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Whole Life Carbon Assessment

City House, Sutton

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Version	Date	Produced By	Checked By
Draft for client issue	15/12/24	M.Gontikaki	H.Cormick
Final report for external issue	02/02/24	A.Dhesi / M.Gontikaki	H.Cormick / C.Behar

Executive Summary

Executive summary
Performance overview

The proposed City House development has been appraised according to the 'London Plan Whole Life Carbon Statement Guidance' (2022). The proposed development is expected to achieve the carbon benchmarks set out by the GLA and summarised in Table 1.

Table 1: Performance of the proposed City House development against GLA Carbon Benchmarks

Whole Life Carbon	**1,450** $kgCO_2e/m^2$		
Embodied Carbon [A-C, excl. B7, B7]	**915** $kgCO_2e/m^2$	**63% of whole life carbon**	**-24% to GLA benchmark**
Upfront Carbon [A1-A5]	578 $kgCO_2e/m^2$	40% of whole life carbon	-32% to GLA benchmark
In-use, end-of-life carbon [B1-B4, C1-C4]	337 $kgCO_2e/m^2$	23% of whole life carbon	-4% to GLA benchmark
Operational carbon [B6, B7]	**535** $kgCO_2e/m^2$	**37% of whole life carbon**	-

The proposed City House development has successfully met the GLA whole life carbon benchmarks by embedding a variety of carbon saving measures in the early-stage design, as described in Section 4. These include lean design of foundations and superstructure, condensing the building form, specifying a refrigerant with low global warming potential for heating/cooling systems and balancing cut and fill for external works to minimise raw material demand.

Based on the design information available at this stage, the upfront carbon and in-use/end-of-life carbon for the proposed development is expected to lie around 12% above the threshold for GLA 'Aspirational' classification. A selection of the 'further carbon saving opportunities' outlined in Section 5 have been appraised for an estimated carbon saving of 111 $kgCO_2e/m^2$. If the estimated carbon savings associated with these measures were implemented within the City House scheme, the proposal could achieve 'Aspirational' status and serve as an exemplar low-carbon development. These measures will be explored in future design stages and taken forward where possible.

