appropriate and efficient solution in each area of the building.

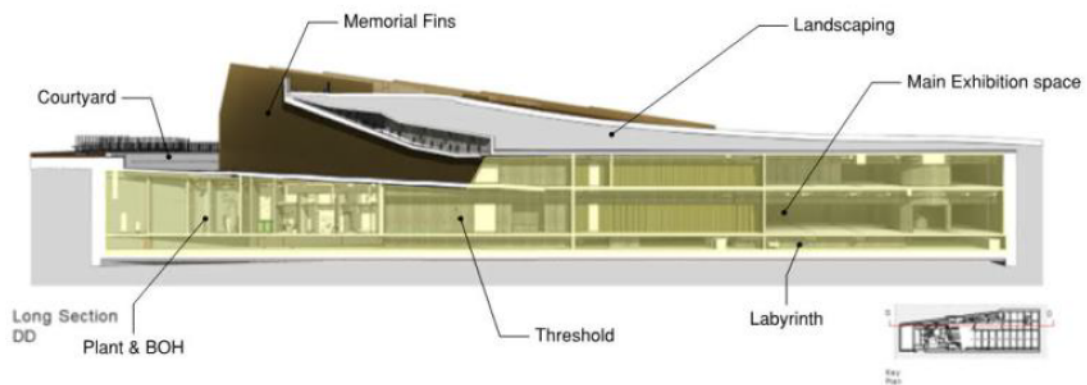


Figure 2-4 –Structural section of the building

The entrance pavilion leads visitors through to a memorial courtyard which features 23 bronze fins. The 22 spaces created between the fins represent the number of countries in which Jewish communities were devastated during the Holocaust. All these paths lead to the Threshold - a large hall which acts as a contemplation space and transition into the learning centre. The learning centre consists of a hall of testimonies and a contemplation court for visitors to experience and be educated about the Holocaust. Departing the learning centre takes visitors once again through the Memorial and out towards the outdoor light.

The main building areas included in the assessment are:

- The Learning Centre
- The Entrance Pavilion
- The café kiosk
- Memorial courtyard and associated landscaping, and

- Horseferry Playground

The memorial itself is set below ground level, with only the entrance pavilion and a small café kiosk visible at street level. The building extends two levels beneath the ground floor. The GIA of the project is 3,757 m².

For further information relating to the project background, see the Design and Access Statement by Adjaye Associates, Ron Arad Architects and Gustafson Poerter + Bowman.



Figure 2-5 –View of proposed Cafe/ Kiosk



Figure 2-6 –View of the entrance stairs between memorial fins

2.4 WHOLE LIFE CARBON REQUIREMENTS

SCOPE AND METHODOLOGY

This Whole Life Carbon assessment includes the following:

- The Learning Centre
- The Entrance Pavilion
- The café kiosk

- Memorial courtyard and associated landscaping

The WLCA was conducted in accordance with the RICS Whole Life Carbon Assessment for the Built Environment, 2nd Edition published in 2023.

All life-cycle modules (A–D) are included in the assessment. Module D is reported separately. The reference study period is 60 years.

All in-scope building element categories, as defined by the RICS Professional Statement and applicable to the Proposed Development, have been included in the assessment.

Materials and quantities were extracted from the architectural and structural Revit models and supplemented by the Cost Plan. Building services estimates were provided by the mechanical engineers and assessed using CIBSE TM65 methodology.

Operational energy was measured using the CIBSE TM54 methodology. Operational Water use was estimated by the Public Health Engineer.

In line with RICS 2 methodology, WLCA uncertainty factor of 11% is applied to all modules.

Further detail on the scope is provided in Section 4 and the methodology in Section 3.

STANDARDS AND GUIDANCE

Adhering to established standards and guidance is essential for ensuring consistency, quality, and compliance in project execution, fostering best practices and enhancing overall outcomes. Key guidance and standards applied to the carbon management and quantification for this project are listed below, with full details given in Appendix D:

- RICS Whole Life Carbon Assessment for the Built Environment, 2nd Edition, September 2023– *note this post-dates the original submission*
- EN 15978:2011
- RIBA Plan of Works and WLC
- National planning policy framework
- Greater London Authority (GLA) Whole Life Carbon Guidance 2021 – *note this post-dates the original submission*
- Westminster City Plan 2019-2040 (Adopted April 2021) – *note this post-dates the original submission*
- Climate Change Act 2008 (2050 Target Amendment), which states the UK is legally required to meet Net Zero by 2050

Please refer to Appendix C for a summary of each policy and guidance.

3 WHOLE LIFE CARBON ASSESSMENT METHODOLOGY

This section of the report summarises the methodology used for the Whole Life Carbon (WLC) Assessment conducted for the Proposed Development which provides a quantitative account of a building's emissions.

3.1 INTRODUCTION TO WHOLE LIFE CARBON ASSESSMENTS

The WLCA has been undertaken in line with the UK standard practice EN15978:2011 and the RICS Professional Statement Guidance for WLC Assessments for the Built Environment 2nd Edition (Referred to as RICS 2.0).

An overview of the building lifecycle stages and modules have been shown in Figure 3-1.

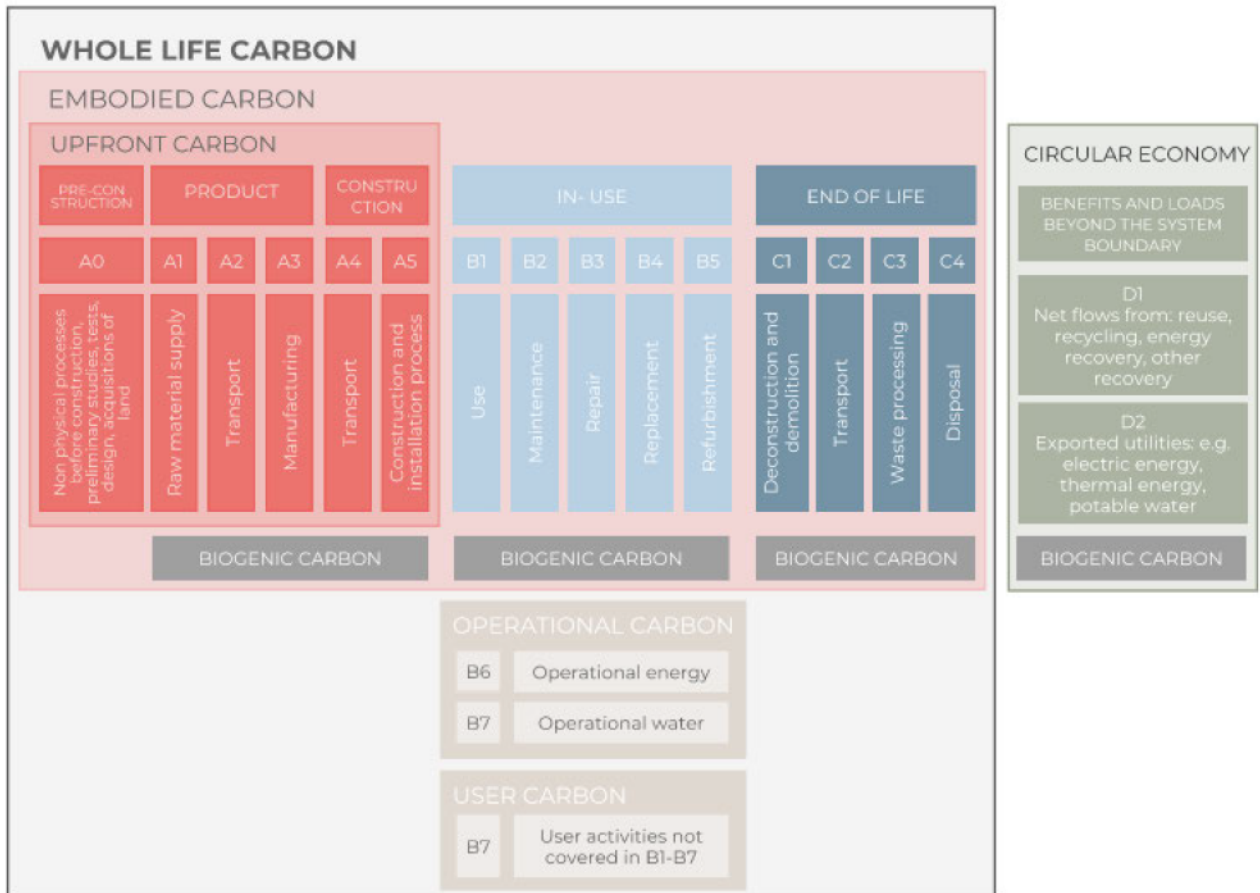


Figure 3-1 – Life Cycle Modules of Whole Life Carbon Assessments based on RICS 2.0

The four main stages are defined as follows:

- **Product (A1-A3 – also known as cradle to gate)**

These modules include the kgCO₂e released during extraction, processing, manufacture (including prefabrication of components or elements) and transportation of materials between these processes, until the product leaves the factory gates to be taken to site. Note that recycled content of a product affects the kgCO₂e released in modules A1-A3. Whether it is recycled after its end of

life or not, does not affect the A1-A3 impact of the project being considered, this is considered in Module D which is reported separately.

- **Construction Process (A4-A5)**

These modules include the kgCO₂e released during transportation of materials/products to site, energy usage due to activities on site (site huts, machinery use etc) and the kgCO₂e associated with the production, transportation, and end of life processing of materials used on site.

- **Use (B1-B7)**

These modules include the kgCO₂e released due to use, maintenance, repair, replacement, refurbishment and operational energy and water while the building is in use. Module B4 (replacement) is often the focus of the use stage when embodied carbon is being considered.

- **End of Life (C1-C4)**

These modules include the kgCO₂e released during decommissioning, stripping out, demolition, deconstruction, transportation of materials away from the site, waste processing and the disposal of materials.

- There is one additional stage beyond the life cycle of the asset that is intended to provide a broader view of its environmental impacts: Benefits and loads beyond the system boundary (Module D).

This estimates any net kgCO₂e benefits of loads beyond the project's life cycle associated with but not limited to:

- Recycling of materials e.g., use of scrap steel (rather than virgin iron) in steelmaking on future projects;
- Energy recovered from materials e.g., energy generated by incinerating timber products; and
- Full reuse of materials/products when compared to the standard practice/standard product it would be replacing.

The metric for assessing the carbon emissions is Global Warming Potential (GWP) which is expressed in units of CO₂ equivalent (CO₂e).

3.2 METHODOLOGY STATEMENT

The WLCA was conducted in accordance with the RICS Whole Life Carbon Assessment for the Built Environment, 2nd Edition published in 2023.

All life-cycle modules (A–D) are included in the assessment. Module D is reported separately. The reference study period is 60 years.

All in-scope building element categories, as defined by the RICS Professional Statement and applicable to the Proposed Development, have been included in the assessment.

These methodologies use various data sources which can be summarised at a high level as:

- AECOM Bill of Quantities
- WSP plant schedules
- WSP structural Revit model
- WSP structural concrete specifications
- Adjaye Associations drawings referenced in the BOQ and specifications

Assumptions based on RICS 2.0 guidance have been used where information is not yet available, including carbon factors based on recommendations of standard practice in the UK. Further details on this are provided in Appendix E.

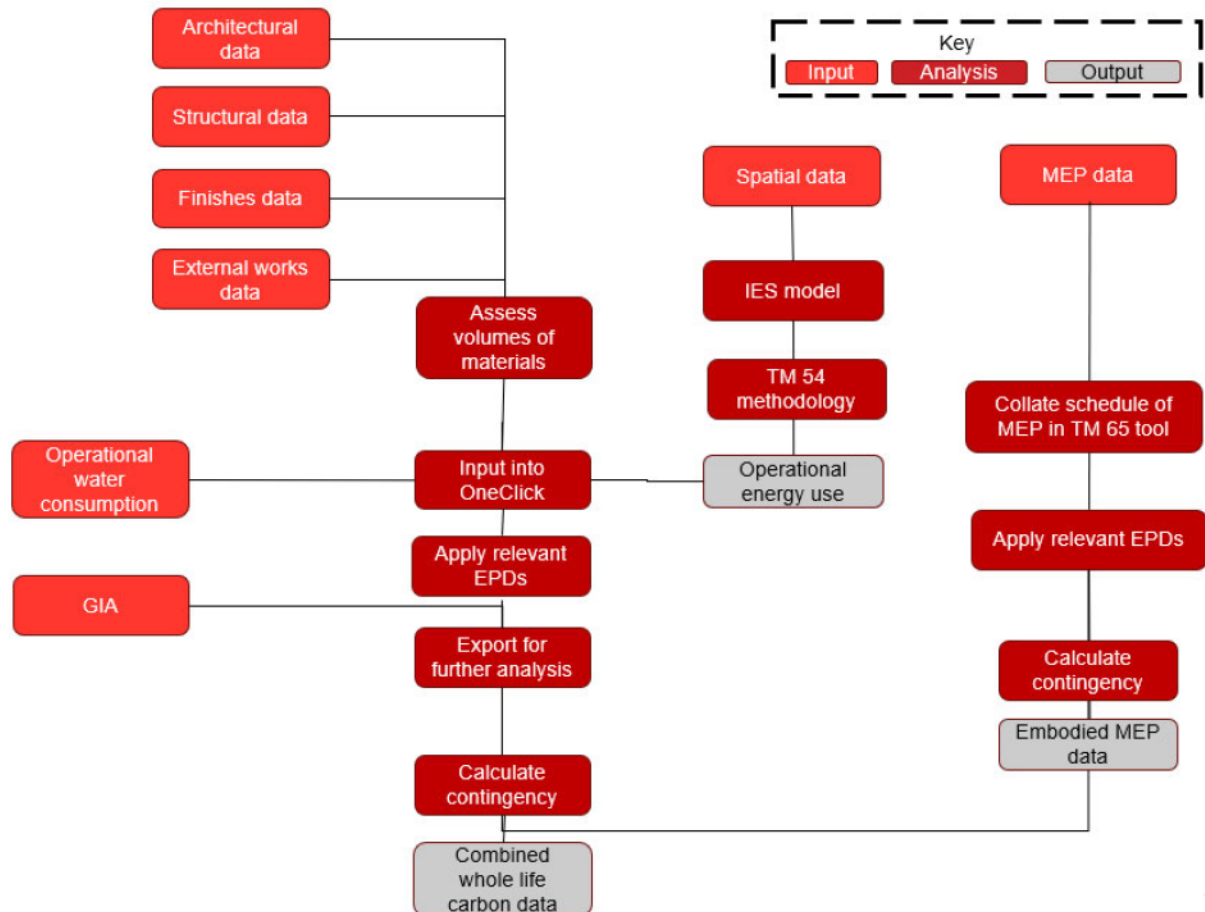


Figure 3-2 – Methodology summary of the WLC assessment for UKHMLC

Materials and quantities were extracted from the architectural and structural Revit models and supplemented by the Cost Plan. Building services estimates were provided by the mechanical engineers and assessed using CIBSE TM65 methodology. The assessment was cross-checked against the Cost Plan to confirm that at least 95% of materials by value are captured.

Operational energy was measured using the CIBSE TM54 methodology. Operational Water use was estimated by the Public Health Engineer. Further detail on specific inputs, assumptions and further explanation of the process of each of these specialist methodologies can be found in Appendices A and B. These methodologies were then brought together to form the combined Whole Life Carbon assessment as shown in Figure 3-2.

3.3 SOFTWARE

The software that has been used to conduct the assessment is OneClick LCA. It has been approved by the BRE and it is compliant to BS EN 1598:2011, ISO 21929, ISO 14040 and EN 15804.

3.4 REFERENCE STUDY PERIOD

A reference study period (RSP) is used for assessments to ensure that there is comparability between results for different projects and to allow for interrogation and interpretation of results compared to benchmarks. This is aligned to the principles within EN 15978. RICS Professional Standard states that a RSP of 60 years should be used for both domestic and non-domestic building projects. This has been used for this assessment. It is accepted that many structures will have a longer useful life, however a cut-off value has been assumed in accordance with the RICS 2.0 guidance.

3.5 WHOLE LIFE CARBON UNCERTAINTY FACTOR

The project phase-specific WLCA uncertainty factor is calculated in line with RICS 2.0 Guidance. The contingency factor for technical design and construction is 6%. The carbon data uncertainty factor is quantified as 2% and the quantities uncertainty factor quantified at 3% resulting in a total **WLCA uncertainty factor of 11%**.

Note that contingency factors are not applied to construction activities. This is because these assessments are based on default data for new build activities which are adopted to provide conservative estimates (e.g., demolition and construction activities across *all building layers* per m² of demolition works and GIA respectively). B6 & B7 also exclude contingency in line with RICS 2.0 guidance.

4 WHOLE LIFE CARBON ASSESSMENT SCOPE

The following tables provide an overview of the information used by WSP in the Whole Life Carbon (WLC) assessment for this development:

- **Table 4-1** describes the data relating to different elements of the proposed works that have been provided to demonstrate the level of information that has been provided in terms of different physical elements
- **Table 4-2** describes the data relating to the RICS 2.0 lifecycle modules of assessment to demonstrate the level of information that has been provided in terms of level of detail as well as site and operational activities

The level of sufficient information provided is defined as:

-  - included in assessment, with any assumptions noted
-  - excluded from assessment

Table 4-1 – Review of Information Provided by Element Scope

Element Category		Included in Assessment Scope?	Detail of Data Provided
0.1 Demolition works and	0.1.1 Toxic/contaminated material treatment Demolition works		Excavation quantities taken from cost plan
0. Facilitating works	0.2 Facilitating works		Average construction site activities have been assumed to be 40kgCO ₂ e/m ² in line with RICS 2.0 Formwork calculated in the cost plan assuming each will be used three times in their lifetime.
1 Substructure	1.1 Substructure		Taken from WSP Revit model and WSP specification
2.1-2.4 Superstructure (Structural)	2.1 Frame		
	2.2 Upper Floors		Concrete volumes taken from WSP Revit model, and concrete specification used as well as reinforcement rate from cost plan.
	2.3 Roof		From WSP and architects' Revit models
	2.4 Stairs and ramps		From WSP and architects' Revit models
2.5-2.6 Superstructure (Façade)	2.5 External walls		Concrete volumes taken from WSP Revit model, and concrete specification used alongside reinforcement rate from cost plan. Finishes taken from architects' Revit model. Bronze façade and stone included as façade elements (as per Table 5-2).
	2.6 Windows and ext. doors		Taken from architects' Revit Models.

