WHOLE LIFE-CYCLE CARBON ASSESSMENT

Trout Road

Produced by XCO2 for Troutbourne LLP

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EXECUTIVE SUMMARY

A Whole Life-Cycle Carbon Assessment (WLCA) has been undertaken for the proposed development at Trout Road. The site is within the London Borough of Hillingdon. This assessment has been carried out in accordance with the latest published GLA Whole Life-Cycle Carbon Assessments guidance (March 2022) and follows the methodology of the RICS Whole Life Carbon Assessment for the Built Environment Guidance (1st Edition, 2017).

The development proposes a phased redevelopment of the site to provide nine plots ranging between 3 storeys and 11 storey's in height (including ground level) to include residential units (Use Class C3), flexible retail/café/restaurant floorspace (Class E (a,b,c)), light industrial floorspace (Class E (g)(iii)), associated hard and soft landscaping, car parking, cycle parking, servicing, refuse and plant areas, public realm improvements, highways works and other works associated with the development.

In line with London Plan Policy SI 2, the development has calculated whole life-cycle carbon through a nationally recognised Whole Life-Cycle Carbon Assessment methodology and has demonstrated the actions taken to reduce embodied carbon emissions.

The methodology used to determine the expected embodied carbon outlined in this report has been developed according to the requirements set out in the GLA's London Plan Guidance for Whole Life-Cycle Carbon Assessments (March 2022) guidance document.

WHOLE LIFE-CYCLE CARBON ASSESSMENT SUMMARY

The estimated whole life-cycle carbon of the proposed development is shown in Table 1.

Table 1: Estimated Whole Life-Cycle Carbon for the Proposed Development

Proposed Assessment	Sequestered (biogenic) Carbon	Module A1-A5	Module B1-B5	Module B6-B7	Module C1-C4	Module D
TOTAL kg CO_2e	-3,118,058	32,404,471	17,365,689	42,010,745	5,743,736	-7,128,966
TOTAL kg CO_2e/m^2 GIA	-80	770	420	1,000	140	-170

GLA WLC BENCHMARKS

The London Plan Guidance for Whole Life-Cycle Carbon Assessments (March 2022) sets out benchmarks based on previous project assessments. These benchmarks should be used as a guide, providing a range rather than a set value to achieve, and are broken down into life-cycle modules.

In addition to the Business-as-Usual benchmark, a further set of aspirational WLC benchmarks has also been developed which are based upon a 40% reduction from the Business as Usual.

The current predicted performance of the proposed developments against these benchmarks has been detailed in Table 2.

Table 2: GLA Benchmark(s) for Residential and Proposed Development performance

Modules	GLA WLC Benchmark	GLA Aspirational WLC Benchmark	Trout Road
	Kg CO_2e per m^2 (GIA)		
A1-A5 (excluding sequestration)	<850	<500	770
B-C (excluding B6 & B7)	<350	<300	550
A-C (excluding B6 & B7, Including sequestration)	<1200	<800	1250

DISCLAIMER

XCO2 does not endorse or recommend specific manufacturers, products or materials.

Any reference to specific materials and components is solely for the purposes of recommendation of their thermal and/or embodied carbon performance.

It will be the responsibility of other design team members to specify exact products suitable for the development to match the set performance recommendations. XCO2 is not responsible for confirming or checking any performance parameters not related to thermal conductivity and/or embodied carbon of a product or component (such as, but not limited to, structural integrity, fire risk rating, hygroscopy/hydrophoby, size or cost differences).

INTRODUCTION

This section introduces the key principles that a Whole Life-Cycle Carbon Assessment for the built environment should adopt. It provides a brief description of the development, the policy framework and the methodology employed for this WLCA.

As buildings become more energy efficient, operational carbon emissions will make up a smaller proportion of a development's whole life-cycle carbon emissions. It is therefore becoming increasingly important to calculate and reduce carbon emissions associated with other aspects of a development's life cycle; namely, embodied carbon.

SITE & PROPOSAL

The Site comprises the Rainbow and Kirby Industrial Estates, which accommodate an approximately 2.3-hectare plot within the London Borough of Hillingdon ('LBH'). Parts of the Site front the south side of Trout Road, the western side of Yiewsley High Street, and the northwest side of St Stephen's Road, with the entire southwest boundary bordered by the Grand Union Canal. The Site largely accommodates a range of single-storey and two-storey industrial buildings, many of which were in a poor state of repair, particularly those fronting Trout Road.

The surrounding area comprises a mix of industrial uses, commercial uses and residential properties, with building heights ranging from two storeys up to five storeys. Both the former church immediately opposite the Site's High Street frontage and the George & Dragon Public House to the north are locally listed buildings. The Site is not located within a conservation area and does not contain any statutory listed or locally listed buildings.

The Site is allocated in the LBH Local Plan, adopted in 2020, for a mixed-use development which is to be brought forward '*in accordance with the broad parameters of the approved scheme, subject to site-specific constraints (Ref: 38058/APP/2013/1756)*'.

The proposal includes the phased redevelopment of the site to provide nine plots ranging between 3 storeys and 11 storey's in height (including ground level) to include residential units (Use Class C3), flexible retail/café/restaurant floorspace (Class E (a,b,c)), light industrial floorspace (Class E (g)(iii)), associated hard and soft landscaping, car parking, cycle parking, servicing, refuse and plant areas, public realm improvements, highways works and other works associated with the development

Figure 1 provides an indicative view of what the proposed development looks like.

Figure 1: Proposed Development

The approximate location and boundary of the application site is shown in Figure 2 on the next page.

Figure 2: Approximate location of application site

POLICY FRAMEWORK

This Whole Life-Cycle Carbon Assessment responds to the relevant whole life-cycle carbon policies of the London Plan. The most relevant applicable embodied carbon policies in the context of the proposed development are presented below.