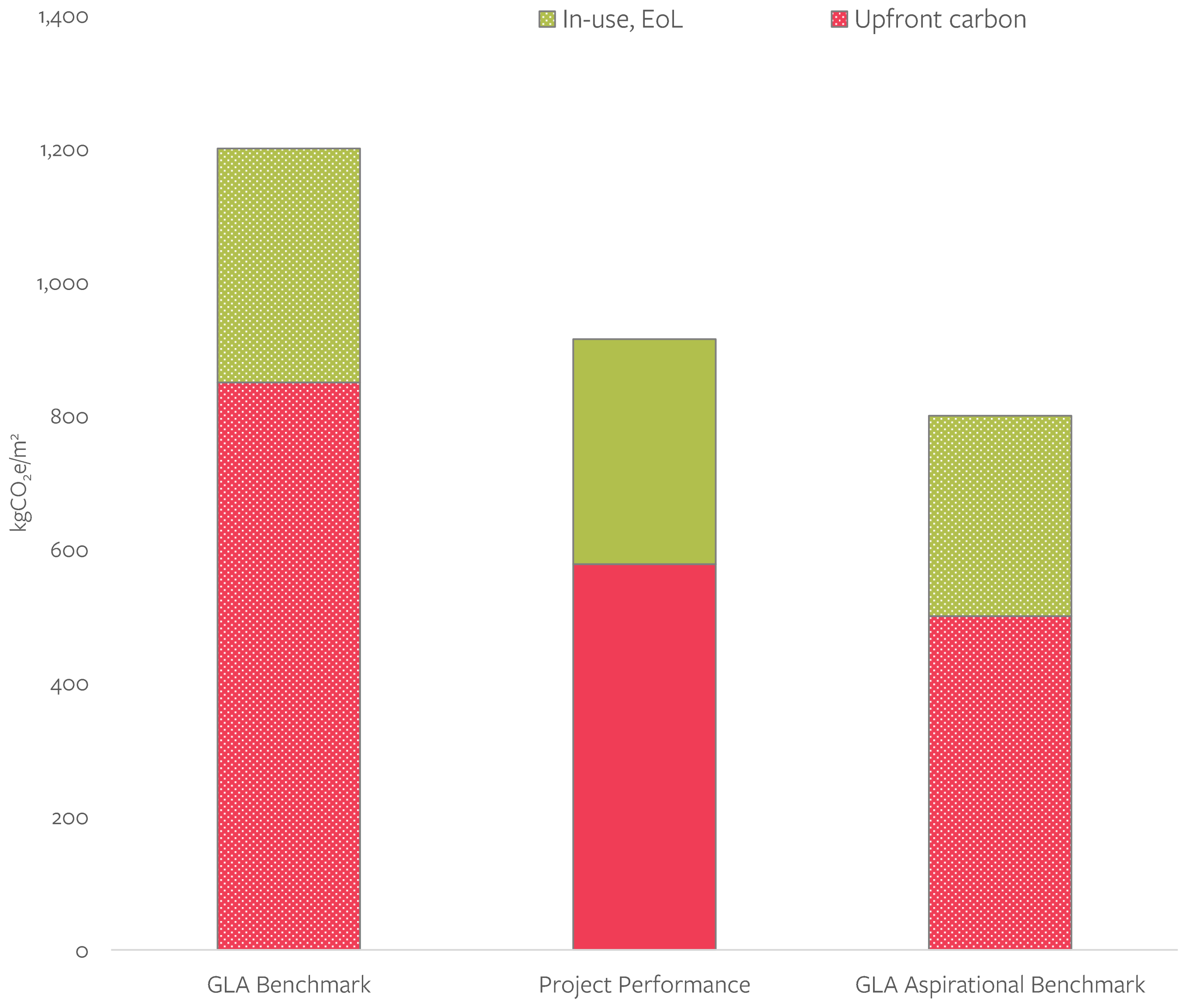


Figure 1: Performance of the proposed City House development against GLA Carbon Benchmarks

1/ Introduction

Introduction
Purpose & structure of the study

Purpose of the study

The whole life carbon assessment (WLC) for City House, in the London Borough of Sutton, presents a robust estimate of the performance of the scheme and demonstrates that the design proposals set the project on track to meet its sustainability aspirations. This study is submitted in support of the scheme's detailed planning application and aligns with the London Plan's Guidance on Whole Life-Cycle Carbon Assessments.

Structure of the report

The main body of the report aims to summarise the key design measures adopted to reduce carbon emissions and how the WLC principles have informed the proposals. It also outlines the assessment's methodology and results. The GLA's WLC assessment template is provided as an Appendix to this report.

The following sections comprise the main body of the report:

- An overview of the project, the policy context, WLC targets & principles
- WLC assessment methodology including limitations, assumptions and data quality assessment
- WLC results and analysis
- Key carbons savings measures included in the proposed design
- Further opportunities & next steps

A note on units
This report describes carbon emissions in terms of tonnes or kilogrammes of '**CO_2e**' or '***carbon dioxide equivalent***'. This is a standard unit used to normalise the global warming potential of all greenhouse gas emissions under an equivalent mass of carbon dioxide.
Where, for example, '**kgCO_2e/m^2**' is used, this refers to the carbon dioxide equivalent emissions ***per metre squared gross internal area*** (GIA) for the development.

Figure 2: Proposed City House conceptual sketch (c/o Wimhurst Pelleriti)

Introduction
Project overview

The proposed City House development is a residential-led development in Sutton, South London comprising a split-level single massing building of 5 and 13 storeys with a commercial ground floor. The development is located adjacent to Sutton Baptist Church, a grade II* listed building and sits on the corner of two A-roads, Carshalton Road and Sutton Park Road. There is an existing 4 storey commercial building located on the site as well as a car park.

Table 3 : Proposed development provision overview

Total provision	6,900m² GIA Split level single massing of 5 and 13 storeys
Residential	6,645m² GIA 70 units
Commercial	255m² GIA
Infrastructure and public realm	580m² hard landscaping 340m² soft landscaping 2 Blue Badge car parking spaces 113 cycle parking spaces

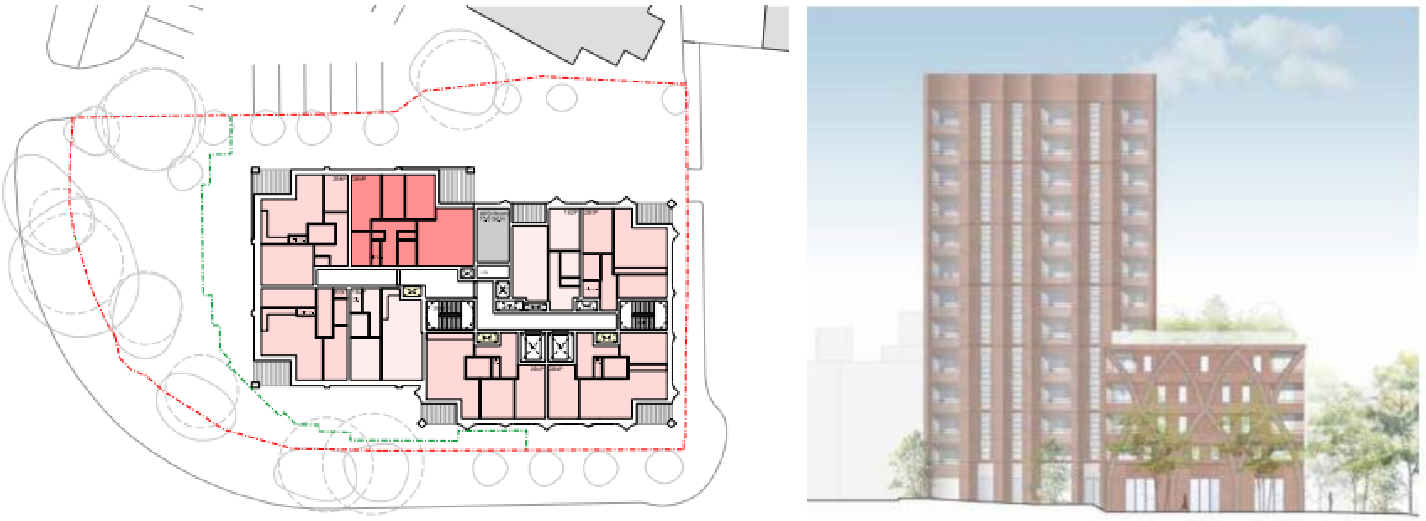


Figure 3: Typical floor plan and elevation of the proposed development (c/o Wimhurst Pelleriti)