2.7-2.8 Superstructure (Non-Structural)	2.7 Internal walls and partitions	✓	Internal walls break down of materials are from architects' details drawings, the quantities are from cost plan and are checked against model.
	2.8 Internal doors	✓	Taken from architects' Revit Models.
3 Finishes	3.1 Wall finishes	✓	From architects' Revit model.
	3.2 Floor finishes	✓	
	3.3 Ceiling finishes	✓	
4 FF&E		✓	A 5% assumption has been used based on industry guidance. This is a conservative assumption, and it will be dependent on final detailed design
5 Services (MEP)	5.1–5.14 Services	✓	TM65 assessment based on WSP plant schedule and design
			Operational energy based on TM54 modelling
			Operational water based on annual consumption estimation
6 Pre-fabricated buildings and building units		✗	Excluded
7 Works to existing buildings		✗	Excluded
8 External works		✓	Hard landscaping added from Cost Plan with some assumptions noted in Appendix E Note soft landscaping is excluded.

Table 4-2 – Review of Information Provided by Lifecycle Module

Lifecycle Stage		Included in Assessment Scope?	Detail of Data Provided
A1-A3 Product	A1 Raw material extraction & supply	✓	A1-A3 Carbon values have been defined based on project specific supplier EPDs representative of specified materials. Where project specific data was not available, embodied carbon values have been based on material specification recommendations of standard practice in the UK (as defined by RICS 2.0 Section 5.1.2)
	A2 Transport to manufacturing plant	✓	
	A3 Manufacturing and fabrication	✓	
A4-A5 Construction	A4 Transport to project site	✓	Assumed from RICS 2.0 typical transport distances
	A5 Construction activities	✓	Assumed from RICS 2.0 defaults
B1-B5 In-use Embodied	B1 Use	✓	MEP based on TM65 assessment, using data from MEP plant schedule and Revit model.
	B2 Maintenance	✓	10kgCO ₂ e/m ² GIA in line with RICS 2.0
	B3 Repair	✓	25% of B2 for all elements, except MEP – where 10% of B2 has been assumed
	B4 Replacement	✓	Replacement rates assumed in line with RICS 2.0 for all elements except MEP which is in line with CIBSE TM65.
	B5 Refurbishment	✗	Excluded. No future refurbishment works currently planned throughout life of building following completion of this project.
B6-B7 Operational Carbon	B6 Operational energy use	✓	Based on TM 54 model
	B7 Operational water use	✓	Based on MEP data estimation
C1-C4 End of Life	C1 Deconstruction and demolition	✓	Assumed to be 25% of A5.2, in line with RICS 2.0.
	C2 Transport to disposal facility	✓	Assumed based on RICS 2.0 defaults
	C3 Waste processing	✓	Waste processing and disposal assumptions taken to be in line with RICS 2.0
	C4 Disposal	✓	Assumed based on RICS 2.0
Module D Benefits beyond the lifecycle	D Benefits and loads beyond the system boundary	✗	Excluded

5 RESULTS

The RICS WLC 2nd Edition requires reporting two scenarios for operational and whole-life carbon.

A) Standard (Business-as-Usual) Scenario

- Uses the current electricity grid carbon factors (UK Government BEIS data or equivalent).
- Includes typical material specifications and maintenance cycles.
- Represents emissions if no further decarbonisation actions are taken.

B) Decarbonised Scenario (New Requirement in RICS 2nd Edition)

- Adjusts electricity-related carbon emissions (parts of stages B and C) based on projected future grid decarbonisation (aligned with UK Climate Goals). The reductions applied are as follows:
 - 50% reduction in in fugitive refrigerant emissions.
 - 50% reduction in all B2-B4 predicted impacts.
 - 50% reduction in all C1-C2 predicted impacts.
 - 50% reduction in all D1 predicted impacts.
- The results for the operational carbon emissions have also been reduced to account for the decarbonisation of the grid. In this case, the results have been reduced assuming the most conservative decarbonisation scenario “Falling Short” according to the Future Energy Scenarios (FES), in line with RICS 2nd Edition (August 2024).

The purpose of reporting both scenarios is to acknowledge the uncertainty of future decarbonisation, as these projections rely on anticipated trends over the next 60 years rather than measured data.

5.1 KEY FIGURES

Overall, the results of the Whole Life Carbon assessment are as follows:

Table 5-1 – WLCA Summary Results (Non-decarbonised)

	Upfront Carbon Module A1-A5 (Excluding sequestered carbon)	In Use Carbon Module B1-B5	Operational Carbon Modules B6, B7	End of Life Carbon Module C1-C4	Embodied Carbon Modules A-C (Excluding B6 & B7; Including sequestered carbon)	Whole Life Carbon Modules A-C
UKHMLC tCO ₂ e	7,243	2,284	5,637	855	10,219	15,856
UKHMLC kgCO ₂ e/m ²	1,928	608	1,500	228	2,720	4,220

Given the distinctive nature of the building—being entirely subterranean—a slightly different categorisation of elements has been used to a “standard” project to allow further interrogation of the results than if all these elements were simply denoted as “substructure”. Table 5-2 delineates the elements included in each RICS category in this whole-life carbon assessment:

Table 5-2 – Elements included in each category for WLC assessment

Categories		Element
Substructure		All structural underground elements including secant walls, piles, liner wall, perimeter concrete walls and the labyrinth wall
Superstructure	External walls	Bronze fins, café and pavilion walls, plasterboards and insulations to external walls
	Frames	Beams and columns
	Internal walls	All internal walls including plasterboards and insulation
	Upper floor and roof	Includes roof, and suspended floor to mezzanine

The following sections break down the results further in terms of the main contributors to upfront, embodied and Whole Life Carbon and the decisions that have been taken to try to limit these impacts.

5.2 STANDARD (BUSINESS-AS-USUAL) SCENARIO

UPFRONT CARBON EMISSIONS RESULTS

Includes only modules A1-A5, is 7,243 tCO₂e or 1,928 kgCO₂e /m². Figure 5-1 shows the most contributing materials to upfront emissions.

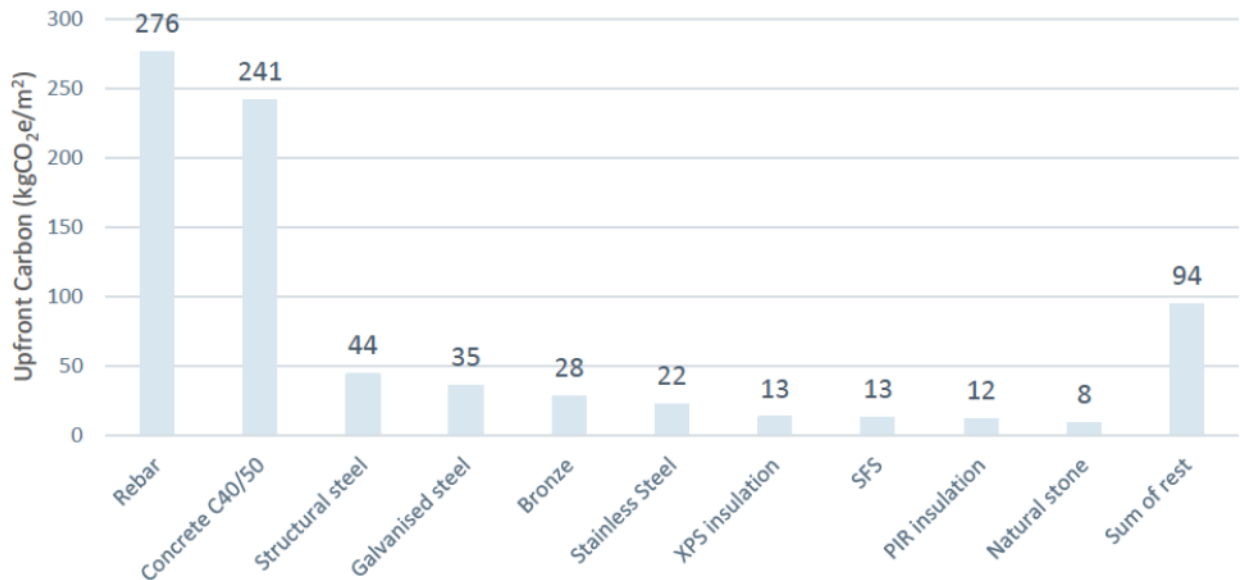


Figure 5-1 – Most contributing materials to UKHMLC upfront carbon product stage (A1-A3)

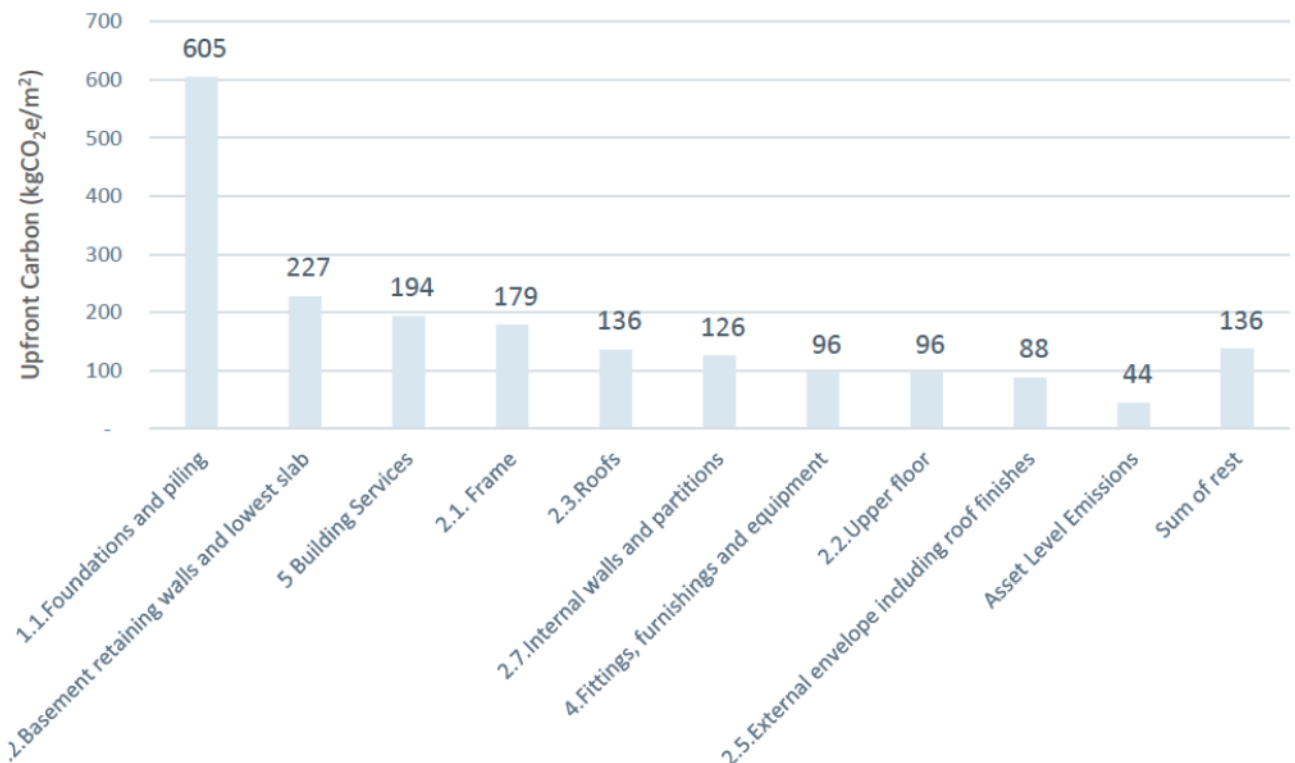


Figure 5-2 - Upfront Carbon (A1-A5) per Building Element with Uncertainty Factor

As observed in Figure 5-2, the substructure is the largest contributor to upfront carbon emissions, accounting for approximately 43% of the total. This high percentage is primarily due to the use of the substructure for several purposes – forming the external envelope, supporting the perimeter of the floors slabs and retaining of the landscaping that maintains the public realm. The substructure includes the foundation such as piles, secant wall, as well as the concrete and rebar used in the underground structural liner walls of the building. The massing and design of the retaining walls is also largely influenced by the Root Protection Areas and aim to limit the impact on nearby mature trees as much as possible. Given that the entire structure is located underground, it is unsurprising that the substructure emerges as relatively the most carbon-intensive component.

EMBODIED CARBON

The lifecycle carbon emissions result for UKHMLC is 10,219 tCO₂e or 2,720 kgCO₂e/m² (modules A-C, excluding B6 & B7, including sequestered carbon).

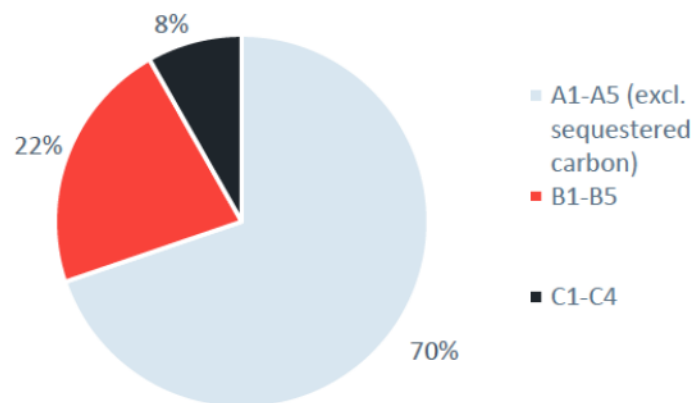


Figure 5-3 - Embodied Carbon Split Non-Decarbonised scenario (A-C)

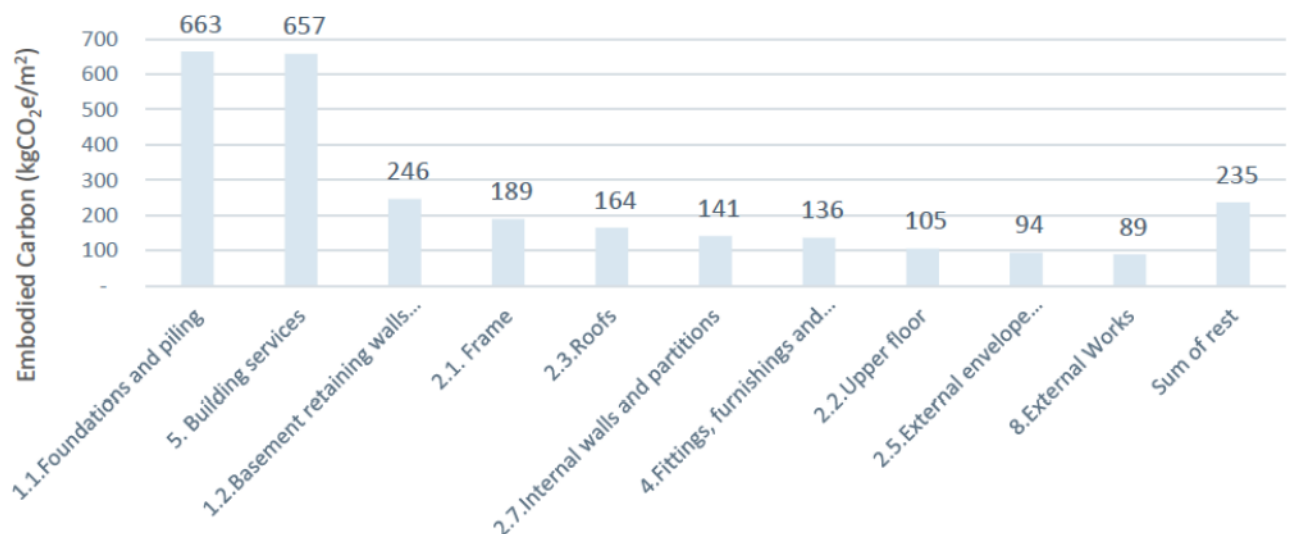


Figure 5-4 - Embodied Carbon Emissions per GIA with Uncertainty Factor (kgCO₂e/m²)

Following substructure, the Building Services (MEP) are the second largest contributor to the total embodied carbon. MEP Services become a much bigger proportion of the embodied carbon than the upfront, as the embodied carbon includes any maintenance and replacement required of within the 60-year building life. Noting that many components of MEP systems have 15- 25-year services life, they will therefore need replacement several times throughout the life of the building. This means that although their initial upfront carbon may be lower, the requirement to replace them means this upfront carbon is effectively multiplied over the lifespan of the building and increases the embodied carbon. Similarly, this is why the finishes are increased compared to the upfront carbon.

Operational energy was measured in line with the TM54 methodology. Additionally, Operational Water use was estimated by the Public Health Engineer. The carbon implications resulting from B6 & B7 are **1,500 kgCO₂e/m²**.

The sequestration associated with the biogenic materials equates to **-43.3 kgCO₂e/m²** resulting primarily from the substructure.

These values are also represented in tabular form in Appendix F.