THE LONDON PLAN (2021)

This Whole Life-Cycle Carbon Assessment responds to the relevant Whole Life-cycle Carbon Policies of the London Plan. The most relevant applicable embodied carbon policies in the context of the proposed development are presented below.

The London Plan (2021) published 2nd March 2021 sets out the Mayor's overarching strategic spatial development strategy for greater London and underpins the planning framework from 2019 up to 2041. This document replaced the London Plan 2016.

The London Plan has a strong sustainability focus with many policies addressing the concern to deliver a sustainable and zero carbon London, particularly addressed in chapter 9 - Sustainable Infrastructure.

The following policies, related to embodied carbon are of relevance for the proposed development:

POLICY SI 2 MINIMISING GREENHOUSE GAS EMISSIONS

The London Plan (2021) includes, under Policy SI 2 Minimising greenhouse gas emissions, a requirement for a Whole Life-Cycle Carbon Assessment for all referable development proposals.

F. Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.

Other supporting polices under the London Plan (2021) include SI 1 Improving Air Quality, SI 4 Managing Heat Risk, SI 5 Water Infrastructure and SI 7 Reducing Waste & Supporting the Circular Economy:

POLICY SI 1 IMPROVING AIR QUALITY

A. Development Plans, through relevant strategic, site-specific and area-based policies, should seek opportunities to identify and deliver further improvements to air quality and should not reduce air quality benefits that result from the Mayor's or boroughs' activities to improve air quality.
B. To tackle poor air quality, protect health and meet legal obligations the following criteria should be addressed:
1) Development proposals should not:
a) lead to further deterioration of existing poor air quality
b) create any new areas that exceed air quality limits, or delay the date at which compliance will be achieved in areas that are currently in exceedance of legal limits
c) create unacceptable risk of high levels of exposure to poor air quality.
2) In order to meet the requirements in Part 1, as a minimum:
a) development proposals must be at least Air Quality Neutral
b) development proposals should use design solutions to prevent or minimise increased exposure to existing air pollution and make provision to address local problems of air quality in preference to post-design or retro-fitted mitigation measures
c) major development proposals must be submitted with an Air Quality Assessment. Air quality assessments should show how the development will meet the requirements of B1
d) development proposals in Air Quality Focus Areas or that are likely to be used by large numbers of people particularly vulnerable to poor air quality, such as children or older people should demonstrate that design measures have been used to minimise exposure.
C. Masterplans and development briefs for large-scale development proposals subject to an Environmental Impact Assessment should consider how local air quality can be improved across the area of the proposal as part of an air quality positive approach. To achieve this a statement should be submitted demonstrating:
1) how proposals have considered ways to maximise benefits to local air quality, and
2) what measures or design features will be put in place to reduce exposure to pollution, and how they will achieve this.
D. In order to reduce the impact on air quality during the construction and demolition phase development proposals must demonstrate how they plan to comply with the Non-Road Mobile Machinery Low Emission Zone and reduce emissions from the demolition and construction of buildings following best practice guidance.
E. Development proposals should ensure that where emissions need to be reduced to meet the requirements of Air Quality Neutral or to make the impact of development on local air quality acceptable, this is done on-site. Where it can be demonstrated that emissions cannot be further reduced by on-site measures, off-site measures to improve local air quality may be acceptable, provided that equivalent air quality benefits can be demonstrated within the area affected by the development.

POLICY SI 5 WATER INFRASTRUCTURE

A. In order to minimise the use of mains water, water supplies and resources should be protected and conserved in a sustainable manner.
B. Development Plans should promote improvements to water supply infrastructure to contribute to security of supply. This should be done in a timely, efficient, and sustainable manner taking energy consumption into account.
C. Development proposals should:
1) through the use of Planning Conditions minimise the use of mains water in line with the Optional Requirement of the Building Regulations (residential development), achieving mains water consumption of 105 litres or less per head per day (excluding allowance of up to five litres for external water consumption)

2) achieve at least the BREEAM excellent standard for the 'Wat 01' water category160 or equivalent (commercial development)
3) incorporate measures such as smart metering, water saving and recycling measures, including retrofitting, to help to achieve lower water consumption rates and to maximise future-proofing.

D. In terms of water quality, Development Plans should:

1) promote the protection and improvement of the water environment in line with the Thames River Basin Management Plan, and should take account of Catchment Plans
2) support wastewater treatment infrastructure investment to accommodate London's growth and climate change impacts. Such infrastructure should be constructed in a timely and sustainable manner taking account of new, smart technologies, intensification opportunities on existing sites, and energy implications. Boroughs should work with Thames Water in relation to local wastewater infrastructure requirements.

E. Development proposals should:

1) seek to improve the water environment and ensure that adequate wastewater infrastructure capacity is provided

POLICY SI 7 REDUCING WASTE AND SUPPORTING THE CIRCULAR ECONOMY

A. Resource conservation, waste reduction, increases in material re-use and recycling, and reductions in waste going for disposal will be achieved by the Mayor, waste planning authorities and industry working in collaboration to:

1) promote a more circular economy that improves resource efficiency and innovation to keep products and materials at their highest use for as long as possible
2) encourage waste minimisation and waste prevention through the reuse of materials and using fewer resources in the production and distribution of products
3) ensure that there is zero biodegradable or recyclable waste to landfill by 2026
4) meet or exceed the municipal waste recycling target of 65 per cent by 2030
5) meet or exceed the targets for each of the following waste and material streams:

a) construction and demolition – 95 per cent reuse/recycling/recovery
b) excavation – 95 per cent beneficial use

6) design developments with adequate, flexible, and easily accessible storage space and collection systems that support, as a minimum, the separate collection of dry recyclables (at least card, paper, mixed plastics, metals, glass) and food.