The bill of materials (BOM) used in the creation of this Whole Life Carbon Statement and as well as the Circular Economy Statement has been based on early-stage designs as provided by the design team; material and product specifications have not yet been finalised, therefore generic specifications have been used for material quantity and embodied carbon calculations.

Table 4: City House proposed Bill of Materials summary

Building element	Design features
Substructure	• Steel-reinforced concrete pile foundations below a concrete ground floor slab
Superstructure	• 225mm thick steel-reinforced concrete slabs (including flat roof slab) • Steel-reinforced rigid concrete frame with bolt-on metal balconies • Stud-framed plasterboard internal and partition walls with acoustic lining, painted plaster finish • 'Stairmaster' staircases
Façade	• Precast concrete panels with brick façade finish • Double glazed aluminium frame windows • Metsec frame with Rockwool insulation
Interior finishes	• Suspended ceiling systems, painted plasterboard finish • Oak veneer internal doors with timber painted frames and stainless steel ironmongery • Engineered wood flooring to main living areas, tiled flooring to bathrooms and ensuites, carpets to bedrooms
FFE	• General allowance made for FFE
MEP	• Mitsubishi CAHV-R450 YA air-source heat pump • ARBE AF-PVW thermal store • Danfoss Flatstation 7 heat interface unit • MRXBOX ECO2AB mechanical ventilation with heat recovery • Lifts (2)
External works	• Permeable block paving for vehicular access • Permeable flag paving for entrances • Grasscrete parking spaces • Resin-bound aggregate footpaths • Safety rubber surfaced play area • Artificial grass areas • SUDS attenuation (plastic crates) at ground level (integrated within above build-ups)

Introduction
Policy context

London Plan (2021)

The Mayor is committed to London becoming a zero-carbon city. As London's homes and workplaces are responsible for around 78% of the city's carbon footprint, new development and major refurbishment projects are required to meet ambitious targets for whole life carbon, outlined in London Plan policy SI 2: *Minimising greenhouse gas emissions.*

In line with policy SI 2, major development proposals are expected to **undertake whole life-cycle carbon assessments** and demonstrate that actions have been taken to reduce embodied carbon emissions.

In 2022 guidance on how to prepare WLC assessments was issued, covering the required process & methodology, reporting content by project stage as well as information on principles and GLA benchmarks. A WLC reporting template accompanied the guidance, which applicants are expected to use to report the required information to Local Authorities and the GLA.

This guidance stipulates that WLC assessments should be undertaken at pre-application (where relevant), planning application stages (outlined and detailed) and at post-construction. They should be undertaken in line with BS EN 15978:2011 *Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method,* with RICS Professional Statement (PS) *Whole Life Carbon assessment for the built environment* (*the RICS PS*) used as the methodology framework (with some exceptions).

The assessments are meant to cover the development's emissions over its lifecycle, accounting for:

- Pre-construction and demolition activities;
- Carbon savings achieved through the retention, reuse and recycling of existing structures and materials;
- Total operational carbon emissions (regulated and unregulated) and life-cycle embodied carbon emissions; and,
- Future potential carbon savings post end-of-life of the development, stemming from the reuse and recycling of building's structure and materials.

The assessment for City House responds to London Plan Policy SI 2 and adheres to the GLA's guidance. The GLA reporting template is included as an Appendix to this report.