WHOLE LIFE CARBON EMISSIONS RESULTS

Includes all stages of the assessment (A-C), and is 16,242 tCO₂e or 4323 kgCO₂e /m²

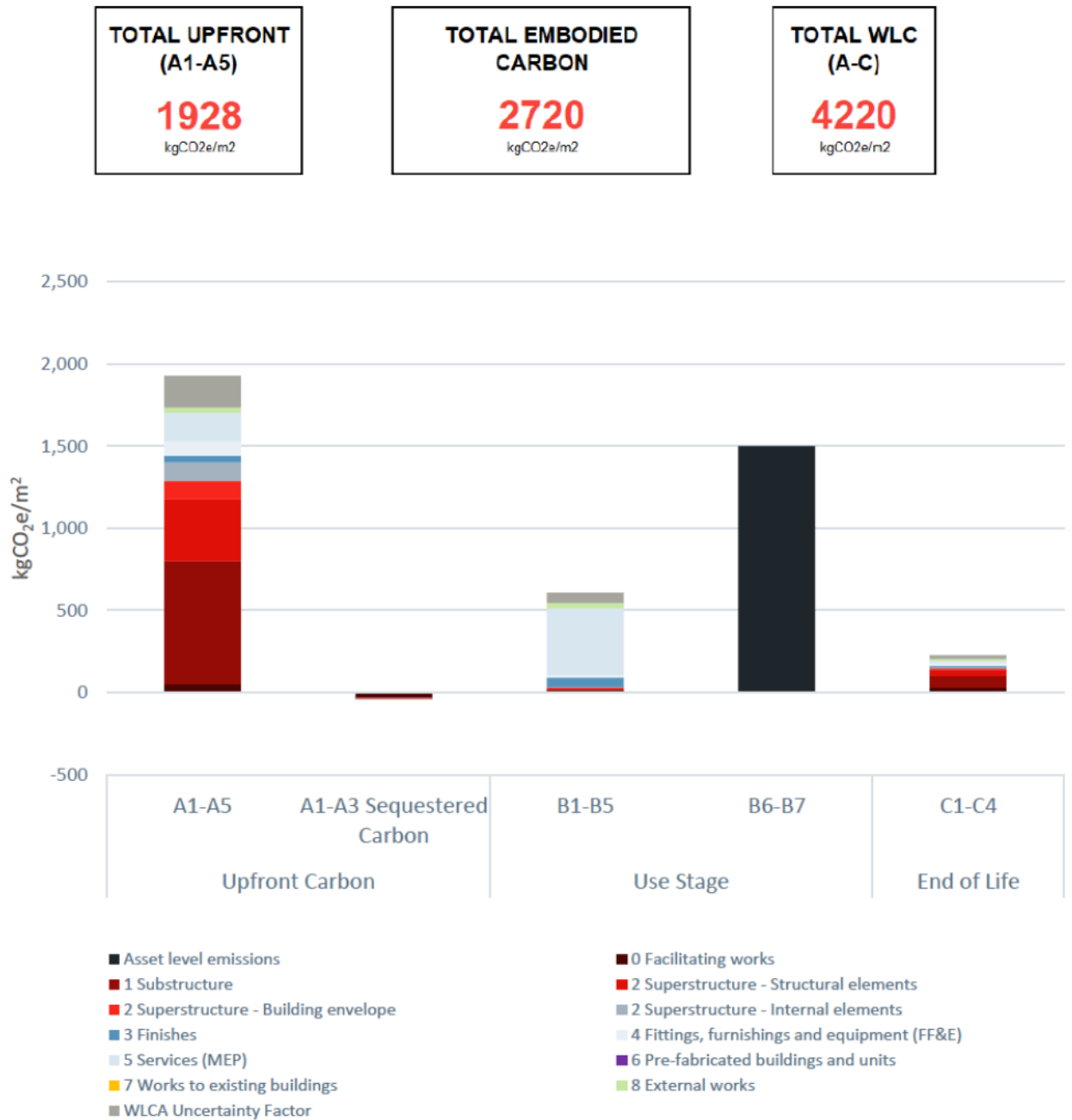


Figure 5-5 – Whole Life Carbon breakdown by lifecycle stage and component, non-decarbonised scenario (kgCO₂e/m²)

5.3 DECARBONISED SCENARIO

UPFRONT CARBON EMISSIONS RESULTS

Includes only modules A1-A5, is 7,243 tCO₂e or 1,928 kgCO₂e /m². The upfront carbon remains unchanged between the two scenarios, as it is not influenced by decarbonisation. However, this indicates a shift in the ratio of upfront to total emissions. In this scenario, 81 % of total emissions are attributed to upfront emissions, compared to 70 % in the non-decarbonised scenario, showing the importance of minimising upfront emissions as much as possible.

LIFECYCLE CARBON EMISSIONS RESULTS

Includes stages A-C excluding B6 and B7 and is 8,810 tCO₂e or 2,345 kgCO₂e /m².

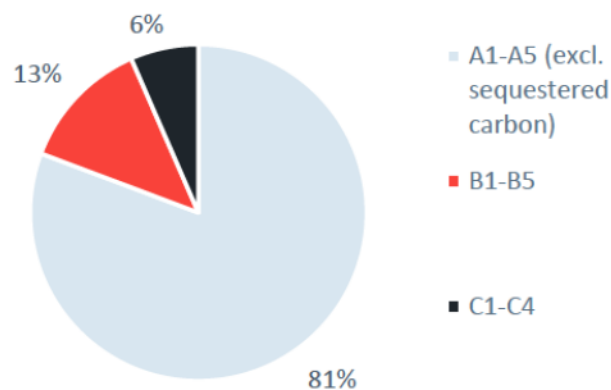


Figure 5-6 - Embodied Carbon Split Decarbonised scenario (A-C)

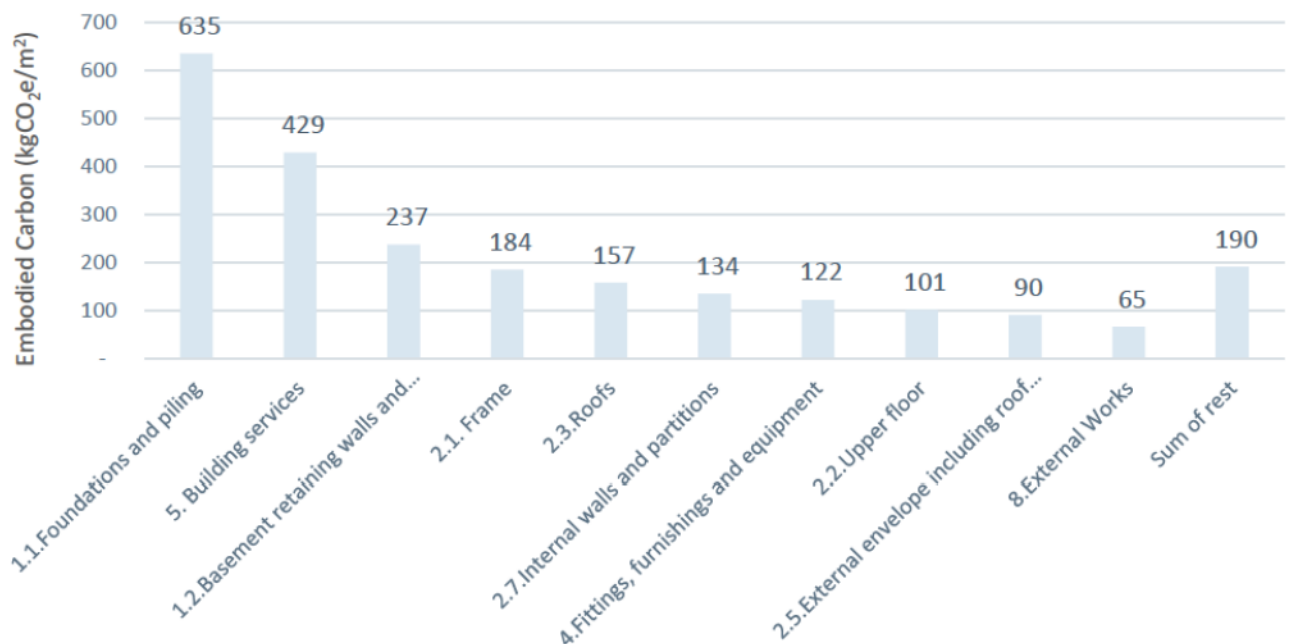


Figure 5-7 - Embodied Carbon Emissions per GIA with Uncertainty Factor (kgCO₂e/m²)

WHOLE LIFE CARBON EMISSIONS RESULTS

Include all stages of the assessment (A-C) and is **10,151 tCO₂e** or **2,702 kgCO₂e /m²**.

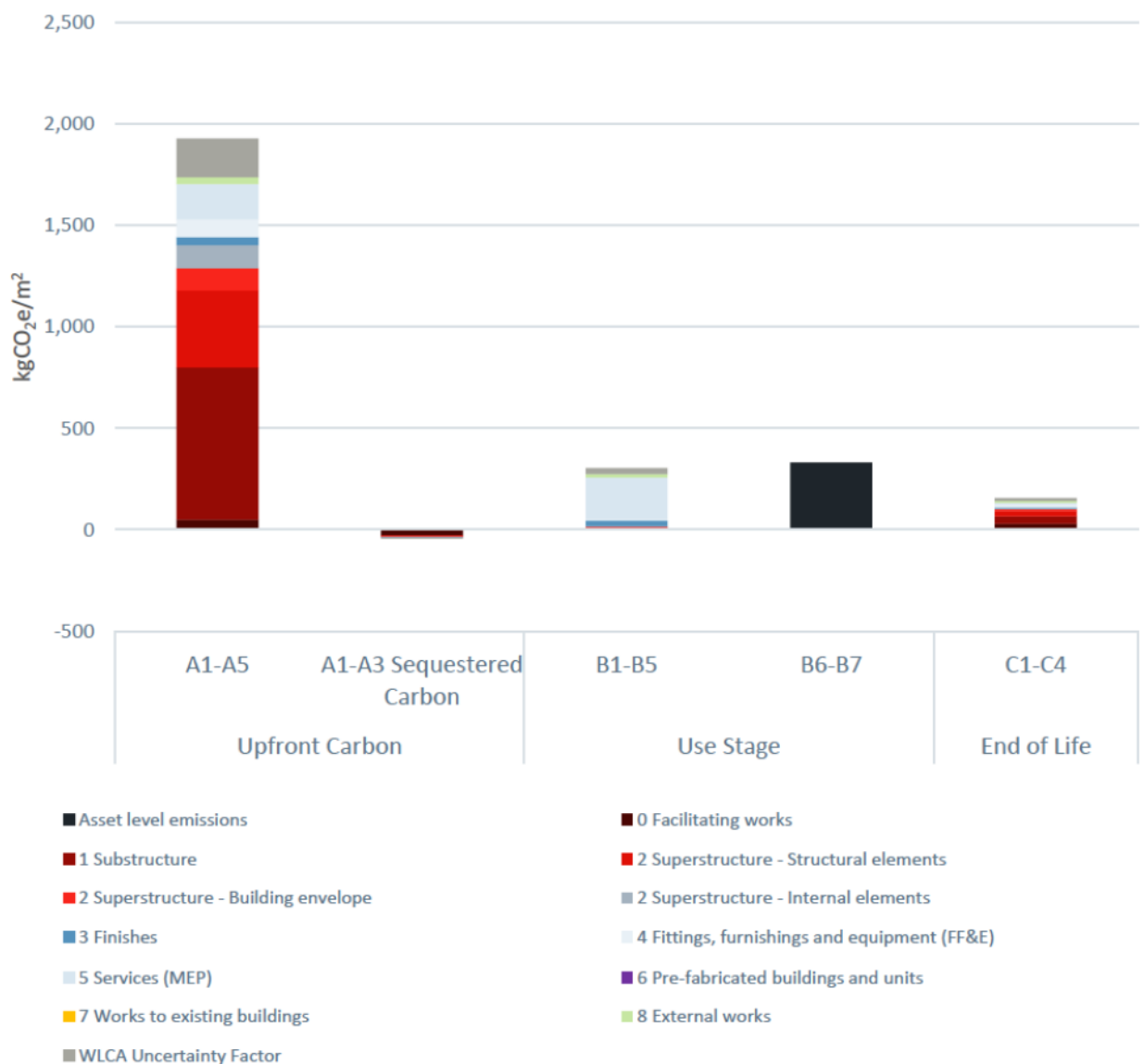
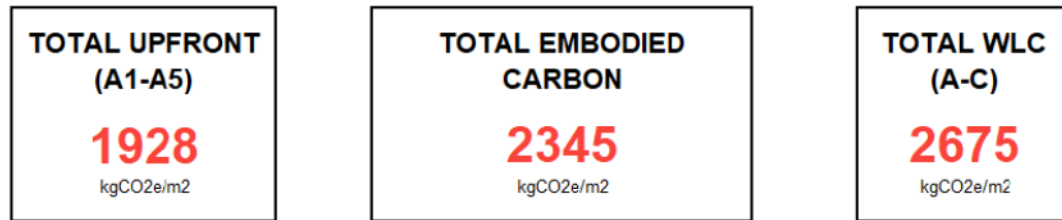


Figure 5-8 – Whole Life Carbon breakdown by lifecycle stage and component, non-decarbonised scenario (kgCO₂e/m²)

5.4 COMPARISON OF RESULTS (NON-DECARBONISED SCENARIO)

UKHMLC has specific characteristics that makes it difficult to identify comparable industry benchmarks or targets for embodied carbon for this type of cultural and commemorative infrastructure, especially when compared on results normalised per m² of GIA.

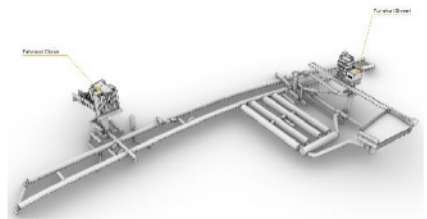
The figures reported throughout this report include works associated with external areas used to maintain the public realm. These areas are not accounted for in the GIA, although they contribute to the carbon figures. While adding external areas has a detrimental impact on carbon numbers, these areas also greatly improve health & wellbeing, biodiversity, and the urban greening factor. Additionally it is a key project objective to combine design, landscaping and placemaking to enhance Victoria Tower Gardens – improving the visual and sensory experience of the green space and giving it focus and civic presence, both for visitors and existing users.

The following sections therefore discuss comparisons for the Whole Life Carbon values, the main contributing elements, the design development that has been undertaken in order to reduce the carbon as much as possible, and opportunities for potential future carbon reductions in the elements that currently have the greatest carbon impact.

UKHMLC has also been compared to other cultural and/or mainly below ground developments in London such as The London Tunnels, the Museum of London and Lord's Cricket Ground. Further details of these projects can be found in Appendix D which are summarised below:

Table 5-3 – Comparison Project Summaries

Project Image



Project Name	MUSEUM OF LONDON WEST SMITHFIELD	Lord's Cricket Ground - Lord's Tavern & Allen Stands	THE LONDON TUNNELS (TLT) (exhibition and cultural attraction)
Storeys Above Ground	4	4	Various in different entrance buildings (up to 5)
Basement Levels	1	0	3
Data Used	Stage 2 Design	Stage 2 Design	Stage 2 Design
Other Comments	Part demolition, refurbishment and extension	Lord's Cricket Ground, Tavern & Allen Stands; demolition, redevelopment, and extension of the existing stands (1930s and 1960s)	Change of use of deep-level tunnels to visitor/cultural attraction; approximately 90% of the existing site (by area), including the entire tunnel network will be retained.

The similarities and differences of each should be considered when comparing the carbon results and features of each development, as observed in Table 5-4.

Table 5-4 - Comparison of Features of Each Development

	UK Holocaust Memorial	Museum of London	Lord's Cricket Ground	The London Tunnels
Year	2029	2026	2023	2029
Size (m² GIA)	3,757	49,996	3,750	11,147
Visitors/year	500,000	2,000,000	300,000	2,000,000
Embodied Carbon total (t CO₂e)	10,219	29,997	11,104	17,588
Embodied Carbon /m² (kg CO₂e)	2,720	600	2,961	1,578
Embodied Carbon /visitor (g CO₂e/visitor over a 60-year period)	341	250	617	147

Here can be seen that the results for UKHMLC approximately matches the average of 339gCO₂e/visitor over a 60-year period when benchmarked against comparable cultural and public buildings. However there are challenges in making direct comparisons as each of these reference projects differs significantly in typology and construction context. For example, the London Tunnel involves the fit-out of an existing underground structure, rather than a new-build, which can greatly affect embodied emissions, including much lower structural embodied carbon due to the presence of existing structures. The Museum of London is a mostly above-ground structure, with part demolition, refurbishment and extension. The Lord's Cricket Ground project also includes partial demolition, redevelopment, and extension of two stands in a cricket ground. It can be seen that the Lord's Cricket Ground has a much higher embodied carbon per visitor compared to UKHMLC, even despite the fact part of the existing structure is retained.

As such, while the carbon per visitor metric offers a useful reference point, it should be interpreted with the fundamental differences in site conditions, building typology, and baseline carbon assumptions between projects in mind

This has been explored in further detail in the following sections by reviewing comparisons between the different elements in relation to various benchmark projects. Note that some of the benchmark projects have been undertaken to the previous RICS Whole Life Carbon Assessment (2013) which is typically deemed to be less conservative and less comprehensive than the later version to which UHHMLC has been assessed against.

5.5 RESULTS SPLIT BY DISCIPLINE

ARCHITECTURE

The upfront carbon for the architectural elements of the UK Holocaust Memorial and Learning Centre including the building envelope, finishes and FF&E is **264** kgCO₂e/m². The internal walls and doors have been excluded as many of the internal walls are structural and are therefore included in the structural analysis.

The carbon impact of architectural elements of UK Holocaust Memorial and Learning Centre has been compared to other benchmarks and projects in the below table - the Greater London Authority (GLA) benchmark for offices, which is a commonly used industry benchmark, and a project example of a typical high-rise office located in the City of London (note both of these comparisons also exclude internal walls and doors for fair comparison).