B. Referable applications should promote circular economy outcomes and aim to be net zero-waste. A Circular Economy Statement should be submitted, to demonstrate:

1) how all materials arising from demolition and remediation works will be re-used and/or recycled
2) how the proposal's design and construction will reduce material demands and enable building materials, components and products to be disassembled and re-used at the end of their useful life
3) opportunities for managing as much waste as possible on site
4) adequate and easily accessible storage space and collection systems to support recycling and re-use
5) how much waste the proposal is expected to generate, and how and where the waste will be managed in accordance with the waste hierarchy
6) how performance will be monitored and reported.

C. Development Plans that apply circular economy principles and set local lower thresholds for the application of Circular Economy Statements for development proposals are supported.

LONDON PLAN (MARCH 2022) GUIDANCE - WHOLE LIFE-CYCLE CARBON ASSESSMENTS

The GLA has also published a Whole Life-Cycle Carbon Assessments Guidance (March 2022 which explains how to prepare a WLC assessment for planning application. As outlined in the WLC Assessments guidance applicants are required to take action at the following stages:

- Pre-application
- Stage 1 submission (i.e. RIBA Stage 2/3)
- Post-construction (i.e. upon commencement of RIBA Stage 6 and prior to the building being handed over, if applicable. Generally, it would be expected that the assessment

would be received three months post-construction)

The GLA has also published a WLCA template which provides separate tabs outlining the information that should be submitted at each stage. The London Plan Guidance for Whole Life-Cycle Carbon Assessments (March 2022) sets out benchmarks based on previous project assessments. These benchmarks should be used as a guide, providing a range rather than a set value to achieve, and are broken down into life-cycle modules.

A further set of aspirational WLC benchmarks have also been developed which are based upon a 40% reduction in WLC embodied carbon on the first set of WLC benchmarks.

Table 3 outlines these benchmarks in further detail.

Table 3: GLA WLC Benchmark for Residential

Modules	WLC benchmark	Aspirational WLC benchmark
	Kg CO_2e per m^2 (GIA)	
A1-A5 (excluding sequestration)	<850	<500
B-C (excluding B6 & B7)	<350	<300
A-C (excluding B6 & B7, including sequestration)	<1200	<800

METHODOLOGY

The methodology followed in preparing this report is in line with the Royal Institute of Chartered Surveyors (RICS) professional statement (PS) and London Plan Guidance on Whole Life-Cycle Carbon Assessments for undertaking detailed carbon assessments. The RICS Whole life carbon assessment for the built environment (2023), follows the European standard EN 15978.

This report summarises the actions taken during Stage 2 (Concept Design). The applicant recognises that the Whole Life-Cycle Carbon calculations presented in this report will need to be revisited and if appointed, amended at post-construction stage (upon commencement of RIBA Stage 6).

LIFE CYCLE STAGES

The life cycle stages covered by the RICS methodology refer to EN 15978, which includes a modular approach to a built asset's life cycle, breaking it down into different stages, as shown in Table 4.

The four main modules are Product stage [A1 – A3], Construction Process stage [A4 – A5], Use stage [B1 – B7] and End of Life stage [C1 – C4]. Module D consists of the potential environmental benefits or burdens of materials beyond the life of the project, and this is usually reported separately to the cradle to grave modules [A – C].

Table 4 shows the life-cycle stages that were considered for the assessment and the assumptions made for some stages due to limitations of the software used.

Table 4: Life-cycle Stages considered for this analysis.

Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits and loads beyond the system boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

BUILDING ELEMENTS

The WLC assessment covers all building elements listed in Table 5 (where applicable). Material quantities have been provided by the Quantity Surveyor (Rund). A minimum of at least 95% of the cost allocated to each building element category has been accounted for where information has been given, in line with GLA policy.

Table 5: Building elements as per RICS NRM

Group	Building Element	Applicable	Included
0. Demolition & facilitating works	0.1. Toxic / hazardous / contaminated material treatment	N	N
	0.2. Major demolition works	Y	Y
	0.3. & 0.5. Temporary / enabling works	N	N
	0.4. Specialist groundworks	N	N
1. Substructure	1.1. Substructure	Y	Y
2. Superstructure	2.1. Frame	Y	Y
	2.2. Upper floors incl. balconies	Y	Y
	2.3. Roof	Y	Y
	2.4. Stairs & ramps	Y	Y
	2.5. External walls	Y	Y
	2.6. Windows & external doors	Y	Y
	2.7. Internal walls & partitions	Y	Y
	2.8 Internal doors	Y	Y
3 Finishes	3.1 Wall finishes	Y	Y
	3.2 Floor finishes	Y	Y
	3.3 Ceiling finishes	Y	Y
4 Fittings, furnishings & equipment	4.1 Fittings, furnishings & equipment	Y	Y
5 Building services / MEP	5.1–5.14 Services	Y	Y
6 Prefabricated Buildings and Building Units	6.1 Prefabricated buildings and building unit	N	N
7 Work to existing building	7.1 Minor demolition and alteration works	N	N
8 External works	8.1 Site preparation works	Y	Y
	8.2 Roads, paths, paving and surfacing	Y	Y
	8.3 Soft landscaping, planting and irrigation systems	Y	Y
	8.4 Fencing, railings and walls	Y	Y
	8.5 External fixtures	Y	Y
	8.6 External drainage	Y	Y
	8.7 External services	N	N
	8.8 Minor building works and ancillary buildings	N	N

SOFTWARE TOOLS

The Bionova OneClick LCA tool, is BRE certified & ensures each EPD included in their database is independently verified. It allows a project to conduct a building lifecycle assessment that aligns with core industry guidance.

LIFECYCLE INVENTORY & DATABASES

One Click LCA integrates data from nearly all available EPD platforms from around the globe as well as EPD data that has not been published under any of these databases. This is done using a 10-point verification process that has been reviewed by the Building Research Establishment (BRE).