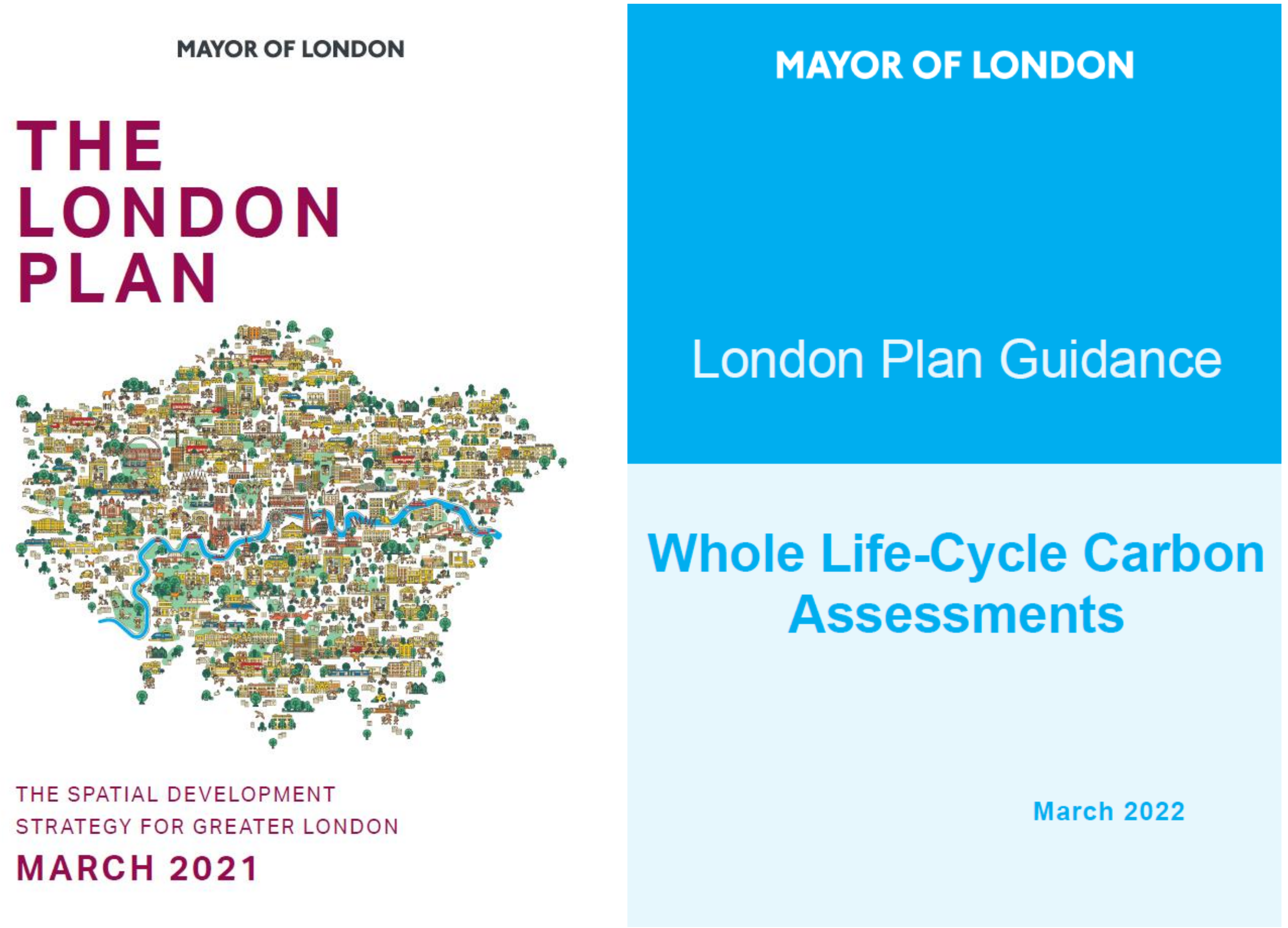


Figure 4: Key policy documents – London Plan and Whole Life Carbon Statement Guidance

Introduction
WLC benchmarks

The City House development has been compared against the residential whole life carbon benchmarks as over 95% of the GIA is designated for residential use.

The scheme is targeting the GLA's benchmark for residential developments of 1,200 $kgCO_2e/m^2$ embodied carbon (A-C), with no more than 850 $kgCO_2e/m^2$ upfront carbon (A1-A5). The whole life carbon assessment has also considered the GLA's 'aspirational' benchmark, with recommendations provided to further embed carbon-saving measures targeting this accreditation in future design stages.

Table 5: LETI embodied carbon bands for residential buildings with industry targets and GLA benchmarks

Band	Office	Residential	Education	Retail
A++	<150	<150	<125	<125
A+	<345	<300	<260	<250
A	<530	<450	<400	<380
B (RIBA 2030 built target)	<750	<625	<540	<535
C (LETI 2020 design target & GLA aspirational benchmark)	<970	<800	<675	<690
D	<1180	<1000	<835	<870
E (GLA Benchmark)	<1400	<1200	<1000	<1050