Table 5-5 - Architectural Whole Life Carbon Summary Results

All values in kgCO ₂ e/m ² Non-decarbonised only	Upfront Carbon Module A1-A5 (Excluding Sequestered Carbon)	Embodied Carbon Modules A-C (Excluding B6 & B7; Including Sequestered Carbon)
UKHMLC	264	382
GLA Office Benchmark*	275	546
High rise office*	222	439

* Undertaken to/based on RICS 2013 methodology

The upfront carbon is below the GLA benchmark for architectural elements, it is important to note that since the GLA benchmark excludes internal partitions and doors, they are also excluded from the figure reported for UKHM in Table 5-5. Furthermore, the total embodied carbon for architectural elements remains below the GLA office benchmark due to the longevity and durability of materials specified. When compared to a typical high-rise office building in London, both the upfront and embodied carbon values appear elevated. However, this is largely attributable to the unique spatial configuration of the UKHMLC, which features predominantly double-height spaces. As a result, the carbon figures are averaged over a smaller floor area, leading to a higher intensity per square metre when directly compared to a high-rise office building with standard floor-to-ceiling heights.

Figure 5-9 shows the 10 most carbon intensive materials of architectural elements of the proposed development. The concrete walls (note this only includes architectural concrete used for finishes, not structural load-bearing concrete) are the highest contributor to the architectural element emissions, followed by the galvanised steel and then bronze elements.

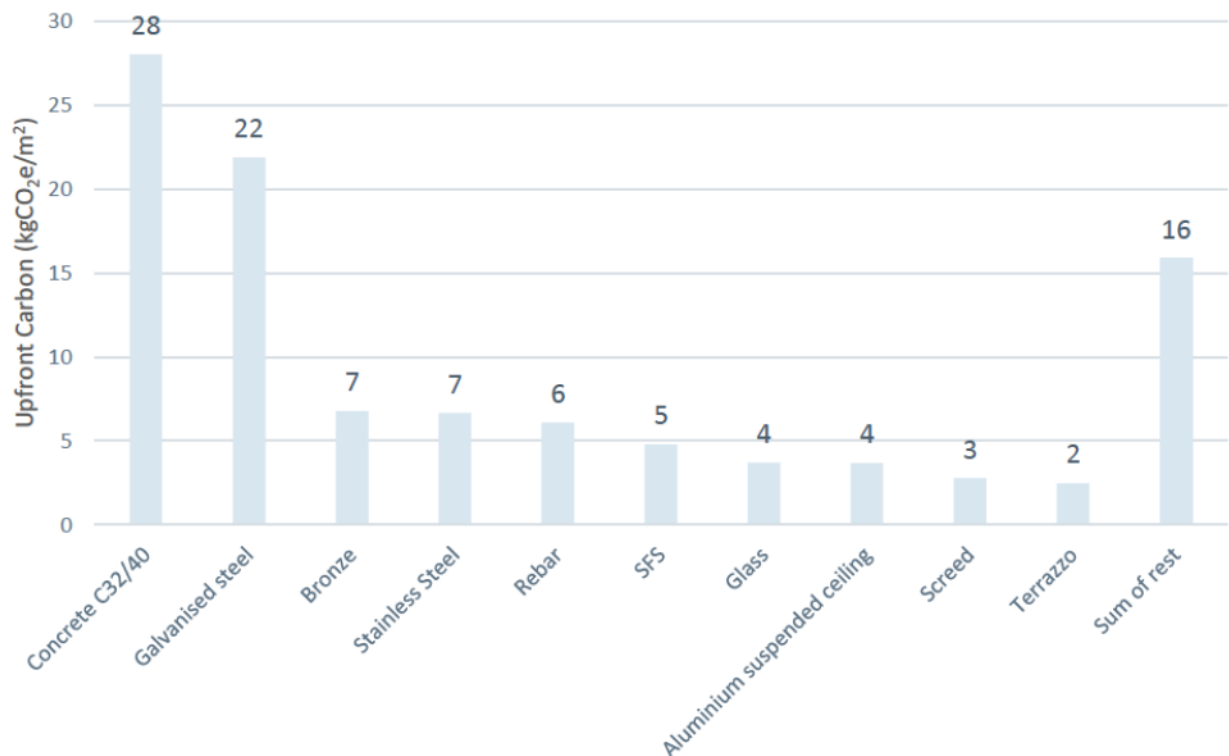


Figure 5-9 – Top 10 highest contributing architectural materials (A1-A3)

The architectural design strategies that have been implemented to reduce the carbon related to architectural elements include:

- Durable materials to minimise maintenance
- High recycled contents where appropriate – e.g. Bronze with 100% recycled content
- Mineral wool insulation rather than insulation made from oil-based polymers
- Unitised fin panels and sub-frames with mechanical fixings only to aid easy maintenance and replacement

In addition to this, the architectural design incorporates several strategies that will help make most of the building as well as ensuring it remains useful in future:

- Make use of versatile/flexible/movable internal walls for the space layout to support multi-use.
- Learning centre exhibition space can be stripped back to shell for alternate use
- Large floor-ceiling height allows a variety of potential future use
- Linear divisions of space planning allow flexibility for future division of space – including ventilation strategy
- House lighting and emergency lighting on separate systems also contributes to future adaptability
- Multiple uses are possible in the spaces at different times to get the most from the space created, aided by the building management strategy
- Facades on entrance pavilion and café kiosk to use mechanical systems for demountability
- Railings and boardwalks to inside of river wall to use mechanical systems for demountability

STRUCTURES

The upfront carbon for the structural element of UKHMLC including the facilitating works, the substructure & the superstructure (structural elements) is **1,384 kgCO₂e/m²**. An element and component level breakdown can be observed in Figure 5-11.

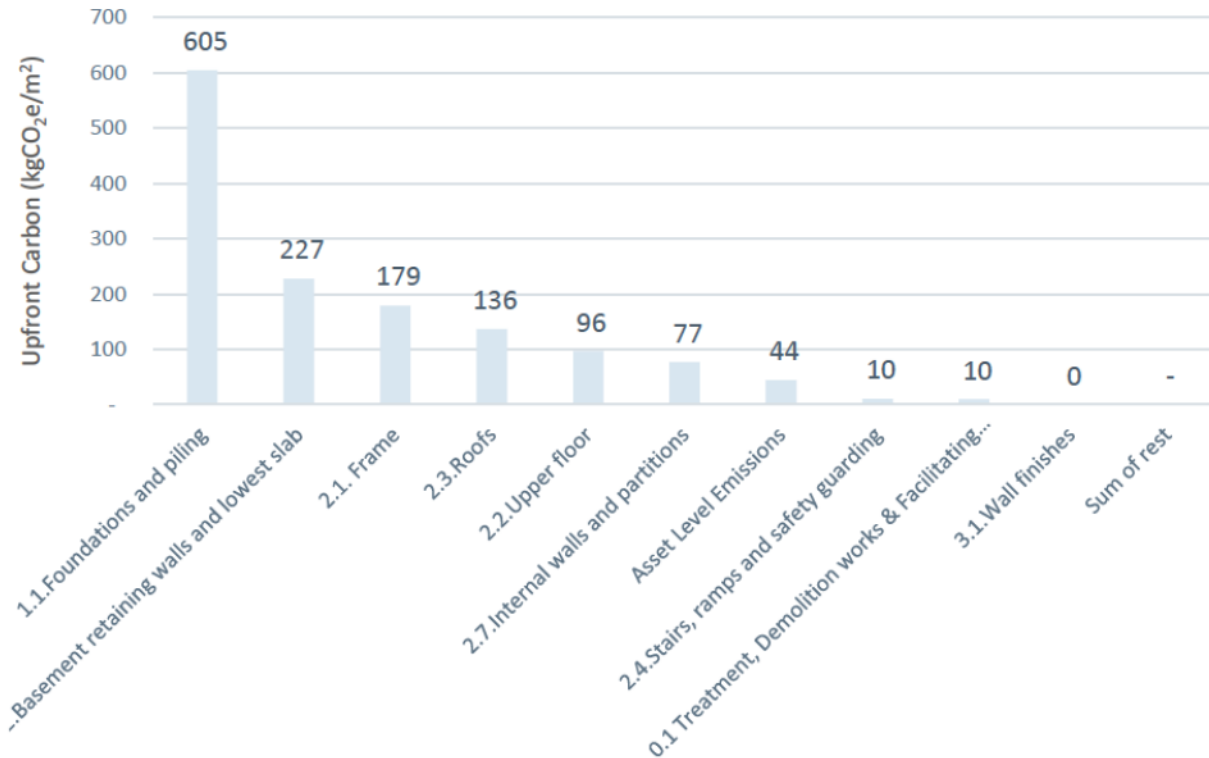


Figure 5-10 – Upfront Carbon (A1-A5) by building category (Structural)

Figure 5-10 shows that the largest contributor to structural building element emissions is the substructure (65%), followed by the frame (13%), the roof (10%).

The carbon impact of structural elements of UK Holocaust Memorial and Learning Centre has been compared to other benchmarks and projects in the below table.

Table 5-6 - Structural Whole Life Carbon Summary Results

All values in kgCO₂e/m²
Non-decarbonised only

	Upfront Carbon Module A1-A5 (Excluding Sequestered Carbon)	Embodied Carbon Modules A-C (Excluding B6 & B7; Including Sequestered Carbon)
UKHMLC	1,384	1,533
Below ground UK Railway Station**	1,341*	Data not available
Hotel extension**	1,137	Data not available

*This figure is A1-A3 and excludes A4 and A5.

** Undertaken to RICS 2013 methodology

Similar typologies of structures have been selected for comparison of the structural elements. The first is a below ground UK railway station in London that will feature six sub-surface high-speed platforms and eight surface-level conventional platforms. The second is a hotel extension in central

London on a constrained site where the main option for extension was below the existing structure. Therefore, the structural solution was two new basements, including one of three storeys constructed with secant piled walls and new bearing piles to support new vertical structure.

Table 5-6 demonstrates that, in comparison with a below-ground UK railway station, the UKHMLC performs similarly, and is slightly higher than the hotel extension. However, the below ground railway station figures exclude A4 and A5 which would further increase the upfront values, demonstrating the efficiency of the UKHMLC design given the site and massing constraints.

The top 10 highest contributing structural materials can be observed in Figure 5-11, consisting primarily of concrete, rebar and structural steel.

The in-situ concrete has been included with a typical value of 25% cement replacement in line with industry guidance. Also, a percentage of concrete has waterproofing additives (as defined in the structural design and cost plan) which increase the carbon figures compared to non-waterproofed mixes.

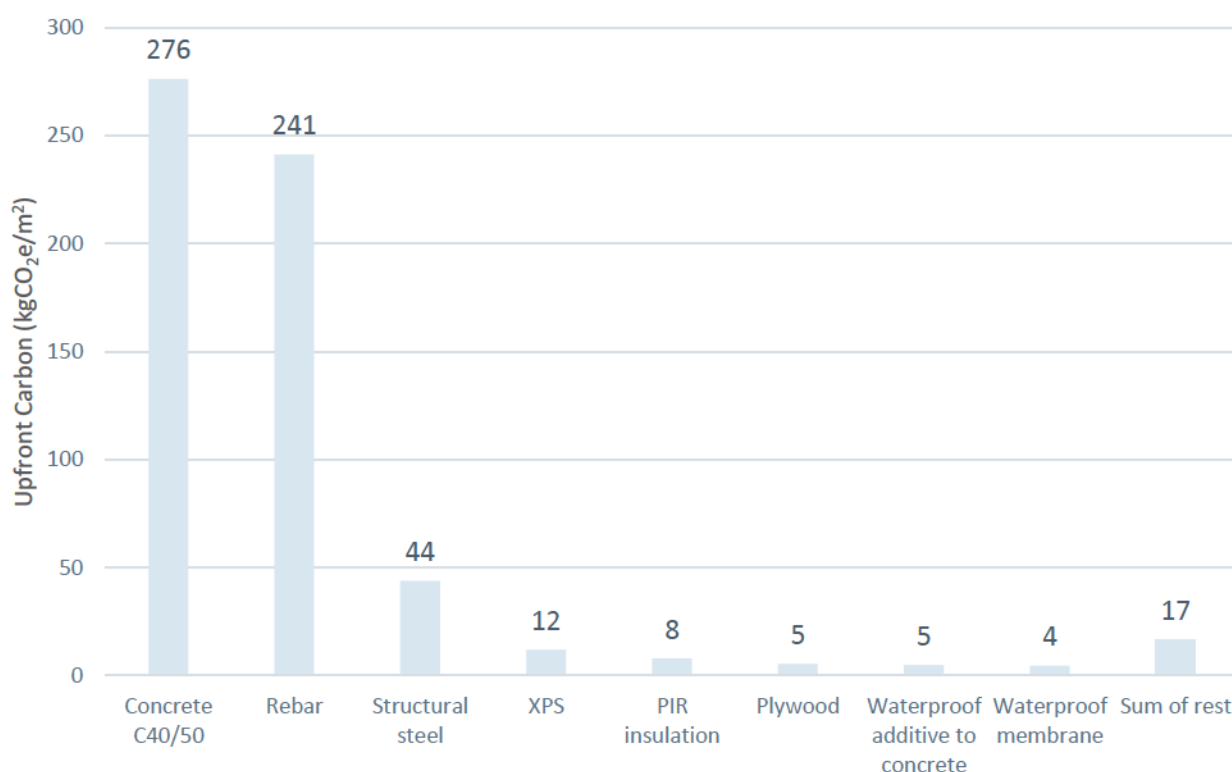


Figure 5-11 – Top 10 highest contributing structural materials (A1-A3)

The design strategies that have been implemented to reduce the carbon related to structural elements include:

- Efficiency and avoiding overspecification
- Raft foundation to reduce pile numbers
- Concrete with 25% GGBS cement replacement for lower carbon without over-using industry stocks
- Structural finishes to be exposed, limiting additional finishes/materials required

- Superstructure elements in hard-to-access locations receive enhanced corrosion protection to minimise maintenance required
- Subject to testing and suitability, crushed and graded demolition arisings will be prioritised for the temporary piling mat and for backfill where specification allows, reusing existing materials

In addition to this, the structure design incorporates several strategies that to support the overall sustainability aims of the building:

- A flat slab system is used to provide flexibility for future services re-routing without invasive structural alterations.
- Responsible supply chain
- Just in time deliveries

BUILDING SERVICES

The embodied carbon impact of MEP elements of UK Holocaust Memorial and Learning Centre has been compared to other benchmarks and projects in the following table

Table 5-7 – Building Services Summary Results

All values in kgCO ₂ e/m ² Non-decarbonised only	Upfront Carbon Module A1-A5 (Excluding Sequestered Carbon)	Embodied Carbon Modules A-C (Excluding B6 & B7; Including Sequestered Carbon)
UKHMLC	175	592
The London Tunnels*	372	1,159
GLA Office Benchmark*	133	294

* Undertaken to/based on RICS 2013 methodology

While the upfront and embodied carbon figures for the UKHMLC exceed the GLA benchmarks, they are notably lower when compared to more contextually appropriate projects, such as The London Tunnels. It should be noted, however, that direct comparisons between such projects require careful interpretation due to differences in function and technical specifications. For instance, the higher embodied carbon in MEP systems for The London Tunnel is partly attributable to the inclusion of large display screens.

It is common for MEP products and services to be replaced 2-3 times throughout the life of the building. Therefore, the embodied carbon results of MEP services can be much higher than the upfront values due to the amount of repair and replacement required. This is evidenced in Figure 5-12.

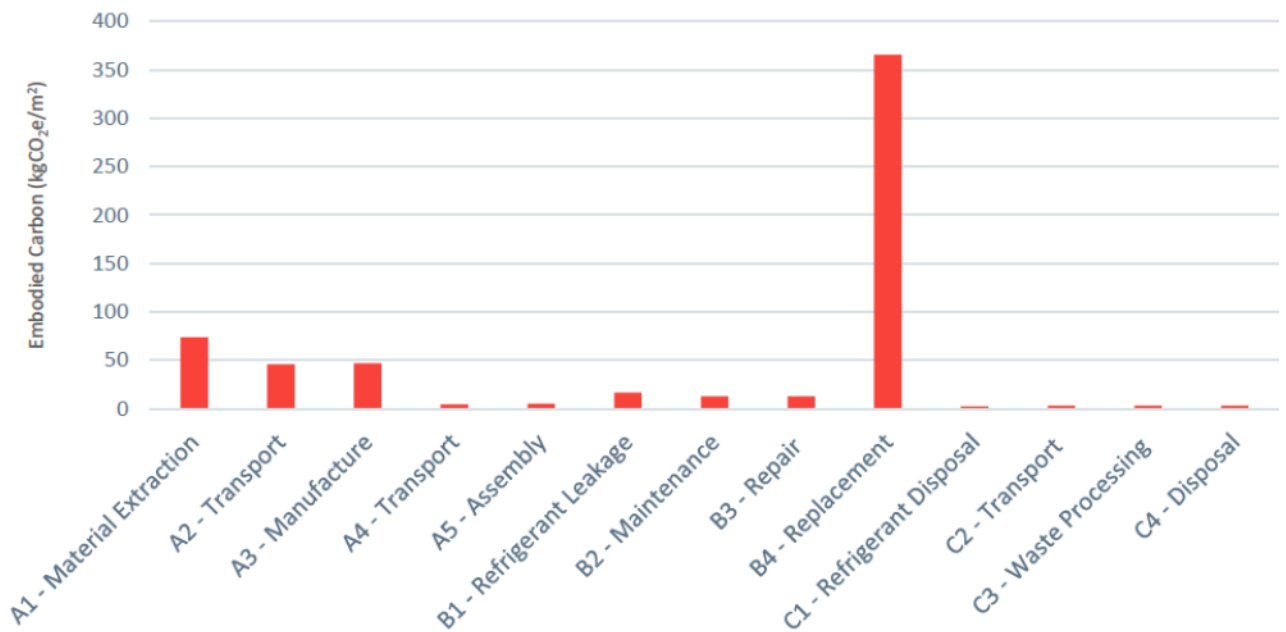


Figure 5-12 – MEP Embodied Carbon of by Lifecycle Stage [kgCO₂e/m²] (non-decarbonised)

The largest contributor to the embodied carbon of the MEP equipment is ductwork and internal lightings and also the ground source heat pumps (GSHPs), including associated boreholes, buried pipework and ancillary equipment. Despite the high upfront embodied carbon, the boreholes and buried pipework are expected to last beyond the expected 60-year lifespan of the building. This is will also be offset by reductions in B1 due to refrigerant leakage when compared with higher GWP Heat pumps, reductions in B4 emissions associated with plant replacement due to the longer lifespan of GSHP systems and reduction in B6 emissions due to higher seasonal efficiency of GSHP systems when compared to an equivalent ASHPs.