These databases are constantly being updated, as EPD's typically only have a validity period of 3 or 5 years, meaning that after this period the emissions of the EPD would have to be recalculated for the EPD to remain valid. Any recalculation then carries with it a risk, that the results will differ from those of the previous EPD.

As such, over time it is expected that results for a building life-cycle assessment will also be subject to a certain level of flux as the constituent EPD data is recalculated to remain valid. For instance, this may mean that a building life-cycle assessment undertaken a year ago and one today could have different results even if modelled using the exact same materials.

MATERIALS & PRODUCTS

WLC calculations have been carried out using:

- Type III environmental declarations (Environmental Product Declaration (EPD)[1] and equivalent) and datasets in accordance with BS EN 15804; and,
- EPDs and datasets in accordance with ISO 14025 and ISO 14040/44.

Sequestered (biogenic) carbon from the use of timber has been reported separately for A1-A3 stages.

Embodied carbon is difficult to calculate for many MEP systems due to a lack of available data. Where manufacturer specific data was not available, figures for embodied carbon have been taken from the closest matching system within the One Click LCA database. In cases where there are no comparable systems, embodied carbon has been calculated based on the key materials used to manufacture the equipment, by weight.

BIOGENIC CARBON SEQUESTRATION

Biogenic carbon is the carbon that is stored in biological materials, such as timber. This process is commonly referred to as sequestration.

Carbon accumulates in plants through the process of photosynthesis and therefore wood products can contribute to reducing the levels of carbon dioxide in the atmosphere and help mitigate climate change.

When a bio-based material is used for a building product, the carbon will be stored as long as the material service life or until the end of life of the building. Biogenic carbon must be reported separately if reporting only upfront carbon but should be included in the total if reporting embodied carbon or whole life carbon.

[1] An Environmental Product Declaration (EPD) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products in a credible way. (Environdec)

RESULTS

The proposed development is for the demolition of existing structures and phased redevelopment of the site to provide nine plots ranging between 3 storeys and 11 storeys in height (including ground level) to include residential units (Use Class C3), flexible retail/café/restaurant floorspace (Class E (a,b,c)), light industrial floorspace (Class E (g)(iii)), associated hard and soft landscaping, car parking, cycle parking, servicing, refuse and plant areas, public realm improvements, highways works and other works associated with the development.

The substructure consists of a concrete piling foundation, pile caps and RC ground floor slab. The superstructure consists of RC core walls, columns and beams alongside RC upper floor and roof slabs. The external walls consist of a brickwork façade with Metsec frame, including insulation, membranes and fibre cement board.

shows the results of the study, which is the scenario that was chosen to form the basis of design decisions. The results show that the highest contribution to the whole life embodied carbon of the project is produced at *Operational Energy and Water Stage & Use Stage*, accounting for about 43% of the total embodied carbon of the building during its lifetime.

The other contributors, the Product Stage and Use Stage account for 33% and 18% of embodied carbon respectively over the lifetime of the building.

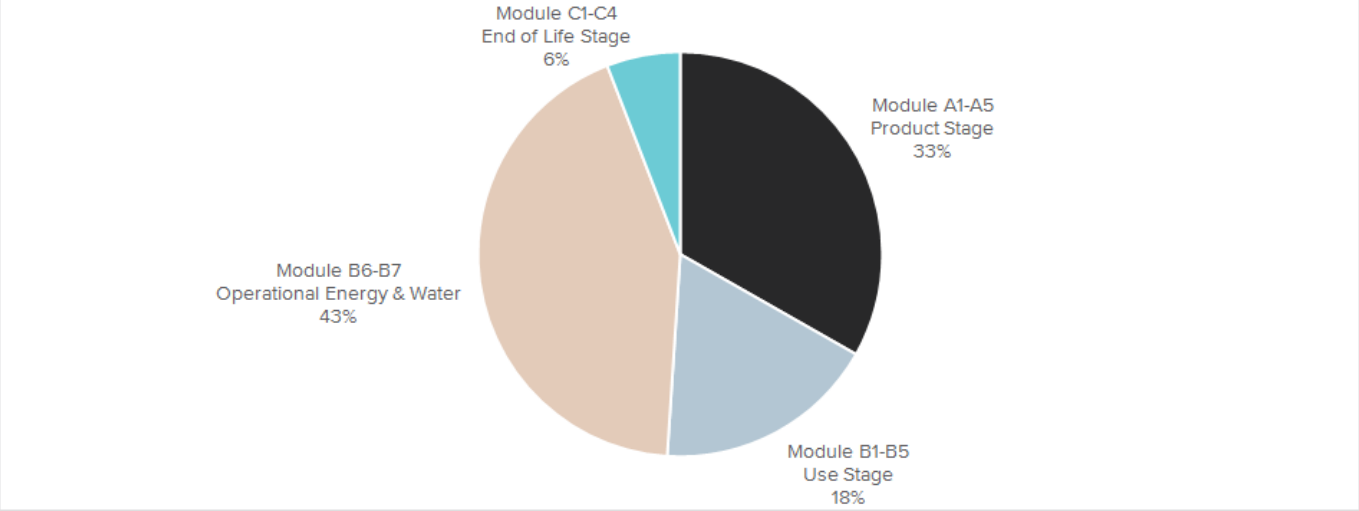

Figure 3 Estimated Whole Life-cycle Carbon by Life-Cycle Assessment Module (KgCO2e)

Figure 4 & Figure 5 overleaf show the embodied carbon by building element type. As can be seen from the figures, the element type that has the highest contribution to the embodied carbon for the project is the Superstructure followed by Services and Finishes elements and then the Substructure building elements.