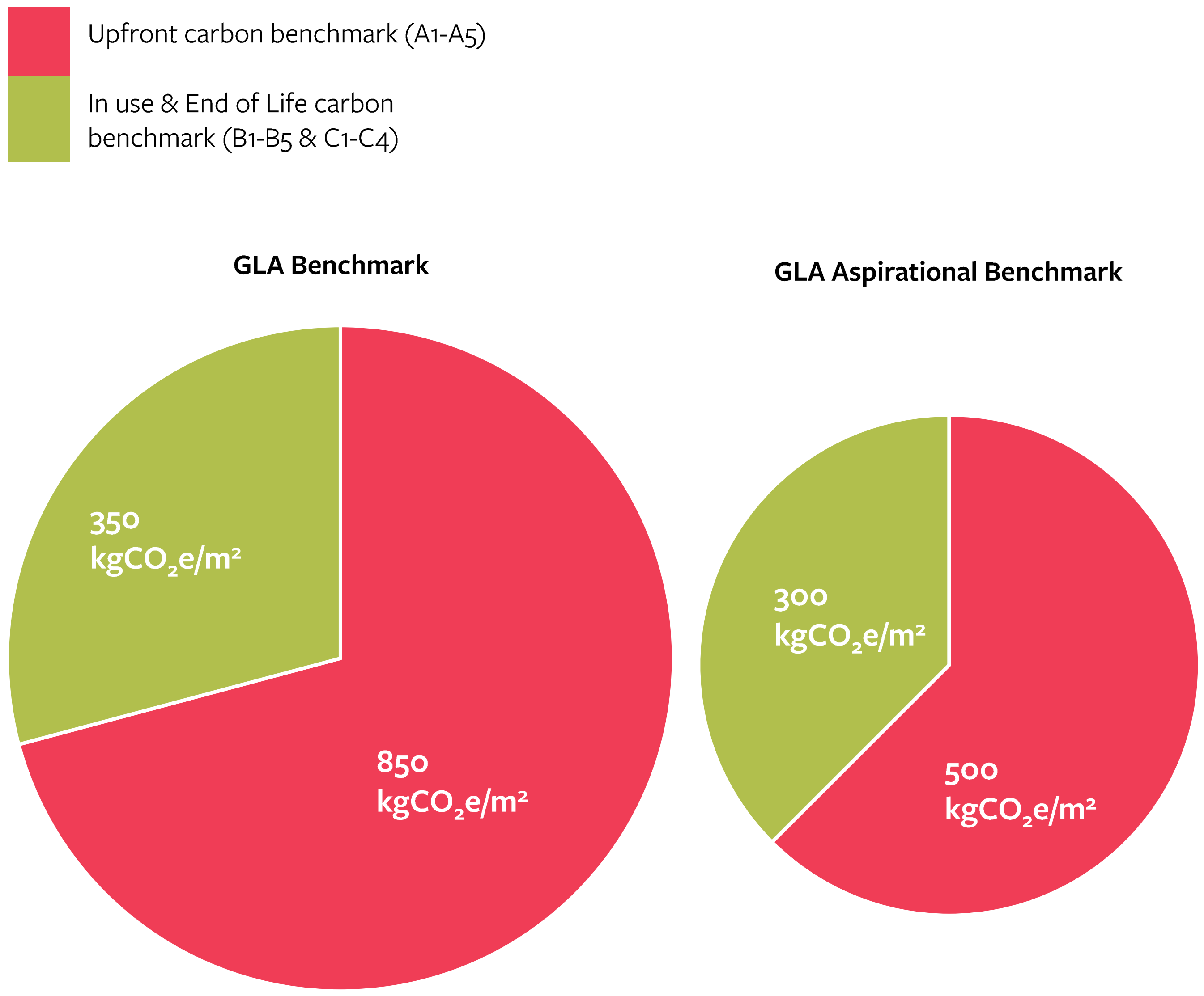


Figure 5: GLA residential benchmark and aspirational benchmark

Introduction
WLC principles

WLC hierarchy and design principles
The carbon saving potential of the development is unlocked by taking a focused approach and prioritising action where it matters most, and at the earliest design stages. The greatest carbon savings are secured by first and foremost reducing the demand ('Need less') for new-built space, buildings and materials. Using less to deliver the required project outcomes through lean, durable and circular designs comes next in the order of priorities ('Use Less').

Once optimization of resource use has been considered, 'Use better' is about selecting low carbon, high environmental performance materials and elements.

To target maximum carbon savings, the below three-tier hierarchy for action has been adopted with the design informed by a set of accompanying WLC principles, in line with GLA's guidance. Figure 6 organizes the WLC principles in the tiers of the hierarchy.