The following strategies are applied to the design of the building services to reduce the embodied carbon of the services:

- Dual purpose smoke extract and ventilation systems are specified to reduce the amount of ductwork required
- Oversizing has been avoided; service runs, diameters and depths are sized to duty, reducing unnecessary material use and insulation volumes.
- Service dimensions and clearances have been coordinated to limit cut-offs and off-cuts during installation, reducing wastage from ducts, pipework and cable containment.
- Where practicable, systems favouring recyclable metals (e.g., copper or steel pipework) over high-impact plastics have been specified, supporting end-of-life recovery.
- Heating, hot water and cooling are provided via heat-pump technology on a central loop serving the development. This delivers high seasonal efficiency and positions the scheme to benefit from ongoing grid decarbonisation (assessed on a conservative basis).
- Efficient heating, cooling and ventilation plant is specified to minimise energy demand; the preferred solution is an open-loop ground-source heat pump system (subject to detailed design and approvals).

OPERATIONAL ENERGY

The TM54 analysis for the Proposed Development estimates a whole building energy use intensity of 118.3 kWh/m² per year (m² NIA). This figure is just slightly above the UKGBC 2025-2030 target of 115 kWh/m² but given the building's function as an exhibition space with higher energy demands, the result is considered reasonable.

Table 5-8 - Comparison of Annual Energy Intensity

	Likely Case	Best Case	High Case	Worst Case
Whole building Energy Intensity (kWh/m² NIA)	118.3	111.3	137.2	150.3

The annual building energy and carbon intensity for each scenario are as follows with the energy break down shown graphically in Figure 5-13.

For Whole Life Carbon analysis, the Likely Case results have been considered, as they provide the most balanced and representative estimate of the building's operational energy performance. This ensures a realistic assessment of the long-term environmental impact, considering typical usage patterns and expected operational conditions.

The TM54 assessment indicates that the operational energy performance of the UK Holocaust Memorial and Learning Centre is largely dependent on the server loads, lighting and building operation. While the projected energy use is slightly above UKGBC 2025-2030 targets for buildings targeting net zero carbon for operational energy, it remains appropriate for the building function.

Further refinements in server loads, lighting fixtures, and equipment gains can provide a more accurate representation of the building's actual energy performance – see Appendix B for the full assumptions.

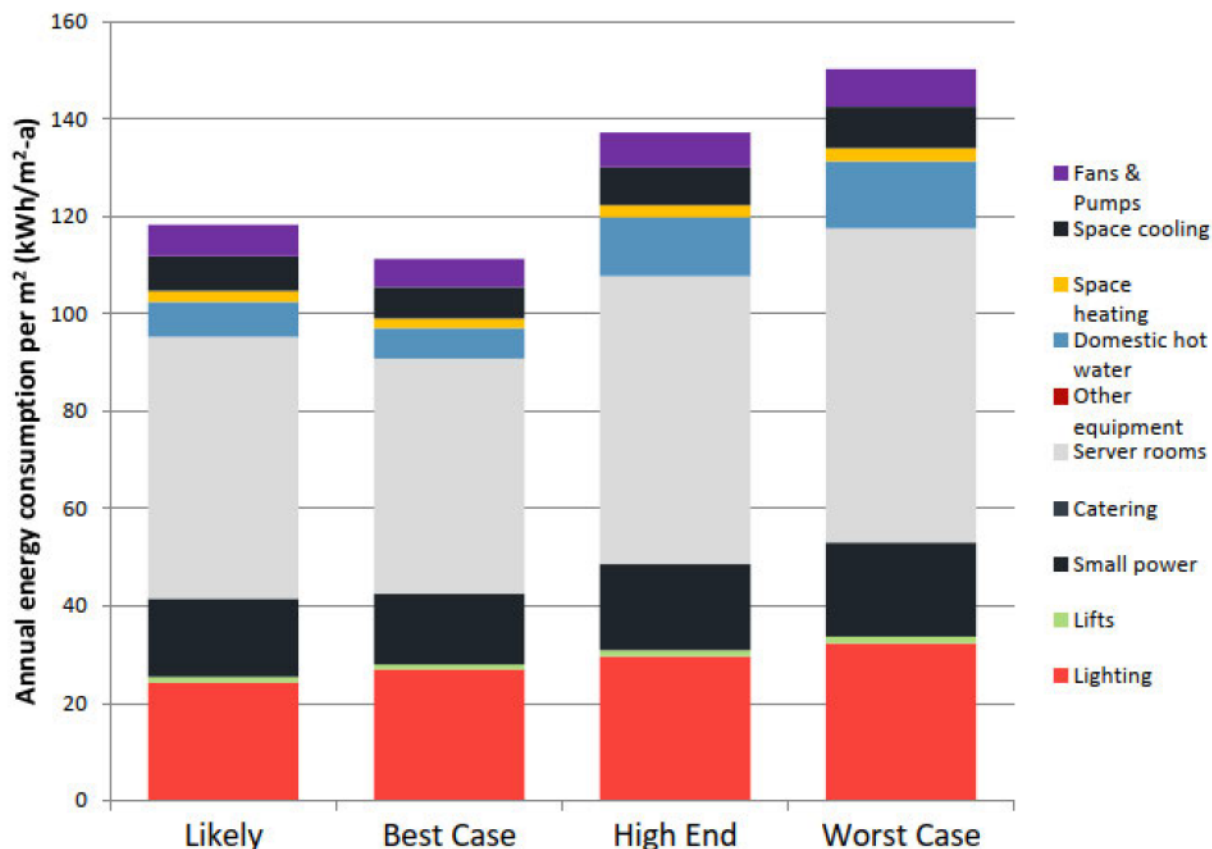


Figure 5-13 – Whole Building Energy Breakdown

The following carbon figures have therefore been calculated based on the Likely Case and an electrical carbon factor of 0.3 kgCO₂/kWh.

Table 5-9 - Carbon Emissions of Operational Energy Over 60 Year Lifespan

Operational Module (non-decarbonised scenario)	Total Carbon Emissions (kgCO ₂ e)	Normalised Carbon Emissions (kgCO ₂ e/m ²)
Energy (B6)	5,580,915	1,485
Water (B7)	55,656	15

Operational water has been calculated based on the water consumption of 50 m³ annually which resulted in 56 tonnes CO₂e over 60 years lifespan of the building.

In addition to strategies to reduce the embodied carbon of the building services, the following strategies have been incorporated to also minimise the operational energy demand:

- Heating, hot water and cooling are provided via heat-pump technology on a central loop serving the development. This delivers high seasonal efficiency and positions the scheme to benefit from ongoing grid decarbonisation (assessed on a conservative basis). The system will be powered by mains electricity with the potential to utilise renewably-generated electricity (generated off-site, arranged with utility supplier) and would have a high efficiency, with a COP of around 5.
- Efficient heating, cooling and ventilation plant is specified to minimise energy demand

- All floors, walls and soffits will be concrete, providing high thermal mass. This will reduce internal temperature fluctuation, providing a stable / comfortable internal environment and free cooling during periods of warm weather, and free heating during cold weather, improving comfort and saving energy and carbon.
- All the lighting in the building will utilise extremely high efficiency lamps and luminaires with optimised controls, including auto on/off sensor controls to minimise energy use when the building is not occupied.
- The air handling plant and the distribution system, including the design of the distribution ducts were selected to minimise specific fan powers and the system will be 'demand controlled' using CO2 sensors concealed within the extract air outlet.

6 CARBON REDUCTION OPPORTUNITIES

Current strategies for carbon reduction already incorporated into the design have been discussed throughout the results section, above, and opportunities for further reducing WLC will be further explored throughout the project. These alternative design ideas will require market assessment and cost consultant review before being considered for adoption. Key opportunities for further reductions are considered below. For further information, also see the UKHMLC Circular Economy Statement.

6.1 DESIGNING FOR LONGEVITY, ADAPTABILITY & FLEXIBILITY

The Proposed Development is designed to ensure a long service life of at least 50 years, following British Standards and Eurocodes, while incorporating Circular Economy principles such as adaptability, flexibility, and longevity. The Proposed Development is designed to make the most of the building at different times, with flexible layouts that can be reconfigured for exhibitions and other uses. It uses durable materials and robust detailing, and the MEP systems are designed so components can be disassembled, reused or recycled. Low-GWP refrigerants and efficient material use reduce whole-life impacts. Further detail is provided in the Circular Economy Statement.

The use of a Building Information Model will be explored in later stages to facilitate disassembly and identify key challenges for end-of-life strategies, future reuse, and waste reduction.

6.2 DESIGNING FOR MATERIAL EFFICIENCY & MAXIMISING RECYCLED CONTENT

Material efficiency is a priority for the Design Team and one of the key considerations during detailed design. Potential measures for reducing the material demand and for designing out waste has been and will be further explored by all key design team disciplines at each design stage. Material efficiency seeks to optimise the use of materials within building design, procurement, construction, maintenance, and end of life; with the aim being to reduce the quantities of new materials used in the development.

High levels of recycled material content (Bronze fins, reinforcement, recycled aggregates, cement replacement) and low impact materials are proposed where feasible and in line with structural specifications.

It is anticipated that at least **20% or more** of the material used in the development should contain reused or/and recycled content by value. Using products with recycled materials can significantly reduce the embodied carbon of a building in comparison with using virgin materials.

6.3 FURTHER OPTIONS FOR THE MOST CONTRIBUTING MATERIALS

As described in the previous sections and as seen in Figure 6-1, it can be seen that a large amount of carbon is from:

- The concrete, especially in the foundations and piling
- Associated reinforcement
- Bronze fins

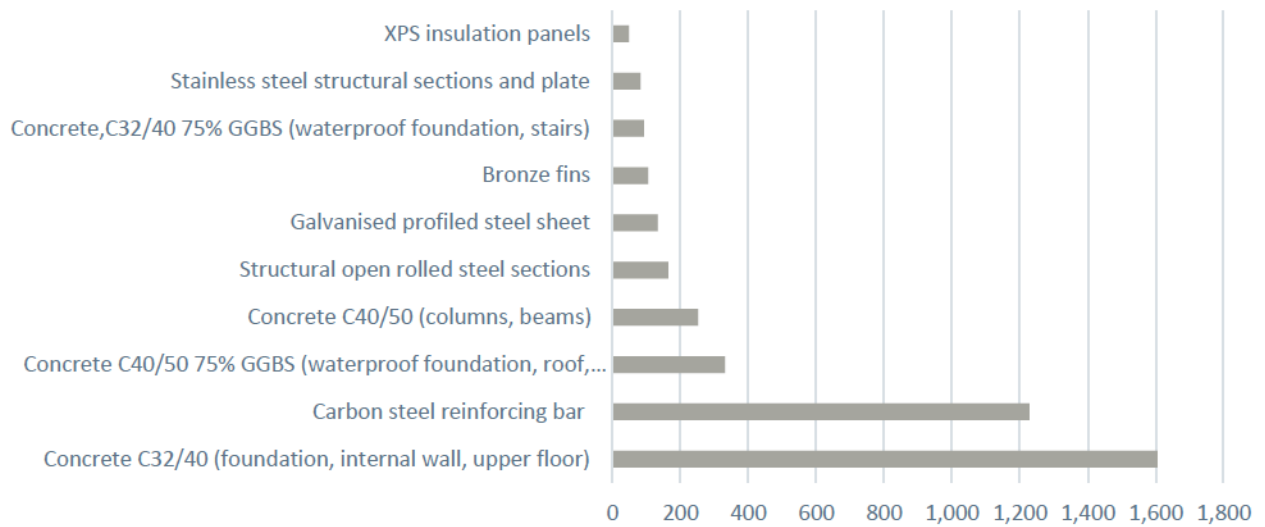


Figure 6-1 – Most contributing material to UKHMLC embodied carbon

As noted, the bronze fins are a flagship part of the aesthetic that forms a major part of the exhibition experience. It is already proposed to use 100% recycled bronze to minimise the environmental impacts – with the benefit of this demonstrated by calculation in Section 6.9. Hence the reinforced concrete presents the best opportunity for further decreasing the Whole Life Carbon intensity.

CARBON SAVING IN CONCRETE ELEMENTS

Concrete is made of several constituent parts, of which cement has the greatest impact on embodied carbon, despite being a relatively small proportion of material by mass – typically concrete is formed of 70-85% aggregates, 3-10% water, and 10-20% cement by mass. Only 10% of the total global greenhouse gas (GHG) emissions associated with the production of concrete are due to aggregates and admixtures. On the other hand, whilst it makes up a small percentage of concrete's total mass, cement is responsible for up to 90% of concrete's total emissions and approximately 7% of total global GHG emissions. Therefore, options of cement replacement or reduction can have a significant impact on the embodied carbon.

Material		Embodied CO ₂ (kg / tonne)
Portland cement, CEM I		860
Secondary cementitious materials (SCMs)	Ground granulated blastfurnace slag (ggbs)	79.6
	Fly ash	0.1
	Limestone	8
Aggregate		2.6
Reinforcement		412

Figure 6-2 – The embodied carbon for main constituents of reinforced concrete, by The Concrete Centre

Across the industry, there is much research into different methods and materials that could be used to reduce or replace cement in order to reduce concrete's environmental impacts. The most commonly used is Ground Granulated Blast-Furnace Slab (GGBS) which is a waste material in the production of steel. It can be used to replace the cement in a concrete mix with no impact on the ultimate strength (although it causes concrete to take longer to cure initially, which should be considered in site programming).

Previously, large amounts of GGBS (up to around 75% cement replacement) were used in projects to reduce embodied carbon of such projects. However, in the last few years, the demand for GGBS has grown that is being imported in large quantities, and overall the global stocks of GGBS are depleting. Due to its origin in a steel-making process that is being phased out, using large amounts of GGBS only reduces overall supplies of a finite material. Therefore, the industry recommendation is to use around 25% cement replacement as GGBS, as has been allowed for in this assessment.

Other methods of reducing the embodied carbon of concrete through changing the mix are being developed and tested across the globe – such as limestone fines, calcined clay, and olivine-based cement replacements – along with other methods of decarbonising concrete such as using concrete to capture and store carbon.

Several potential options are described below

Limestone fines

Limestone fines powder can be added to a cement mix to reduce the embodied carbon of a mix. They are readily available and proven in UK projects. They can currently be used as part of a multi-component “ternary” blend, up to a maximum of 20% cement replacement and remain code compliant.

Calcined clays

Clays are abundant globally and many are suitable for calcination. Kaolinitic clays are most favourable, which when heated and processed form a reactive material known as calcined clay. Whilst they cannot fully replace cement, they have the potential to displace huge quantities of it at a global scale. Historically in the UK, calcined clays have not been widely utilised but have had extensive use in other markets in parts of Central and South America.

It should be noted that calcined clays can be used in compliance with current British Standards (BS 8500) to maximum 35% cement replacement. There is currently no domestic supply of calcined clays in the UK, and they therefore must be imported, most likely from Europe, with stakeholders looking for UK demonstration projects to illustrate demand for a UK shipment.

Carbon-sequestering aggregates

This technology does not affect cement but instead sequesters carbon in the aggregate used in concrete. They are typically sourced from waste streams and given the large volume of aggregate (65-75%) compared to cement (10-15%) in concrete there is scope to produce low or even negative embodied carbon, compared to conventional concrete.

They can be designed in compliance with BS EN 13055. Blockwork made using these aggregates is commercially available in the UK but in-situ concrete applications are yet to be demonstrated at scale.

In some cases, materials such as [OSTO](#) also are a lighter weight than traditional aggregates and reduce loads on any supporting structure (such as columns, walls and foundations) which can lead to a secondary carbon benefit of reduced sizes and material volumes of these elements.

Carbon injection

This technology involves injecting small amounts of CO₂ into concrete during mixing to increase its strength via CO₂ mineralisation, allowing the cementitious content (and thus embodied carbon) to be reduced for a given concrete strength. The CO₂ is injected either directly in liquid form, or using a carrier derived from waste streams. There is limited demonstration in the UK but [CarbonCure](#) has example projects in the Canada and the USA. It should be noted that capturing CO₂ from the atmosphere is currently a very complex and expensive operation, and the necessary infrastructure is currently still under development in the UK to do this.

The pure CO₂ required for injection should be appropriately sourced to ensure a net emissions reduction. It should be captured as a by-product from an unavoidable process (e.g. cement or blast-furnace steel production), as opposed to fossil fuels being burnt specifically to provide CO₂ for this process. It is important to establish how the injection of CO₂ affects concrete properties (strength, workability, durability etc), and whether any CO₂ leakage may occur during injection.

Implementation in design

There are a range of options above that are under varying levels of development and include a range of options in from research stages to constructed examples. Where novel methods or concrete mixes are not yet demonstrated at large scale, they could be incorporated into the scheme in the lower risk areas, such as:

- Soft piles in the secant walls
- Single storey elements such as the
 - Café-kiosk
 - Courtyard and pavilion
- External works items such as benches, pavements and hard landscaping or decorative features

Using the UK Holocaust Memorial and Learning Centre as a demonstrator project in this way could provide reassurance to future developments in the proof of concept of these materials as well as proving the market demand for them.

6.4 RESPONSIBLE SOURCING & SPECIFICATION OF MATERIALS

The responsible sourcing of materials will be a key consideration in the selection of suppliers. A Sustainable Procurement Strategy should be produced for the Proposed Development prior to commencement of construction to control this aspect. Materials from suppliers who participate in responsible sourcing schemes such as the BES 6001: Issue 4.0 Responsible Sourcing Standard should be prioritised.

All timber should be certified sustainable in line with the UK government's timber procurement policy. Additionally, any steel, aluminium and copper should be sourced using BES 6001 Excellent/Very Good and CARES Sustainable Construction Steel Scheme.