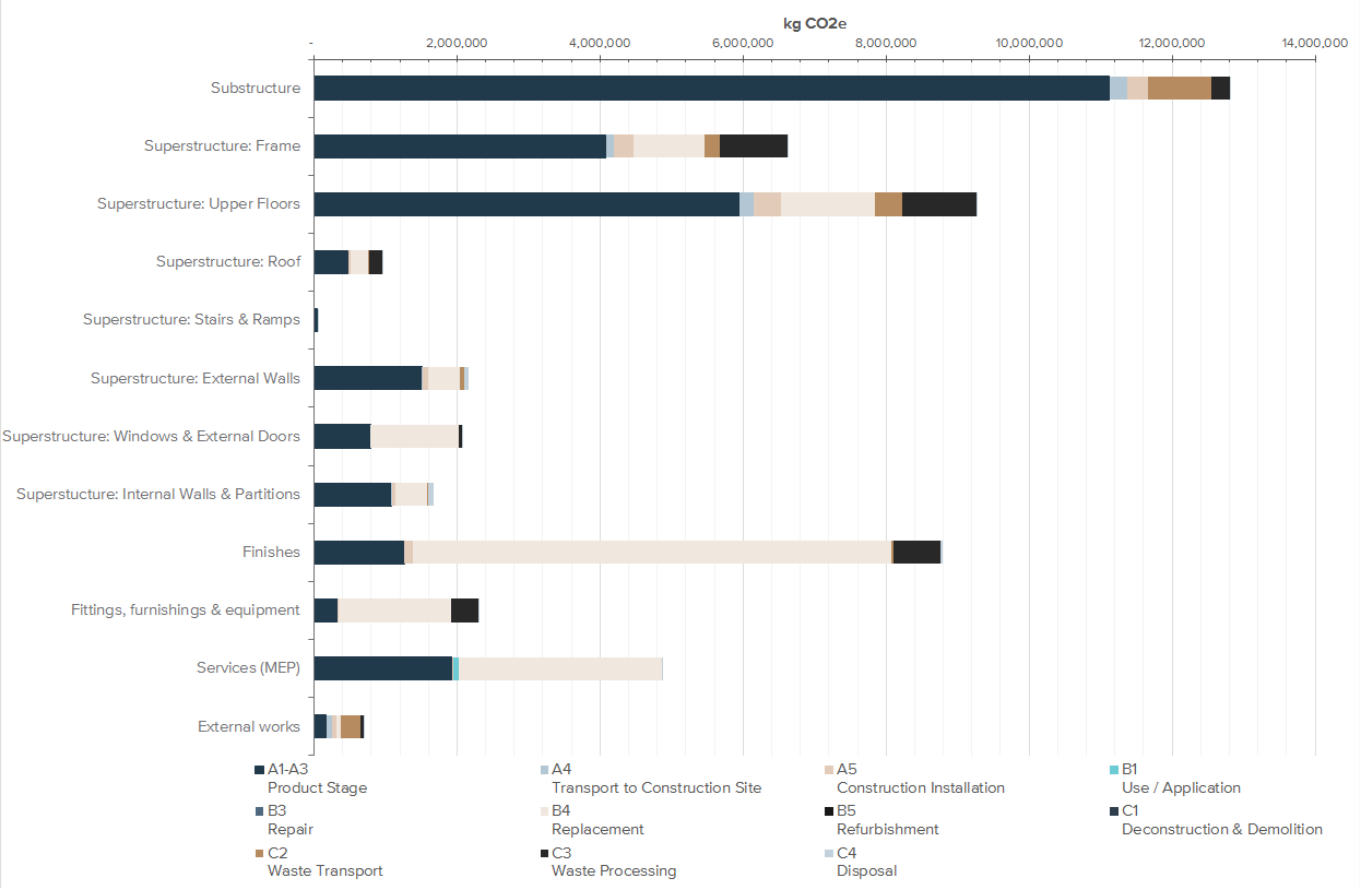

Figure 4 Estimated Whole Life-cycle Carbon by building element category (Kg CO2e)

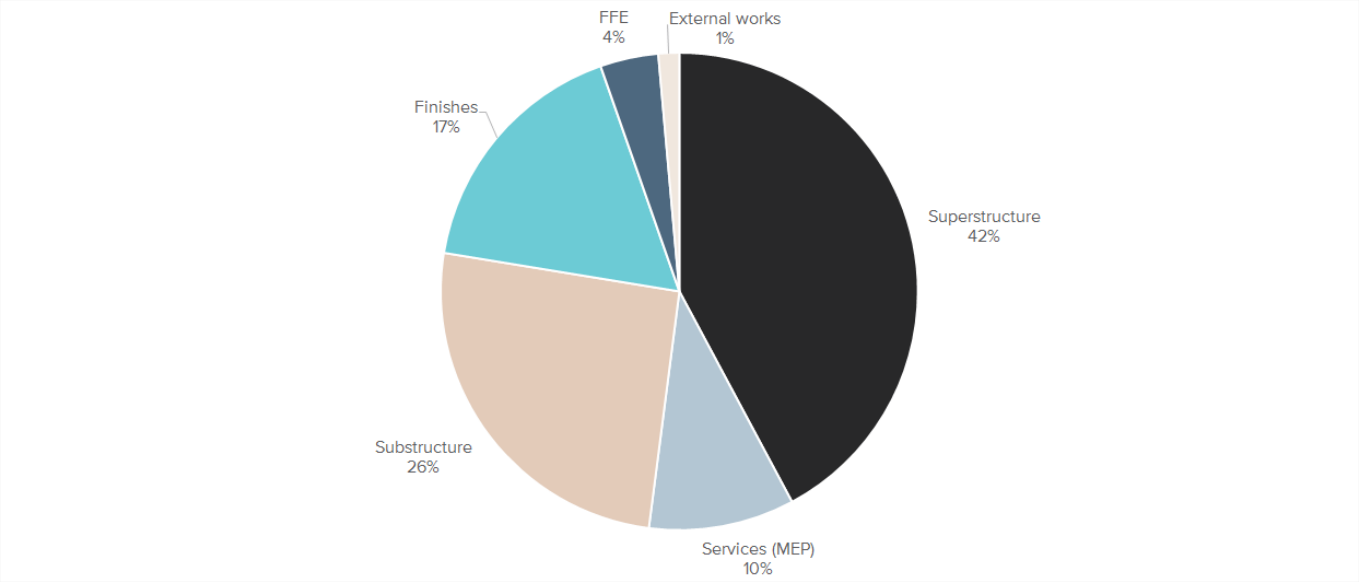

Figure 5 Estimated Embodied Life-cycle Carbon by building element category (%)