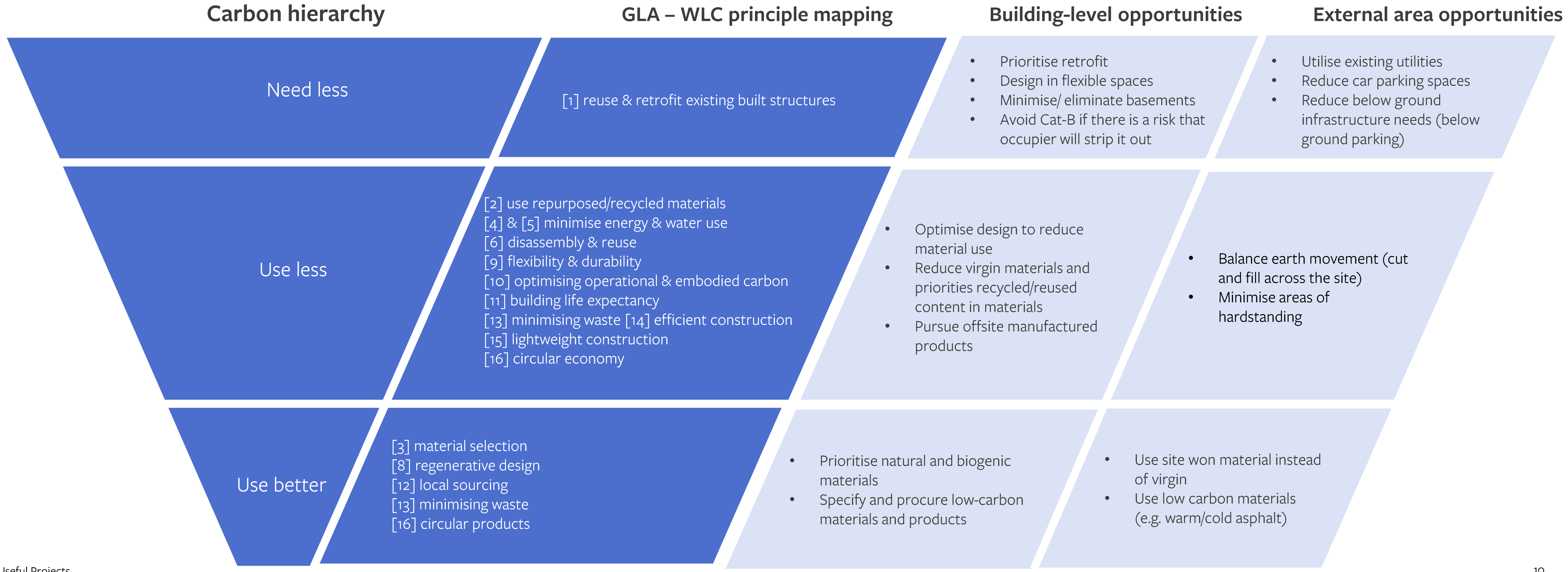


Figure 6: Embodied carbon hierarchy

2/ Methodology

Methodology
Outline and scope

The whole life carbon study has been carried out in alignment with the 'RICS Whole Life Carbon Assessment for the Built Environment' (1st edition, 2017) Professional Statement ("RICS PS") methodology and calculated in accordance with BS EN 15978. Building proposal data was collected (summarised on pages 14-15) and developed into an early-stage bill of materials (BOM) as input for a Whole Life Carbon assessment model in OneClick LCA. The results of the WLC analysis are presented in Section 3. Workshops and consultations were carried out with the City House design team to discuss carbon-saving measures already embedded in the proposal (Section 4) and opportunities for future carbon savings to be explored in later design stages (Section 5).

In accordance with the RICS PS, for domestic projects, the reference study period (RSP) is 60 years. This assessment is intended to comprise modules [A1–A5], [B1–B7] & [C1–C4].

- **Module A** (includes sub-modules A0-A5) covers emissions from all activities undertaken to complete the construction of the asset. Emissions take place 'upfront' or 'upstream' of the asset's in-use stage, and this module's emissions are also referred to as 'upfront carbon'. Module A typically makes up the majority of whole life emissions (>50%) of new developments.
- **Module B** (includes sub-modules B1-B7) covers all emissions from the use stage of the asset; B1 covers direct emissions from construction products (e.g. typically refrigerant leakage emissions), B2-B5 cover the embodied carbon emissions of materials used for maintenance, repairs/replacements and refurbishment, whilst B6 and B7 cover the emissions associated with the use of energy and water during the use stage.
- **Module C** (includes sub-modules C1-C4) covers emissions that occur at the end-of-life stage of the asset (i.e. from deconstruction or demolition, transport and management or disposal of waste).
- **Module D** covers the potential carbon costs (or 'loads') and benefits beyond the asset's system boundary; D1 covers the impacts of recovery and reuse or repurposing of the asset's materials during construction, use or end-of-life stages, whilst D2 covers the benefits of any utilities exported from the asset during the use stage, e.g. from generated electricity or treated water.