Consideration will be given to locally sourcing materials where possible, to reduce site related transport emissions. This will be implemented through procurement routes with contractors.

Natural resource depletion will be minimised throughout the development. The WLC assessment has been undertaken and used to guide the material selection of products.

During the design process it will be necessary to consider what relevant responsible sourcing schemes apply to selected materials.

6.5 DESIGNING FOR RE-USE & RECOVERY

Building information will be stored using Building Information Modelling to allow for end-of-life strategy, future reuse, disassembly, and waste reduction/avoidance.

6.6 REDUCE/REUSE/RECYCLING OF MATERIALS

The Design Team are committed to reducing, reusing, and using recycling the materials as much as possible. Considering that there is no existing building on site, there is no immediate potential for reuse. However, subject to on-site testing, the possibility of using recycled fill to form landscaping levels and reusing the topsoil will be explored.

6.7 OPERATIONAL ENERGY (MODULE B6)

The module B6 has been taken from the findings of the TM54 analysis. The key strategies for the Proposed Development outlined within the Operational Energy study are considered to maximise the potential carbon savings.

Overall, the proposed development incorporates various energy-efficient measures to minimize carbon emissions and improve operational energy performance, with ongoing refinement expected as design advances and optimization efforts continue.

6.8 MINIMISING ON-SITE ENERGY

During the construction stage, the Principal Contractor will be required to set targets for energy and water used on site and ensure measures are put in place to minimise consumption of these resources. These could consist of:

- Low carbon energy sources used during construction phase (renewable sources of energy and offset of main utilities); and
- Use of highly efficient plant and battery power energy storage.

6.9 SUMMARY

A summary of carbon saving strategies and opportunities through material selection can be seen in the table below:

Table 6-1 presents the current strategies adopted to reduce the project's upfront embodied carbon as well as further opportunities to be explored. As the design progresses and actual material specifications become available, additional carbon reduction measures will be identified and implemented. At this stage, it is not yet possible to fully quantify the potential impact of these strategies due to the provisional nature of the material data.

Table 6-1 - UKHMLC carbon reduction strategies

Case	Description	Reduction in Upfront Carbon (kgCO ₂ /m ²)
Baseline	0% GGBS in concrete, 0% recycled content in Bronze	-
Case 1	25% GGBS in concrete	-73
Case 2	25% GGBS in concrete, 50% recycled content in Bronze	-285
Project	25% GGBS in substructure, 100% recycled content in Bronze	-216
Further Reduction 1	15% cement replacement with Limestone fines in soft piles, café and courtyard and pavilion	-4*
Further Reduction 2	35% cement replacement with calcined clays in in soft piles, café and courtyard and pavilion	-5*
Further Reduction 3	Blockworks using carbon-sequestering aggregates	Upfront carbon is unchanged; sequestered carbon increases by 1,693 kg CO ₂

* Note these have the potential to have greater impact if higher % cement replacement can be used or a greater number of elements utilise the proposed specification

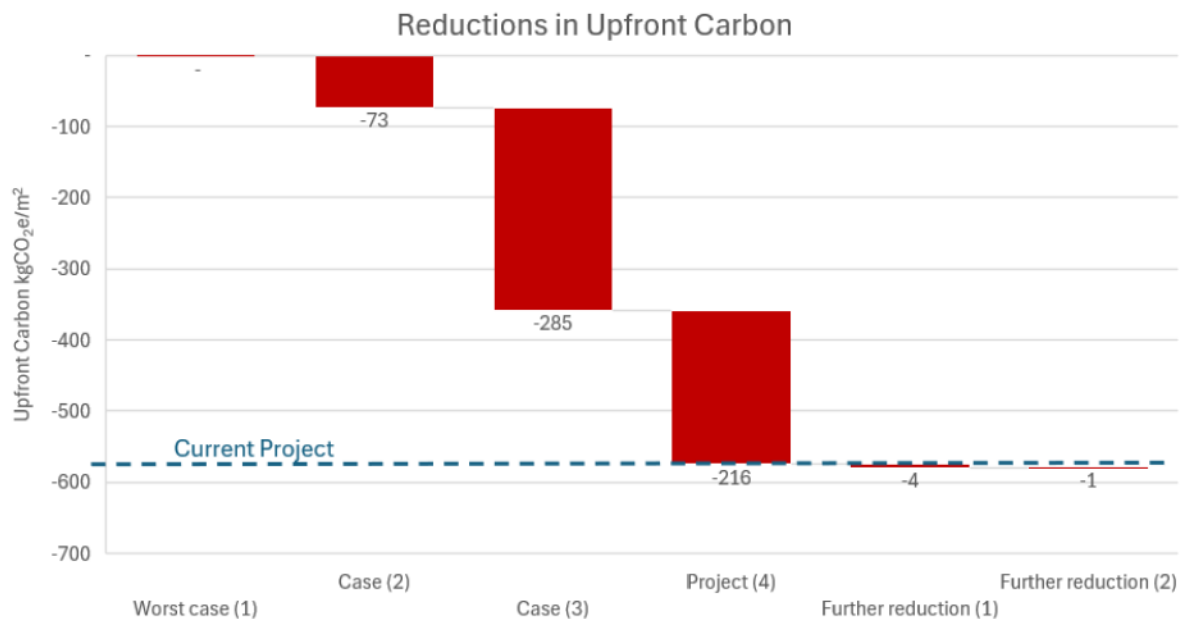


Figure 6-3 – UKHMLC carbon reduction strategies impact on Upfront Carbon

Figure 6-1 shows the impact decision making has made to date on the bronze fins and concrete specification. The further options on concrete reduction are focussed on the lower risk elements for more novel solutions, but the impact would vary depending on the final percentage of cement replacement use and the extent of elements that are deemed appropriate to use it in.

This report has set out the Whole Life Carbon emissions estimated for the Proposed Development, completed following the GLA's Whole Life-Cycle Carbon Assessment Guidance.

For the decarbonised scenario:

- Upfront carbon (A1–A5): 7,243 tCO₂e (1,928 kgCO₂e/m² GIA)
- Embodied carbon across life (A1–C): 10,219 tCO₂e (2,720 kgCO₂e/m² GIA)
- Operational carbon (B6 energy + B7 water, 60 years): 5,637 tCO₂e (1,500 kgCO₂e/m² GIA)
- Whole-Life Carbon (A–C + B6 + B7): 15,856 tCO₂e (4,220 kgCO₂e/m² GIA)
- Module D (beyond the site, reported separately): –4,776 tCO₂e (not included in totals above)

The assessment shows that embodied carbon is primarily concentrated in the structure. In this building typology the structure performs multiple roles—vertical loadbearing, external envelope and retention of the landscaping for public realm—which concentrates emissions within structural elements that are designed for long life and durability.

While the project's retaining wall structure, bespoke finishes and unusual massing (including bronze fins, a deep basement adjacent to the Thames, and double-height volumes) mean direct like-for-like benchmarks per m² of GIA are limited, normalising by visitor numbers (indicating building use) shows a more rational comparison. With an anticipated 500,000 visitors annually and embodied carbon emissions of 10,219 tCO₂e (60-year RSP), the scheme equates to 341 g CO₂e per visitor per year, comparable to a ~3 km petrol car trip and slightly below the 357 g/visitor benchmark for similar cultural/public buildings.

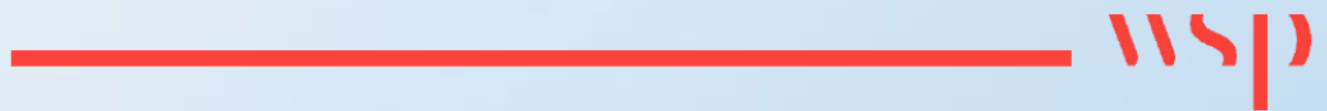
Results per element category (structures, MEP and architecture) indicate that the building performs at a broadly low-to-moderate carbon intensity relative to comparison projects and industry benchmarks - MEP is similarly efficient, and architectural items are higher reflecting the intentionally high-quality, durable finishes that are integral to the visitor experience and interpretive aims. The principal contributors to carbon are concrete elements (walls, slabs, foundations and retaining works), which is typical for this typology and offers clear, actionable opportunities for further reductions through material specification in later stages of the project, as discussed in Section 6.

The design team has identified targeted measures to drive down embodied carbon while safeguarding heritage, safety and visitor experience, including optimised concrete specifications (strength grading aligned to exposure classes), efficient structural strategies, bespoke finishes with high percentage of recycled content, and ongoing supplier engagement for EPD-backed products.

Overall, considering the constraints associated with the building typology, its architectural form, and its careful integration into a constrained and historically sensitive site, and when compared to other similar-profile projects, the WLC results appear reasonable. This is combined with the unique opportunity and brief of creating a long-lasting building in a landmark location that maintains and enhances the existing public realm and acts as a cultural landmark in its own right. These actions provide a robust pathway to reduce impacts within the project's unique constraints while delivering a lasting, high-quality public asset that will serve as an enduring reminder of the need for our democracy to stand up against intolerance, injustice and hatred for generations to come.

Appendix A

TM65 ASSESSMENT



TM65 ASSESSMENT

METHODOLOGY

Embodied carbon of building services has been calculated based on TM65 methodology in line with RICS 2nd Edition methodology. The TM65 outlines three levels of detail, the WSP calculator follows this hierarchy of information and used project specific EPD and TM65 manufacturer data where available. Where this information is not available the TM65 follows the basic methodology estimating a material breakdown for each plant item. Where masses of materials were available these have been included in the calculation, where masses are unavailable in the TM65 document, the default values have been used.

The input data has been based on The WSP MEP schedules and Revit model. A full breakdown of assumptions is noted in Appendix E

This assessment has been based on design information. All other specialist subcontractor packages that go beyond the WSP MEP Stage 4 Scope, have been excluded.

The WSP MEP Embodied Carbon Calculator has been developed in accordance with guidance from CIBSE (CIBSE TM65). For building services plant, it uses the plant schedule including the number and predicted weight of each component. If EPD data can be found for the product type, then the calculator uses this for the calculation. If no EPD data can be found for the product, then the calculation follows the CIBSE TM65 methodology, which involves estimating the material breakdown of the product and then applying the relevant carbon factor based on the Inventory of Carbon and Energy (ICE) materials database, with appropriate scale up factors to account for the complexity of the supply chain of the product. If neither of these data types is available for the product, the calculation defaults to the most appropriate generic value from the OneClick LCA database.

One of the key assumptions that form the basis of this calculation is the estimation of the equipment weight for building services components. At this stage of the project the majority of the equipment hasn't been procured and finalised yet. Therefore, much of the equipment weights have been estimates based on similar selections.

OVERALL RESULTS

Both the upfront and whole-life embodied carbon of the MEP systems for UK Holocaust Memorial and Learning Centre are presented in Table A-1. This has been calculated using MEP schedules and WSP Revit model, following the RICS 2.0 methodology and processes outlined by CIBSE TM65 (the full methodology is described in Section 3).

The assessment applies the TM65 calculation methodology incorporating Environmental Product Declarations (EPDs) and TM65 manufacturer data where available.

The embodied carbon impact of MEP elements of UK Holocaust Memorial and Learning Centre has been compared to other benchmarks and projects in the following table

Table A-1 – Building Services Summary Results

All values in kgCO ₂ e/m ² Non-decarbonised only	Upfront Carbon Module A1-A5 (Excluding Sequestered Carbon)	Embodied Carbon Modules A-C (Excluding B6 & B7; Including Sequestered Carbon)
UKHMLC	175	592
The London Tunnel	372	1,159
GLA Office Benchmark	133	294

While the upfront and embodied carbon figures for the UKHMLC exceed the GLA benchmarks, they are notably lower when compared to more contextually appropriate projects, such as The London Tunnels. It should be noted, however, that direct comparisons between such projects require careful interpretation due to differences in function and technical specifications. For instance, the higher embodied carbon in MEP systems for The London Tunnel is partly attributable to the inclusion of large display screens.

LIFECYCLE RESULTS

It is common for MEP products and services to be replaced 2-3 times throughout the life of the building. Therefore, the embodied carbon results of MEP services can be much higher than the upfront values due to the amount of repair and replacement required. This is evidenced in Figure A-1.

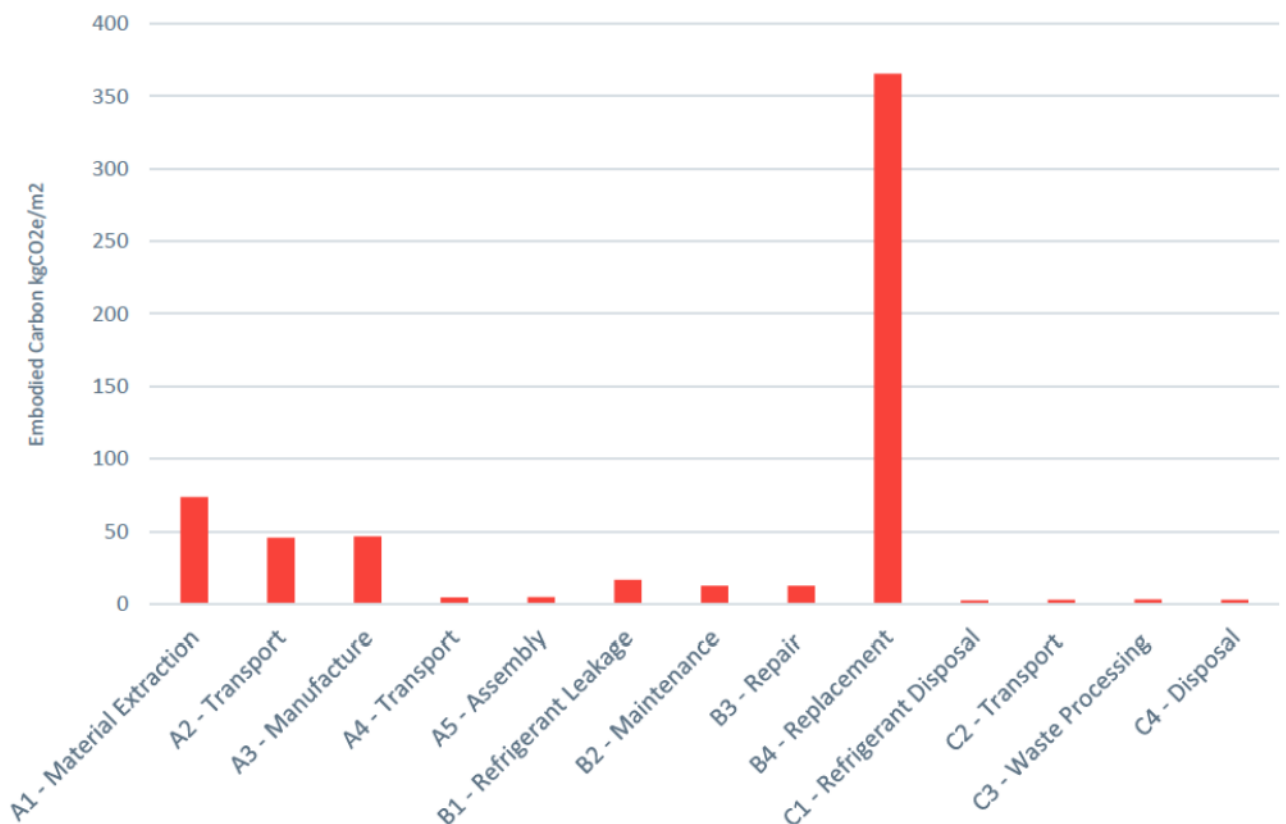


Figure A-1 – MEP Embodied Carbon of by Lifecycle Stage [kgCO₂e/m²] (non-decarbonised)

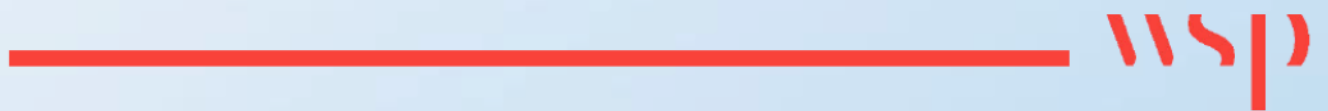


CARBON HOTSPOTS

The largest contributor to the embodied carbon of the MEP equipment is ductwork and internal lightings and also the ground source heat pumps (GSHPs), including associated boreholes, buried pipework and ancillary equipment. Despite the high upfront embodied carbon, the boreholes and buried pipework are expected to last beyond the expected 60-year lifespan of the building. This is will also be offset by reductions in B1 due to refrigerant leakage when compared with higher GWP Heat pumps, reductions in B4 emissions associated with plant replacement due to the longer lifespan of GSHP systems and reduction in B6 emissions due to higher seasonal efficiency of GSHP systems when compared to an equivalent ASHPs.

Appendix B

TM54 ASSESSMENT



TM54 OPERATIONAL ENERGY

The TM54 analysis has been conducted using design parameters, together with assumptions regarding levels of occupancy and operation, have been used to predict the energy consumption for: lighting, lifts, small power, catering, servers, domestic hot water, space heating, cooling, fans and pumps through the construction and analysis of a project model using the software IES.

While every attempt has been made to make a realistic model with conservative estimates, it is always an idealised case, and the actual operation of a building will have faults, unexpected events, and unpredictable tenant behaviour. A further set of simulations, which purposefully introduced decreased and increased occupancies and loads as well as inefficiencies were run to examine the robustness of the building. It will be very important to carefully monitor the construction, commissioning and operation of the building to ensure the predicted energy consumption is achieved. The following three scenarios have been considered:

- **Likely Case:** Based on anticipated occupancy and operation, incorporating the proposed HVAC efficiencies.
- **Best Case:** Assumes lower occupancy and improved energy management.
- **High Case:** Assumes higher occupancy and greater utilisation of equipment and systems.
- **Worst Case:** Assumes higher occupancy with inefficient operation and systems left running unnecessarily.