REDUCTION MEASURES

Proposed carbon reduction measures were discussed with the team, and carbon reductions were incorporated into the proposed scheme as follows:

1. The use of 25% GGBS within concrete mixtures used for foundation, sub-structure and superstructure building elements.

The use of these reduction measures results in carbon reductions of -1,903,000kg CO2e over the projects lifetime. Detailed results can be found in below comparing the 'Business-as-Usual' assessment, (the assessment where no improvements to the design have been implemented to reduce the whole life carbon of the design), and the 'Proposed' assessment (the assessment where the measures detailed above have been implemented).

Table 6 Implemented Whole-life carbon reduction measure(s) (A-C (excluding B6 & B7, including sequestration))

Scenario	Total Kg CO_2e	TOTAL kg CO_2e/m^2 GIA	Reduction - Kg CO_2e	Percentage Reduction %
Business as Usual Assessment	54,299,000	1287	-	-
Proposed Assessment	52,396,000	1242	-1,903,000	-4%

POTENTIAL REDUCTION MEASURES

In addition to the above, additional potential measures were explored to further reduce the Life-Cycle embodied carbon from the proposed development.

The following LCA embodied carbon reduction opportunities will be investigated, with a view to achieving further reductions in embodied carbon as illustrated in .

Table 7 Potential further Whole-life carbon reduction measures (A-C (excluding B6 & B7, including sequestration))

Scenario	Total Kg CO_2e	TOTAL kg CO_2e/m^2 GIA	Reduction - Kg CO_2e	Percentage Reduction %
Scenario 1 – Brickwork cladding system	53,619,000	1271	-680,000	-1%
Scenario 2 - Timber-aluminium composite windows	54,085,000	1282	-214,000	-0.4%
Scenario 3 - 50% GGBS in concrete mixes	50,732,000	1203	-3,567,000	-7%

SCENARIO 1 – BRICK EFFECT CLADDING

Iteration 1 proposes the implementation of further embodied carbon reduction measures including:

- the specification of lightwork brick effect cladding system for the entire façade of the superstructure

Bricks are carbon intensive to produce, and thus specifying lightwork brick effect cladding system could result in a notable reduction of around 680,000 kg CO_2e in embodied carbon associated with those elements. Further detail can be found within Table 8 and **Error! Reference source not found.Error! Not a valid bookmark self-reference.**.

SCENARIO 2 – TIMBER-ALUMINIUM COMPOSITE WINDOWS

Scenario 2 proposes the implementation of further Embodied Carbon reduction measures including:

- Specifying Timber-Aluminium composite windows

An option looking at replacing the uPVC windows with timber-aluminium composite windows would result in a reduction of 214,000 kg CO_2e in embodied carbon associated with those elements. Further detail can be found within Table 8 and **Error! Reference source not found.Error! Not a valid bookmark self-reference.**.

SCENARIOS 3 – SUPPLEMENTARY CEMENTITIOUS MATERIAL BLENDS

Cement within concrete is one of the most carbon-intensive materials within the project, and the specification of Supplementary Cementitious Material Blends or SCMs can have a large impact in reducing the embodied carbon associated with its use. Further detail can be found within Table 8 and **Error! Reference source not found.Error! Not a valid bookmark self-reference.**.

Supplementary Cementitious Material Blends, is a catch all term used to describe a wide variety of materials that can be added to concrete mixtures, these include:

- Fly Ash; a by-product of coal combustion in electricity generating power plants.
- Ground Granular Blast Furnace Slag (GGBS); a by-product of the manufacture of iron and steel. (Our chosen option)
- Silica Fume; also known as micro silica this is a by-product material created from the reduction of high purity steel with coal in an electric arc furnace
- Calcium Carbonate Fines (CCF's); a limestone filler material that can help to accelerate the hydration of cement leading to earlier strengths and improving durability of concrete.
- Natural Pozzolans (Such as calcined clays, shale and metakaolin); a variety of naturally occurring materials that have pozzolanic qualities.

In addition to reducing the associated embodied carbon intensity of concretes they are added to, these materials have a variety of other reasons for use such as improving durability, decreasing permeability, aiding pumpability and finishability, mitigating alkali reactivity and improving the overall hardened properties of concrete through hydraulic and pozzolanic activity or both.

Scenarios 3 propose the implementation of further Embodied Carbon reduction measures, including:

- the use of 50% GGBS in Foundations, Substructure and Superstructure concrete mixes.

The use of GGBS rates of 50% in Foundations, Substructure and Superstructure could result in a reduction of 3,567,000 kg CO_2e in embodied carbon associated with those elements.