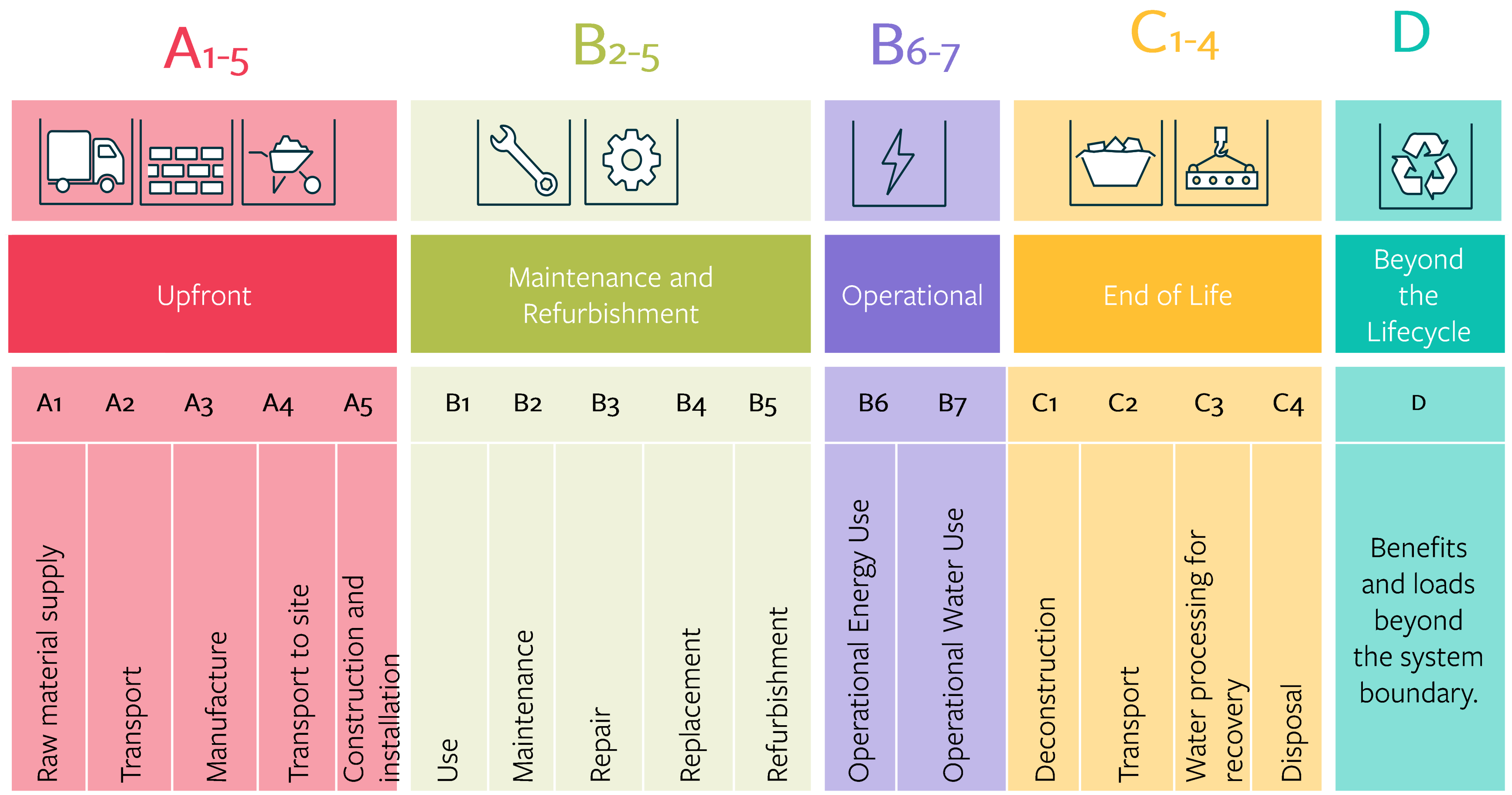


Figure 7: Building life cycle stage modules included in the WLCA. Adapted from RICS PS 2017 and EN 15978

Methodology
Assumptions and limitations

Reference study period

In accordance with the RICS Professional Statement, for domestic projects, the reference study period is 60 years.

Spatial boundary

A site boundary in line with the outer building perimeters has been used. An assessment of the upfront embodied carbon of the external works of the resulting enclosed area has been made and split between the two halves of the development.

Assessment tool

The assessment has been undertaken using OneClick LCA online software tool using the approved GLA plug-in.

Building elements coverage

The RICS Professional Statement requires that a minimum of 95 per cent (EN 15804; 6.3.5, p.25) of the cost allocated to each building element category (0–7 of Table 3) should be accounted for in the assessment. Items excluded should each account for less than 1 per cent of the total category cost.

Compliance with the above has been verified using the latest cost plan, 'Indicative Cost Estimate' (QSetc, December 2023).

Specific assumptions and sources of information

Operational energy use emissions (B6)

Total annual operational energy emissions (accounting for regulated and unregulated energy use) have been confirmed by the project's Building Services engineers (Integration) and align with the emissions reported in the Energy Statement submitted for planning. These emissions have been estimated based on the GLA's guidance, using SAP/SBEM compliance modelling for regulated emissions and CIBSE TM54 for unregulated. The life cycle operational energy use emissions are estimated using the annual emissions multiplied by the building's operational lifetime (60 years).

Operational water use emissions (B7)

Estimates of anticipated water consumption have been made using Table 22 of the BSRIA Rules of Thumb – guidelines for the building services (fifth edition). This is in line with the recommendation of the GLA's Guidance on WLCAs (2.5.15), in the absence of project-specific figures. The 2022 UK Government's carbon factors for water supply (0.149 kgCO_2e/m^3) and wastewater treatment (0.272 kgCO_2e/m^3) have been used to calculate the water use emissions.

Material data references are included in the appended GLA template. Module-specific assumptions used throughout the modelling are provided below:

A4 – Transport Impacts

In accordance with the RICS methodology guidance for a baseline assessment, all materials have assumed HGV freight when from national or European sources, using an emissions factor of 0.1065 kgCO_2e/km/tonne, for all HGVs, average laden, in accordance with the 2020 BEIS Conversion Factors.

A5 – Construction Impacts

A gross value for site related activities has been estimated based on the allowance of 1400 kgCO_2e/£100,000 of project value proposed in the RICS Professional Statement. The material wastage on site was included for each element based on default waste rates suggested in RICS guidance.

B2-B3 – Maintenance and repair

A generic allowance of 10 kgCO_2e/m^2 was applied to the model in line with RICS Whole Life Carbon Guidance for B2. A further 2.5 kgCO_2e/m^2 was applied to cover B3. These lump sums were apportioned 50/50 across FF&E and internal finishes in the GLA WLC template, due to a lack of input space for this additional sum.