For the Whole Life Carbon analysis, the Likely Case results have been considered, as they provide the most balanced and representative estimate of the building's operational energy performance. This ensures a realistic assessment of the long-term environmental impact, considering typical usage patterns and expected operational conditions.

DSM CALCULATION

A Dynamic Simulation Model (DSM) has been produced for the development, which simulates conditions within the building based on the building's construction, internal loads & usage patterns (lighting, occupancy and small power, etc.) and weather data based on location.

A model was constructed using the IES VE, version 2024.0.0.0 building performance modelling software and populated with accurate data to represent the local climate, building type, building fabric and building services.

The model was updated using the latest BIM model revision dated January 13th, 2021, as shown below.

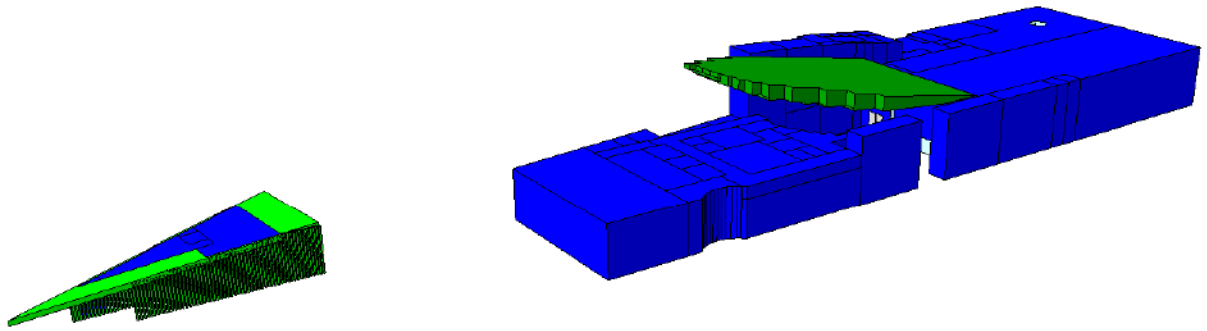


Figure B-1 – IES – VE Model

The following weather file has been used in the analysis following the GLA guidance for overheating assessments:

- London_LWC_DSY1_2020High50 (a moderately warm summer)

The details of assumptions used in this model are shown in Appendix B.

KEY ASSUMPTIONS

Full list of detailed assumptions is given in Appendix A, but the key assumptions to note are:

- Generally, information taken from Revit information and checked against the cost plan (further details are given in the tables in Section 4)
- FF&E has been based on a percentage assumption as the final elements are subject to further design development.
- The bronze carbon factor has been based on an EPD for a similar product, but it should be noted there are limited availability of EPDs similar to the product required and therefore could be greater variation in the final carbon values
- Formwork is assumed to be used 3 times
- External works has been taken from the cost plan, and it is noted that:
 - Mainly hard landscaping has been included

Assumptions have been made on the thicknesses of materials where not stated, typically 50mm limestone and 30mm mortar.

TM 54 MODELLING

The UK Holocaust Memorial and Learning Centre consists of office, BOH, and exhibition spaces, with varying operational schedules and energy demands.

The key assumptions are as follows:

Fabric Performance

The building fabric of the Proposed Development aims to reduce heat loss in winter months and minimise heat gains in summer months with the aim of maximising the passive performance of the Proposed Development. These values shown in Table B-2 were used in the previous Part L simulations.

Table B-2 – Fabric Performance Targets

Element	Commercial
Exposed Floor U-value	0.18 W/m ² K
Roof U-value	0.16 W/m ² K
External Wall U-value	0.19 W/m ² K
Glazing U-value (Ticket Pavillion)	1.5 W/m ² K
Glazing U-value (UKHMLC)	1.6 W/m ² K
Curtain Wall U-value	1.5 W/m ² K
Rooflight U-value	2.3 W/m ² K
Glazing g-value	0.35

Internal Gains and Occupancy Profiles

- Most spaces operate from 8:00 AM to 5:00 PM, except for the exhibition areas, which close at 8:00 PM.
- Server rooms are operating continuously.
- Internal gains are assigned as shown in Table 2:

Table B-3 - Internal gains per space type

Space type	Lighting (W/m ²)	Equipment (W/m ²)	Occupancy (People)
Circulation	10	-	-
Comms	10	200	10
Exhibition Area	5	4	10
Kitchen	10	15	10
Kitchenette	10	15	10
Meeting Room	10	5	10
Office	10	15	10
Plant room	10	50	-
Shower/Changing Room	10	-	-
Store	10	-	-
W.C.	10	-	-

Air Exchange and Ventilation

- Air Infiltration: 0.10 ACH
- Auxiliary Ventilation: 10 l/s per person from 8:00 AM to 5:00 PM, except for the exhibition area where occupancy extends until 8:00 PM.

HVAC and Domestic Hot Water Systems

- Exhibition Areas: Chilled beams and displacement ventilation
- Toilets, Showers, and Changing Rooms: Underfloor heating with WC extract
- Offices and General Spaces: Fan coil units with supply and extract ventilation
- Temperature Setpoints:
 - Heating: 21°C (constant)
 - Cooling: 25°C (constant)
- Comms Room: Continuous cooling profile assigned
- Domestic Hot Water:
 - Offices: 14 litres per person per day
 - Exhibition Areas: 5 litres per visitor per day

Lifts and Servers

- Lift energy consumption estimated using BS EN ISO 25745-Energy performance of lifts, escalators and moving walks.
- Total server loads assigned as 250 W/m²

TM54 OPERATIONAL ENERGY RESULTS

The TM54 analysis for the Proposed Development estimates a whole building energy use intensity of 118.3 kWh/m² per year (m² NIA). This figure is slightly above the UKGBC 2025-2030 target of 115 kWh/m² but given the building's function as an exhibition space with higher energy demands, the result is considered reasonable.

Table B-4 - Comparison of Annual Energy Intensity

	Likely Case	Best Case	High Case	Worst Case
Whole building Energy Intensity (kWh/m ² NIA)	118.3	111.3	137.2	150.3

The annual building energy and carbon intensity for each scenario are as follows with the energy break down shown graphically in Figure B-2:

For Whole Life Carbon analysis, the Likely Case results have been considered, as they provide the most balanced and representative estimate of the building's operational energy performance. This ensures a realistic assessment of the long-term environmental impact, considering typical usage patterns and expected operational conditions.

The TM54 assessment indicates that the operational energy performance of the UK Holocaust Memorial and Learning Centre is largely dependent on the server loads, lighting and building operation. While the projected energy use is slightly above UKGBC 2025-2030 targets for buildings targeting net zero carbon for operational energy, it remains appropriate for the building function.

Further refinements in server loads, lighting fixtures, and equipment gains can provide a more accurate representation of the building's actual energy performance – see Appendix B for the full assumptions.

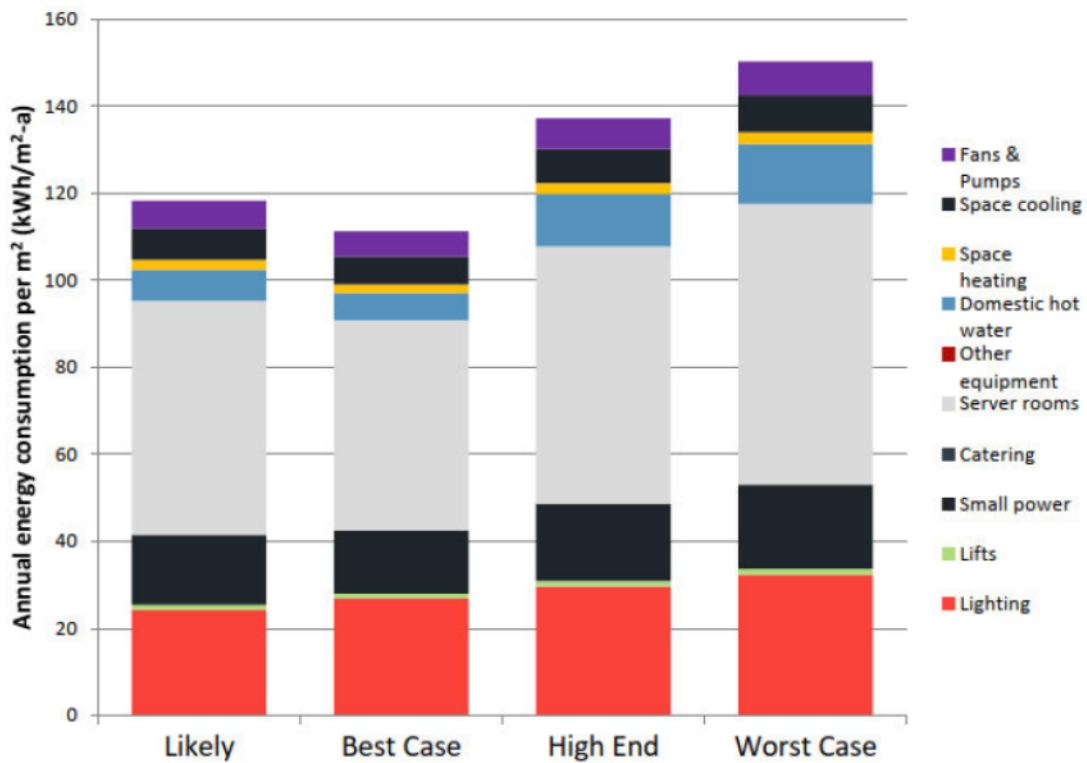


Figure B-2 – Whole Building Energy Breakdown

CARBON EMISSIONS

The following carbon calculations are based on an electrical carbon factor of 0.3 kgCO₂/kWh.

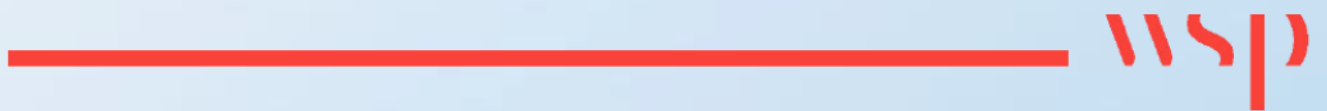
Table B-5 - Carbon Emissions of Operational Energy Over 60 Year Lifespan

Operational Module (non-decarbonised scenario)	Total Carbon Emissions (kgCO ₂ e)	Total Carbon Emissions (kgCO ₂ e/m ²)
Energy (B6)	5,580,915	1,485
Water (B7)	55,656	15

Operational water has been calculated based on the water consumption of 50 m³ annually which resulted in 56 tonnes CO₂e over 60 years lifespan of the building.

Appendix C

POLICIES



POLICY REQUIREMENTS

The following section summarises the key Whole life carbon Policy Requirements and Guidance relevant to the project.

National Policies

- **Building Regulations:** The UK government regularly updates building regulations to improve the energy efficiency of new buildings and reduce their carbon emissions. These regulations set standards for insulation, heating systems, and overall energy performance.
- **Net Zero by 2050 Commitment:** The UK government's official commitment to achieve net-zero greenhouse gas emissions by 2050, enshrined in law through the Climate Change Act 2008 (2050 Target Amendment) Order 2019.
- **The Clean Growth Strategy:** A government strategy document outlining plans for reducing carbon emissions across various sectors, including the built environment.

Regional Policies

- **The London Plan:** Under the legislation establishing the Greater London Authority (GLA), the Mayor is required to publish a Spatial Development Strategy (SDS) and keep it under review. The SDS is known as the London Plan. As the overall strategic plan for London, it sets out an integrated economic, environmental, transport and social framework for the development of London over the next 20-25 year

Local Policies

- **Greater London Authority (GLA):** The Greater London Authority (GLA) outlines the key Whole life carbon Policy Requirements and Guidance in their document titled "Whole Life-Cycle Carbon Assessments Guidance." This guidance provides a framework for developers and design teams in London to assess and minimize the Whole Life Carbon emissions of new construction projects.
- **Partial City Plan Review:** The Partial City Plan Review is a process conducted by the Greater London Authority (GLA) to review specific aspects of the London Plan. The London Plan is the strategic planning document that guides the development and growth of the city. Through a Partial City Plan Review, the GLA aims to update and refine certain parts of the London Plan to ensure it remains effective and aligned with current priorities and policies.
- **Westminster City Plan:** The Westminster City Plan integrates policies to reduce Whole life carbon emissions by promoting energy-efficient building design, renewable energy adoption, and sustainable construction practices. It encourages efficient building operations and supports retrofit programs for existing buildings. Through these initiatives, the plan aims to minimize carbon footprints across the lifecycle of infrastructure within the City of Westminster, contributing to broader sustainability goals.

NATIONAL POLICIES

BUILDING REGULATIONS

Building regulations play a crucial role in supporting Whole life carbon reduction by setting standards for energy efficiency, construction materials, and building design. These regulations often require

newly constructed buildings to meet specific energy performance targets, which can include requirements for insulation, heating, ventilation, and lighting systems. By mandating the use of sustainable construction practices and energy-efficient technologies, building regulations help minimize carbon emissions associated with the operational phase of buildings. Additionally, some regulations may encourage the use of low-carbon materials and the adoption of renewable energy sources, further reducing a building's carbon footprint over its entire lifecycle. Compliance with building regulations ensures that new developments contribute to the broader goal of mitigating climate change by reducing greenhouse gas emissions from the built environment.

NET ZERO BY 2050 COMMITMENT

The Net Zero by 2050 Commitment, enshrined in the Climate Change Act, provides a legislative framework for the UK's transition to a low-carbon economy. By setting a legally binding target to achieve net-zero greenhouse gas emissions by 2050, it drives action across various sectors, including construction and infrastructure. This commitment influences the development of policies and regulations aimed at reducing Whole life carbon emissions, such as stricter building codes, incentives for renewable energy adoption, and support for sustainable construction practices. The Climate Change Act reinforces the government's commitment to addressing climate change comprehensively, ensuring that policies and actions prioritize carbon reduction throughout the lifecycle of buildings and infrastructure to achieve the net-zero target by 2050.

THE CLEAN GROWTH STRATEGY:

The Clean Growth Strategy is a comprehensive government plan aimed at reducing carbon emissions across the UK economy while promoting economic growth. It supports Whole life carbon reduction by providing a strategic framework for policies and initiatives that prioritize sustainability and energy efficiency. Specifically, the Clean Growth Strategy outlines measures to improve energy efficiency in buildings, including the promotion of low-carbon heating systems, enhanced insulation, and energy-efficient appliances. It also encourages investment in renewable energy technologies, such as solar panels and wind turbines, to reduce reliance on fossil fuels in both new construction and existing buildings. By fostering innovation and supporting clean technologies, the Clean Growth Strategy aims to drive down carbon emissions throughout the lifecycle of buildings and infrastructure, contributing to the UK's transition to a low-carbon economy.

REGIONAL POLICIES

LONDON PLAN

The London Plan Policy SI 2: Minimising Greenhouse Gas Emissions Part F sets out a requirement for major and referable developments to measure and reduce **Whole life carbon** emissions. This should be done in line with the GLA Whole life carbon Assessment Guidance (based on the RICS Professional Statement 2017).

The SI 2 policy additionally sets operational energy and carbon offsetting requirements.

LOCAL POLICIES

Greater London Authority (GLA) Whole Life Carbon Guidance

The GLA Whole life carbon Assessment Guidance, March 2022, requires a WLC Assessment to be carried out at the following intervals:

- Pre-Application (where relevant).
- Planning application submission (i.e. RIBA stage 2/3).
- Post construction.

The guidance also includes current and aspirational benchmarks for various building typologies for both upfront and Whole life carbon. A comparison of the project's carbon performance against the GLA benchmarks typically provides an initial indication of the Proposed Development's performance against industry practice.

Table C-1 - GLA Benchmarks for Commercial Office Buildings

Stages	GLA Benchmark kgCO ₂ e/m ² GIA	GLA Aspirational Benchmark kgCO ₂ e/m ² GIA
Upfront Carbon (A1-A5)	<950	<600
In-use and EoL Embodied Carbon (B-C excl. B6-B7)	<450	<370
Whole life carbon (A-C excl. B6-B7)	<1,400	<970

WESTMINSTER CITY PLAN 2019-2040 (ADOPTED APRIL 2021)

The Westminster City Plan is a strategic document that guides development within the City of Westminster, and it includes measures to support Whole life carbon reduction. The plan integrates policies aimed at promoting sustainable construction practices, energy efficiency, and renewable energy adoption. It may require new developments to adhere to stringent energy performance standards and incorporate low-carbon technologies, such as solar panels or heat pumps. Additionally, the plan may encourage retrofitting of existing buildings to improve their energy efficiency and reduce carbon emissions. By incorporating these measures, the Westminster City Plan contributes to the broader goal of reducing the carbon footprint of buildings and infrastructure within the city, aligning with sustainability objectives and supporting the transition to a low-carbon future.

The Plan has no specific WLC reporting requirements for planning applications, however the document aligns with the guidance outlined within the London Plan, focusing on operational energy reduction approaches, and setting requirements for carbon offsetting.

Table C-2 - Westminster City Plan (April 2021) – Relevant to WLC

Westminster City Plan 2019-2040 (April 2021)

Policy 36. Energy	A. The council promotes zero carbon development, urging all projects to decrease on-site energy demand and maximize low carbon energy use to combat climate change. B. Development proposals must adhere to the Mayor of London's energy hierarchy, with major projects striving for net zero carbon emissions. An energy strategy must demonstrate how this target will be achieved. C. If it's not feasible to achieve zero-carbon on-site, any carbon reduction shortfall should be addressed through off-site measures or carbon offset payments, as stipulated by legal agreements.
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WESTMINSTER CITY COUNCIL PARTIAL CITY PLAN REVIEW

Westminster City Council is currently in the midst of a Partial City Plan Review, following Regulation 19 of the Town and Country Planning (Local Planning) (England) Regulations 2012. This review aims to update the existing City Plan 2019-2040 to better align with current needs and priorities.