Table 8 Estimated life-cycle embodied carbon for all assessment options (kg CO_2e)

Scenario	Sequestered (biogenic) Carbon	Module A1-A5	Module B1-B5	Module B6-B7	Module C1-C4	Module D
Business-as-Usual	-3,118,058	34,307,261	17,365,689	42,010,745	5,743,736	-7,200,285
Proposed	-3,118,058	32,404,471	17,365,689	42,010,745	5,743,736	-7,128,966
Scenario 1 - Brickwork cladding system	-3,118,058	33,674,299	17,365,689	42,010,745	5,696,637	-7,187,545
Scenario 2 - Timber-aluminium composite windows	-3,114,194	34,232,951	17,258,566	42,010,745	5,707,059	-7,209,786
Scenario 3 - 50% GGBS in concrete mixes	-3,118,058	30,742,278	17,365,689	42,010,745	5,741,912	-7,089,213

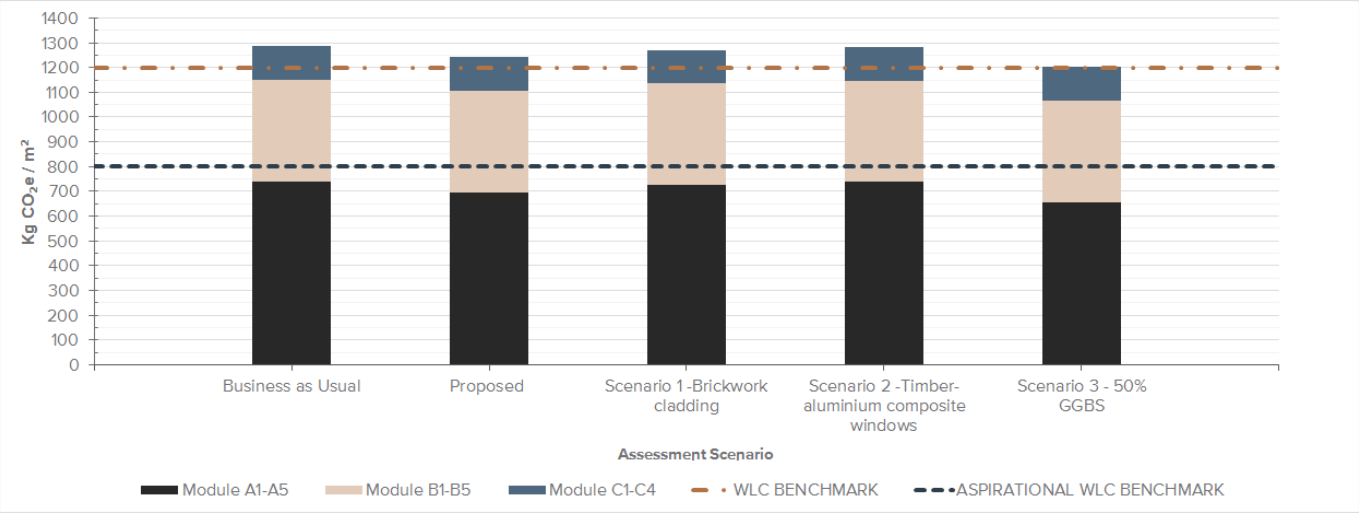

Figure 6 Estimated Life-Cycle Embodied Carbon by Assessment Scenario

CONCLUSION & RECOMMENDATIONS

A Life-Cycle Embodied Carbon assessment has been undertaken for the proposed development at Trout Road within the London Borough of Hillingdon. The embodied carbon assessment has been carried out in accordance with the latest published GLA 'Whole Life-Cycle Carbon Assessments Guidance (March 2022) as well as the RICS Whole Life Carbon Assessment for the Built Environment Guidance (1st Edition, 2017).

The results show that the highest contribution to the embodied carbon of the project are expected to be the 54,298,628 kg CO_2e. The following options should be implemented in order to reduce the building's whole life embodied carbon:

- The use of 25% GGBS within concrete mixtures used for foundation, sub-structure and superstructure building elements.

Comparing this to the modelled 'Business as Usual' case of 'no improvements implemented beyond the cost plan quantities', this strategy allowed a predicted reduction in embodied carbon of 1,903,000 kg CO2e, equivalent to 4% of the total life-cycle embodied carbon. The estimated life-cycle embodied carbon assessment option is captured in Table 9 as our recommended option.

A number of additional opportunities for carbon reduction were identified to be investigated at the next stage, with a view to achieving further reductions in whole life carbon, as outlined in Table 10. The largest potential reduction could be the use of 50% GGBS within concrete mixtures used for foundation, sub-structure and superstructure building elements.

Table 9: Estimated life-cycle embodied carbon for the proposed assessment (A-C (excluding B6 & B7, including sequestration))

Assessment	Sequestered (biogenic) Carbon	Module A1-A5	Module B1-B5	Module B6-B7	Module C1-C4	Module D
TOTAL kg CO_2e	-3,118,058	32,404,471	17,365,689	42,010,745	5,743,736	-7,128,966
TOTAL kg CO_2e/m^2 GIA	-80	770	420	1,000	140	-170

Table 10: Potential reduction measures scenarios (A-C (excluding B6 & B7, including sequestration))

Scenario	Total Kg CO_2e	TOTAL kg CO_2e/m^2 GIA	Reduction - Kg CO_2e	Percentage Reduction %
Business-as-Usual	-3,118,058	34,307,261	17,365,689	42,010,745
Proposed	-3,118,058	32,404,471	17,365,689	42,010,745
Scenario 1 -Brickwork cladding system	-3,118,058	33,674,299	17,365,689	42,010,745
Scenario 2 - Timber-aluminium composite windows	-3,114,194	34,232,951	17,258,566	42,010,745
Scenario 3 - 50% GGBS in concrete mixes	-3,118,058	30,742,278	17,365,689	42,010,745

BENCHMARKING

Following the GLA Whole Life-Cycle Carbon assessments guidance, the estimated embodied carbon has been compared against the benchmark provided by the GLA in the WLC assessments guidance, shown in Appendix B. The results of Modules A1-A5 and B & C, have been compared against the WLC benchmark for apartments, and the Aspirational WLC benchmark which is based on the World Green Building Council's target to achieve a 40% reduction in whole life-cycle embodied carbon by 2030.