As of May 2024, the Council has completed the Regulation 19 consultation phase, which ran from March 14 to April 25, 2024. This phase allowed stakeholders to review and comment on the proposed changes to the City Plan. The review process focuses on several key areas, including the promotion of retrofit-first policies to enhance sustainability, the allocation of underused sites for development, and the provision of more affordable housing.

The Council is now in the process of reviewing the feedback received during the consultation period. The aim is to finalize the amendments and ensure the updated plan supports the Council's vision for a fairer Westminster, addressing long-term housing, commercial, and infrastructure growth needs. The updated Local Development Scheme reflects the priorities and timelines for this partial review, ensuring compliance with statutory requirements and setting the framework for future planning decisions in Westminster.

The WCC Partial City Plan Review can impact carbon emissions in a number of ways, particularly if it addresses policies related to sustainability, environmental efficiency, and carbon reduction.

Key aspects of the WCC Partial City Plan Review include:

- **Targeted Updates:** The review focuses on specific policies or topics within the London Plan (which the WCC Partial City Plan aligns with) that require updates or changes. This allows for a more efficient and targeted approach to updating the plan.
- **Evidence-Based:** The review is based on evidence gathered through research, data analysis, and stakeholder consultations. This ensures that any changes made are grounded in current needs and trends.
- **Stakeholder Engagement:** The GLA involves a wide range of stakeholders, including borough councils, developers, community groups, and other interested parties, in the review process. This allows for diverse perspectives and inputs to shape the updated policies.
- **Consultation and Feedback:** The Partial City Plan Review includes opportunities for public consultation and feedback. This allows residents and other stakeholders to provide input on proposed changes and ensure that the final updates reflect the needs and preferences of the community.

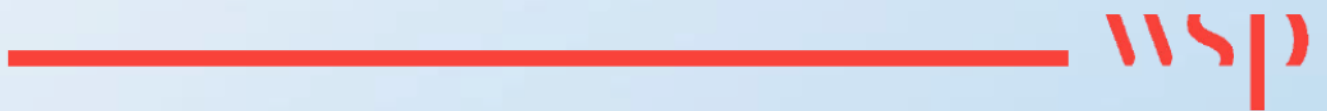
- **Alignment with National and Regional Priorities:** The review ensures that the London Plan remains consistent with national planning policies and regional priorities, such as housing, transportation, and sustainability.
- **Implementation and Monitoring:** Once changes are made to the London Plan, the GLA monitors the implementation of the updated policies to ensure they achieve the desired outcomes. In terms of the WCC Partial City Plan Review WCC will review and monitor the impact of their updated policies.

Overall, the WCC Partial City Plan Review is an important process for aligning with the London Plan and responding to the evolving needs of the city and its residents.

Westminster City Council has defined new proposed planning policies to make Westminster a 'retrofit first' city. New rules set out by the WCC Plan Partial Review, to be out for consultation between the 14th of March and 9th of May 2024. Key changes within this review include new rules to ensure developers explore the option of retrofit before demolishing building in the city, an update to embodied carbon targets in line with London Energy Transformation Initiative (LETI) benchmarks. Also, an update to the methodology for carbon offsetting which sets the prices of carbon at £330/CO₂t for electric-based schemes as opposed to the current price of £95/CO₂t as set out in the London Plan.

Appendix D

COMPARISON BUILDINGS



MUSEUM OF LONDON WEST SMITHFIELD

A Whole Life Carbon Assessment has been prepared for the Museum of London (MOL) located in Farringdon, based on Stage 2 of the design process, which is proposed to be finished in 2026 (Figure D1-1). The assessment comprises of two options, option 1, part demolition, refurbishment and extension, and option 2, full demolition & new build. Option 1 was the 'chosen option' to be taken forward. It is proposed that as much of the historic existing building components are retained as far as technically possible, consequently the project would involve:

- "Partial demolition, repair and refurbishment with an extension of the existing building on site:
 - General Market: basement, ground, first floor and roof levels
 - Poultry Market: basement, ground & first floor levels
 - Annexe site: basement, ground, first, second and third floor levels
- The Engineer House at basement and ground floor levels will involve refurbishment and minor alterations to the existing building



Figure D1-1 - Image of the Proposed Museum of London

The Whole Life Carbon Assessment for the MOL was carried out in May 2022 and resulted in approximately 600 kg CO₂e/m² of Whole Life Carbon. Upfront carbon was not reported at this stage. Furthermore, the façade has been based on benchmark data from previous projects with similar typologies, MEP services has been based on 'typical' benchmarks, and the finishes were also based on LETI guidance benchmarks. As per GLA guidance (March 2022) it is worth noting that these three elements alone typically contribute to approximately 32% of whole life emissions for new build retail developments. Assessment data was also more limited with regards to façade components and MEP systems in 2022 and when compared to UKHMLC the scope is also more limited excluding FFE & external works. Consequently, due to the combination of benchmark data and the limitations of available information it is anticipated that the carbon impact could be significantly underestimated.

THE LONDON TUNNELS (TLT)

A Whole Life Carbon Assessment has been prepared for The London Tunnels (TLT) stage 2 design. The project involves converting existing deep-level tunnels into a visitor and cultural attraction, including a bar. It includes demolishing structures at 39 Furnival Street for a new mixed-use building (up to 5 storeys), redeveloping 40 Furnival Street for the main entrance, retail, and offices, adding basement levels, and creating a new pedestrian entrance at Fulwood Place with retail and bar access.

The Whole Life Carbon for The London Tunnels has been calculated to be 1,738 kg CO₂e/m² (modules A-C, excluding B6 & B7; including sequestered carbon) which is higher than the WLC benchmark of <1,050 for retail buildings. The upfront carbon of TLT is 783 kg CO₂e/m².

It should be noted that although TLT is primarily located underground, it is a fit-out of an existing tunnel structure alongside a new construction. In contrast, The UK Holocaust Memorial and Learning Centre involves solely new construction, including extensive piling, deep foundations, and significant structural works, all of which contribute to a much higher embodied carbon footprint when normalised across the GIA than a combined refurbishment and new build project.

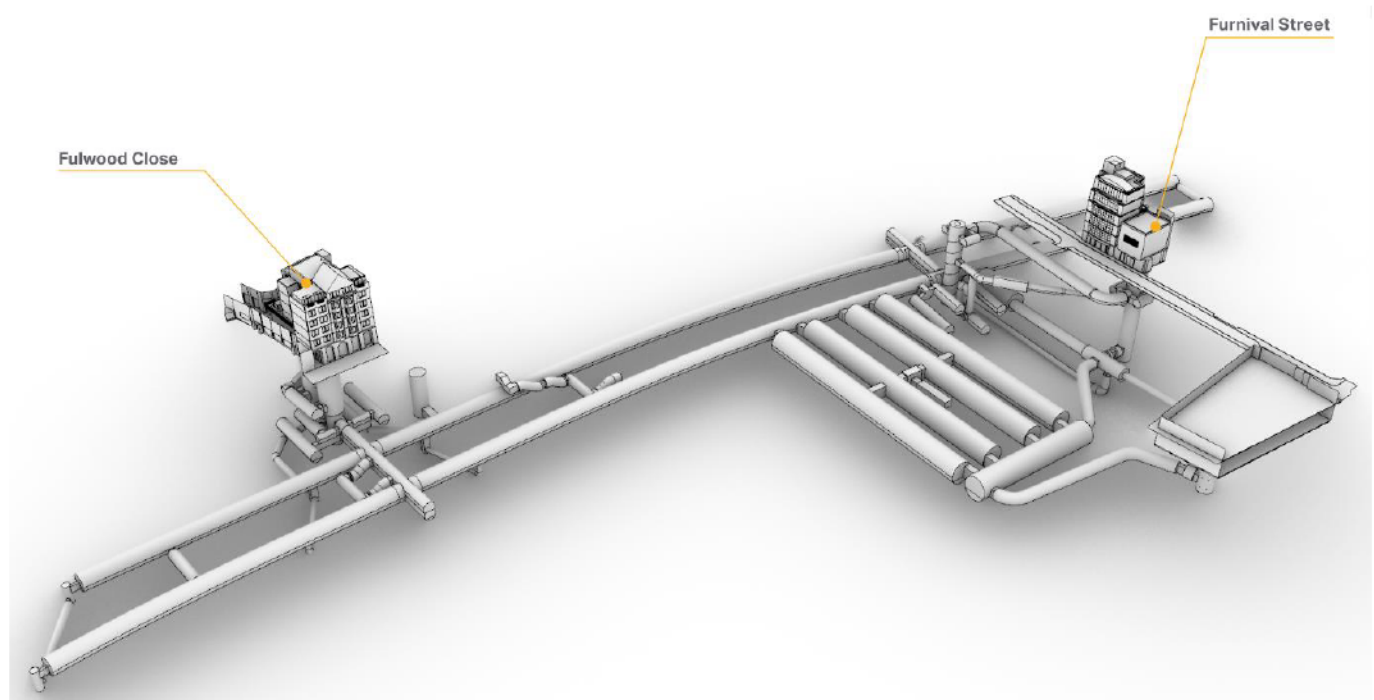


Figure 1 D-2 Schematic extent of the London Tunnel

LORD'S CRICKET GROUND - LORD'S TAVERN & ALLEN STANDS

Lord's Tavern & Allen Stands at Lord's Cricket Ground, located in St John's Wood, Westminster. The assessment supports a planning application for the redevelopment and extension of the Tavern Stand and the demolition and new build of the Allen Stand, aiming to deliver world-class, sustainable facilities in line with the Marylebone Cricket Club's (MCC) Net Zero Strategy (2023).

The project involves:

- Retention and refurbishment of the Tavern Stand (constructed in the 1960s), maximizing reuse of the existing structure to save embodied carbon.
- Demolition and new build of the Allen Stand (originally from the 1930s), which no longer meets modern standards for accessibility, safety, or spectator experience.
- Creation of new hospitality, retail, and food & beverage spaces, improved accessibility (including lifts), and new landscaping.
- Installation of PV panels and other energy-efficient systems.

The whole life Carbon assessment results for two stands is:

- Upfront embodied carbon (A1–A5): 5,881 tCO₂e (1,568 kgCO₂e/m²)
- In-use and end-of-life (B–C): 1,382 kgCO₂e/m²
- Total GIA: 3750 m²

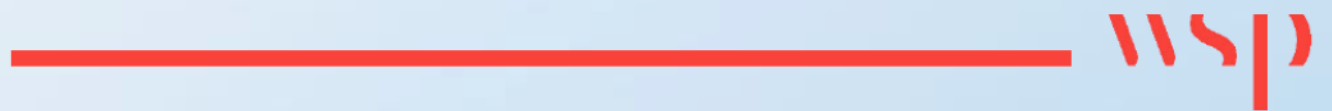
It should be noted that unlike UKHM which is a wholly new construction and is primarily located underground, the Lord's project, combines refurbishment (Tavern Stand) and new build (Allen Stand) above ground.



Figure 1 Lord's Tavern & Allen Stands, Lord's Cricket Ground

Appendix E

ASSUMPTIONS



KEY ASSUMPTIONS

Full list of detailed assumptions is given in Appendix A, but the key assumptions to note are:

- Generally, information taken from Revit information and checked against the cost plan (further details are given in the following tables in Section 4)
- FF&E has been based on a percentage assumption (according to GLA benchmark). The final elements are subject to further design development.
- The bronze carbon factor has been based on an EPD for a similar product, but it should be noted there are limited availability of EPDs similar to the product required and therefore could be greater variation in the final carbon values
- Formwork is assumed to be used 3 times
- External works has been taken from the cost plan, and it is noted that:
 - Mainly hard landscaping has been included
 - Assumptions have been made on the thicknesses of materials where not stated, typically 50mm limestone and 30mm mortar

CONCRETE SPECIFICATION

As part of the Whole Life Cost (WLC) assessment undertaken by WSP for the UK Holocaust Memorial and Learning Centre project, the concrete specification has been assumed based on the WSP structural specification:

From concrete spec	GGBS	Strength
Liner wall	25%	C32/40
Internal elements C32/40	25%	C32/40
Internal elements C40/50	25%	C40/50
Water resistant concrete for podium slab and café roof and pavilion roof	25%	C40/50
Water resistant concrete for foundations	25%	C32/40
Concrete on metal deck	25%	C32/40

As noted in Section 6, previously large amounts of GGBS were used in projects to reduce embodied carbon of such projects, including at the time of writing the concrete specifications. However, in the last few years, the demand for GGBS has grown that is being imported in large quantities, and overall the global stocks of GGBS are depleting. Due to its origin in a steel-making process that is being phased out, using large amounts of GGBS only reduces overall supplies of a finite material. Therefore, the industry recommendation is to use around 25% cement replacement as GGBS and this has been incorporated into the WLCA.

ASSUMPTIONS FROM THE COST PLAN

Where information was not available in the cost plan by AECOM or design drawings, a series of informed assumptions have been made to support the assessment. The following table outlines the assumptions made for this assessment.

Reference	Description	Assumption
Various	Raft/RFt	= reinforcement
1.1.2/K	Piles to exhibition area; Round column, Ø1800mm x 24.5m depth; including C32/40 grade, 150kg/m3 rebar weight	None included as 0 nr noted
1.1.3/F	Extra over for foundation slab edge to Spicer memorial	not significant
1.1.5/L	Piling mats/platforms: details, including thickness of mat/platform (mm), to be stated.	Assumed 500mm thick
2.1.3/E	special formwork e.o.	notes type of formwork not doubled area of formwork
2.1.4/H	Wall; double 200mm thick reinforced concrete wall to exhibition area; including C32/40 grade concrete, 100kg/m3 rebar weight and smooth fair faced concrete formwork finish	Insulation stated in cost plan, but none shown on Adjaye Associates drawings for INW-02
Various to concrete walls	acid etch	assumed 1mm over area given
2.1.4/B	micro cement	Assume EXTW-13 on AA drawings therefore 15mm of micro cement
2.3.1/F	slope	assumed site works
2.3.2/D	metal deck	assumed error and no metal deck within pedestal system



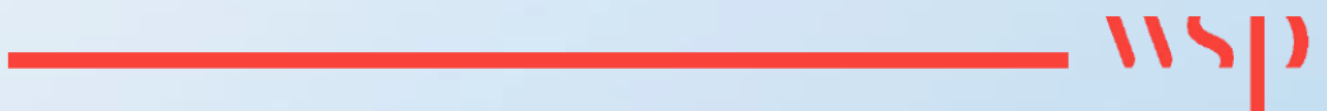
MEP ASSUMPTIONS

MEP embodied carbon assessment used the following assumptions for TM65 analysis

Quantity Assumptions	Value
Use RICS (2023) MEP supplementary tables (S3 and Below)	yes
Number of Levels (above ground) [n]	1
Number of Levels (below ground) [n]	2
Number of Levels [n]	3
Number of Units [n]	1
Number of Toilet Blocks per floor	3
Floor Areas per Number of Public Health Fixtures [m2/fixture]	50
Floor Area per Number of Heating Fixtures [m2/fixture]	50
Floor Area per Number of Cooling Fixtures [m2/fixture]	50

Appendix F

RESULTS



Non-decarbonised							
Global warming potential - Decarbonised scenario kg CO ₂ e/m ²	Upfront Carbon		Use Stage		End of Life	TOTAL	Module D
	A1-A5	A1-A3 Sequestered Carbon	B1-B5	B6-B7	C1-C4		
Asset level emissions	-	-	12.5	1,500.3	-	1,512.8	-
0 Facilitating works	50.3	-28.5	2.7	-	29.2	53.6	-6.0
1 Substructure	749.6	-0.4	-	-	70.0	819.2	-641.4
2 Superstructure - Structural elements	379.3	-0.4	5.4	-	38.7	423.0	-346.1
2 Superstructure - Building envelope	109.7	-8.6	7.8	-	9.1	117.9	-36.9
2 Superstructure - Internal elements	113.6	-0.5	5.6	-	8.4	127.1	-84.4
3 Finishes	39.2	-0.6	56.8	-	6.7	102.1	-22.9
4 Fittings, furnishings and equipment (FF&E)	86.8	-	15.3	-	20.4	122.5	-
5 Services (MEP)	174.7	-	407.0	-	10.7	592.3	-
6 Pre-fabricated buildings and units	-	-	-	-	-	-	-
7 Works to existing buildings	-	-	-	-	-	-	-
8 External works	33.7	-	34.7	-	11.8	80.2	-7.5
WLCA Uncertainty Factor	191.0	-4.3	60.3	-	22.5	269.6	-126.0
TOTAL	1,928	-43.3	608	1,500	228	4,220.3	-1,271.1

Decarbonised							
Global warming potential - Decarbonised scenario kg CO ₂ e/m ²	Upfront Carbon		Use Stage		End of Life	TOTAL	Module D
	A1-A5	A1-A3 Sequestered Carbon	B1-B5	B6-B7	C1-C4		
Asset level emissions	-	-	6.3	330.2	-	336.5	-
0 Facilitating works	50.3	-28.5	1.3	-	29.0	52.2	-3.0
1 Substructure	749.6	-0.4	-	-	36.4	785.6	-320.8
2 Superstructure - Structural elements	379.3	-0.4	2.8	-	26.4	408.0	-173.1
2 Superstructure - Building envelope	109.7	-8.6	3.9	-	8.3	113.2	-18.6
2 Superstructure - Internal elements	113.6	-0.5	2.8	-	4.7	120.6	-42.2
3 Finishes	39.2	-0.6	28.4	-	4.7	71.7	-11.7
4 Fittings, furnishings and equipment (FF&E)	86.8	-	7.6	-	15.3	109.8	-
5 Services (MEP)	174.7	-	203.5	-	8.2	386.3	-
6 Pre-fabricated buildings and units	-	-	-	-	-	-	-
7 Works to existing buildings	-	-	-	-	-	-	-
8 External works	33.7	-	17.4	-	8.0	59.0	-3.8
WLCA Uncertainty Factor	191.0	-4.3	30.1	-	15.5	232.4	-63.0
TOTAL	1,928	-43.3	304	330	156	2,675.3	-636.2



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