The results in Table 8 show the WLC Benchmark figures for a Residential building, and estimated embodied carbon of the proposed development. The anticipated embodied carbon of the proposed development is below/above the WLC benchmark for Modules A1-A5.

Results for Modules B-C are below/above the WLC Benchmark, as such it is indicated that the project currently surpasses/does not achieve the GLA's targets.

The results show the estimated embodied carbon calculated based on the information available to date and provided by the design team. At the current design stage there is a high level of uncertainty in terms of specified materials as well as maintenance/use and end of life considerations. These will be reviewed at the next stage when specifications are detailed.

Table 11: GLA WLC Benchmark for Residential

Modules	WLC benchmark	Aspirational WLC benchmark	Trout Road – Proposed Scheme
	Kg CO_2e per m^2 (GIA)		
A1-A5	<850	<500	770
B-C (excluding B6 & B7)	<350	<300	550
A-C (excluding B6 & B7)	<1200	<800	1250

RECOMMENDATIONS

The Trout Road development is currently not/achieving the GLA benchmark whole-life carbon targets.

As such, next steps for the project should the following recommendations to ensure that the GLA benchmarks for Whole-life carbon are considered and to increase the accuracy of reporting at subsequent stages:

1. *Adopt and retain all measures in Proposed Option*

   The WLC figures are below/above to the benchmark targets, with the incorporation of the measures in the Proposed Option (measures TBC). It is recommended that all of these measures are retained as the design progresses to ensure that the embodied carbon figures do not rise above the GLA targets.

2. *Adopt additional options into design.*

   Furthermore, it is recommended that as many as possible of the additional WLC reduction options explored are adopted. Measure TBC savings for example, and XCO2 recommend that this is explored in more detail in subsequent stages.

3. *Work with contractor to accurately calculate formwork reuse quantities.*

   For the accurate calculation of reused formwork, it is recommended to have a workshop early from the appointment of the main contractor to understand the optimum minimum quantities of plywood required based on the construction programme and concrete drying times. This will enable a more accurate assessment of the savings possible through reuse throughout the construction process.

4. *Appoint Cost Consultant for accurate cost plans at subsequent stage WLCAs.*

   While the material quantity calculations for this assessment have been undertaken by XCO2 using drawings provided, for subsequent detailed design and construction stage WLCAs it will be necessary to have appointed a Quantity Surveyor and utilise cost plan quantities, to ensure robustness of the measurements and alignment with the construction costing estimates.

5. *Third-Party Assessment*

   To further ensure the robustness of this assessment, 3rd party verification of the embodied carbon life-cycle analysis (LCA) referenced in this report would provide a level of additional rigor to the model and results.

While it is recommended that other options (such as those listed in this report) for reducing the proposed developments embodied carbon can and should be considered, any decisions taken should take into account the current stage of the project (Concept Design) which may limit or impact on the implementation of such options.

APPENDIX A – SITE PLANS

APPENDIX B – ESTIMATED EMBODIED CARBON ASSESSMENT RESULTS IN FULL

Building element		KG's of carbon dioxide equivalent															
		Biogenic carbon	A1-A3 Product Stage	A4 Transport to Site	A5 Construct. works	B1 Use	B2 Maintenance	B3 Repair	B4 Replace	B5 Refurbish	B6 Regulated Energy Use	B6+ Unrig. Energy Use	B7 Water Use	C1 Deconst. & Demo.	C2 Waste Transport	C3 Waste Process	C4 Disposal	D Benefits & loads beyond system boundary
0.1	Demolition: Toxic / Hazardous / Contaminated Material Treatment																	
0.2	Major Demolition Works													12,250				
0.3	Temporary Support to Adjacent Structures																	
0.4	Specialist Ground Works																	
0.5	Temporary Diversion Works																	
1	Substructure	-207,100	11,292,993	244,417	298,370			0							888,078	254,985	3,526	-1758895.89
2.1	Frame	-925,974	4,597,283	109,464	297,328			0	998,133	0					216,781	942,951	7,924	-926579.43
2.2	Upper Floors	-1,023,898	7,089,494	193,678	438,279			0	1,313,967	0					376,605	1,045,867	9,458	-1286693.22
2.3	Roof	-177,314	478,855	2,742	31,814			0	245,407	0					11,274	181,677	1,512	-100051.45
2.4	Stairs & Ramps	0	48,146	1,843	2,480			0							3,525	99	7	-10534.43
2.5	External Walls	0	1,508,992	10,905	79,977			0	433,979	0					65,916	2,424	54,913	-92856.36
2.6	Windows & External Doors	-3,863	791,958	1,289	0			0	1,228,652	0					3,788	36,887	765	-422681.56
2.7	Internal Walls & Partitions	0	1,082,354	3,783	50,069			0	441,292	0					22,249	486	72,992	-126201.86
2.8	Internal Doors	-57,803	41,926	212	0			0	84,433	0					623	58,300	394	-22417.36

3	Finishes	-372,352	1,262,024	6,086	111,379			0	6,697,729	0					30,714	656,262	20,469	-149384.03
4	Fittings, furnishings & equipment	-349,752	332,840	2,399	9,727			0	1,566,727	0					3,907	377,892	2,158	-393534.47
5	Services (MEP)	0	1,930,941	4,155	11,795	74,289		0	2,841,763	0	15,687,112	26,323,633			6,545	565	8	-1292441.13
6	Prefabricated Buildings & Building Units																	
7	Work to Existing Building																	
8	External works	0	173481.83	81934.48	53136.51			0	70561.41	0					274908.56	44579.75	579.66	-114534.91
-	Other or overall site construction				527048.63													
-	Unclassified	0	1053831.14	19142.08	28685.78		421790	105447.5	841519.6	0					36512.52	12292.53	86.37	-503478.91

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