B4 – Replacement

Generic services lives were applied to each building product according to the RICS Whole Life Carbon Guidance.

C1 – Demolition (at end of life)

In the absence of more specific information, a generic rate of 25 kgCO_2e/m^2 demolished building was assumed, as suggested in the draft RICS Professional Statement (version 2.0).

C2 – Transport emissions

The carbon emissions associated with the transportation of deconstruction and demolition arisings were calculated using an emissions factor of 0.1065 kgCO_2e/km/tonne, for all HGVs, average laden, in accordance with the 2020 BEIS Conversion Factors. The different end-of-life scenarios were accounted for in accordance with RICS methodology guidance, which suggests assuming a 50km distance to the recycling facility and for landfill/incineration taking the average between 2 of the closets landfill locations – in this case approximately 10km.

Methodology
Embodied Carbon: Data sources & quality

Table 6 summarises the data sources used in the assessment to calculate material quantities and specification. The RAG data quality indicator is based on the accuracy and quality of data received. Environmental Product Declarations have been assigned to each material based on the RICS PS allowable carbon data (section 3.3.1) order of preference. The assessment has not been third party audited, however does endeavour to follow the recently published UKGBC quality assurance guidance, detailed in Appendix B.

Table 6: Overview of data sources and assessment of data quality

Building Part / Element Group	Building Element	Data Sources	Data Quality
Demolition	0.1 Toxic/ Hazardous/ Contaminated Material treatment	*N/A*	-
	0.2 Major Demolition Works	Generic allowance of 25 $kgCO_2e/m^2$ of demolished buildings	Poor
0 Facilitating Works	0.3 & 0.5 Temporary/ Enabling Works	*Excluded*	-
	0.4 Specialist groundworks	*N/A*	-
1 Substructure	1.1 Substructure	Structural design & materials' quantity information provided by structural engineers	Good
2 Superstructure	2.1 Frame	Structural design & materials' quantity information provided by structural engineers	Good
	2.2 Upper floors incl. balconies	Structural design & materials' quantity information provided by structural engineers. Quantities provided assumed to include balconies.	Good
	2.3 Roof	Structural design & materials' quantity information provided by structural engineers Non-structural layers' information provided by architects	Good
	2.4 Stairs & Ramps	Location and number as per architects' drawings, quantities based on reference estimates of similar assets	Fair
	2.5 External Walls	Design & materials' quantity information provided by architects	Good
	2.6 Windows and External Doors	Windows' areas and materials provided by architects	Fair
	2.7 Internal Walls and Partitions	Design & materials' quantity information provided by architects	Good
	2.8 Internal Doors	Doors' areas and materials provided by architects	Fair

Methodology
Embodied Carbon: Data sources & quality

Table 6 (continued): Overview of data sources and assessment of data quality

Building Part / Element Group	Building Element	Data Sources	Data Quality
3 Finishes	3.1 Wall Finishes 3.2 Floor Finishes 3.3 Ceiling Finishes	Finishes types and areas provided by the architect	Fair
4 Fitting, furnishings, and equipment (FF&E)	4.1 Fittings, Furnishings & Equipment incl. Building-related* and Non-building-related**	• Generic FF&E specification created from QSetc's cost plan	Poor
5 Building services/MEP	5.1–5.14 Services incl. Building-related* and Non-building-related**	• Allowance for 2 lifts • Heat dissipation through the heating element (radiators), sanitary facilities and electrical distribution as per KBOB Report, 2016 • Product-level emissions for key equipment assessed using CIBSE TM65 Basic input methodology • Non-building related services excluded	Fair
6 Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units	*N/A*	
7 Work to Existing Building	7.1 Minor Demolition and Alteration Works	*N/A*	
8 External Works	8.1 Site preparation works 8.2 Roads, Paths, Pavings and Surfacings 8.3 Soft landscaping, Planting and Irrigation Systems 8.4 Fencing, Railings and Walls 8.5 External fixtures 8.6 External drainage 8.7 External Services 8.8 Minor Building Works	• Specifications for hard landscaping and integrated surface water drainage provided by Civils team. • All other items excluded from the assessment.	Poor

3/ Results

Results
Whole Life Carbon Overview

The City House development's whole life carbon emissions (A-C incl. B6-B7) are estimated to be 1,450 kgCO$_2$e/m².

The lifecycle embodied carbon emissions (A-C excl. B6-B7, hereby referred to as embodied carbon for simplicity) represent 63% of whole life emissions, whilst operational energy and water emissions (B6-B7) represent the remaining 37%; mostly associated with operational energy use (Table 7, Figure 8).

The embodied carbon estimate for the proposed City House development outperforms the GLA's embodied carbon benchmarks for a residential development by 24%. The embodied carbon performance of the proposed development is discussed in more detail in the sections that follow.

Figure 8 and Table 7 depict the breakdown of the projected whole life carbon for the City House development. The most significant contributors to the total figure are upfront emissions associated with raw material extraction, transportation and processing into building products (A1-A3), replacement of those building materials across the expected 60-year lifespan of City House (B4) and the operational energy demand of the development (B6).

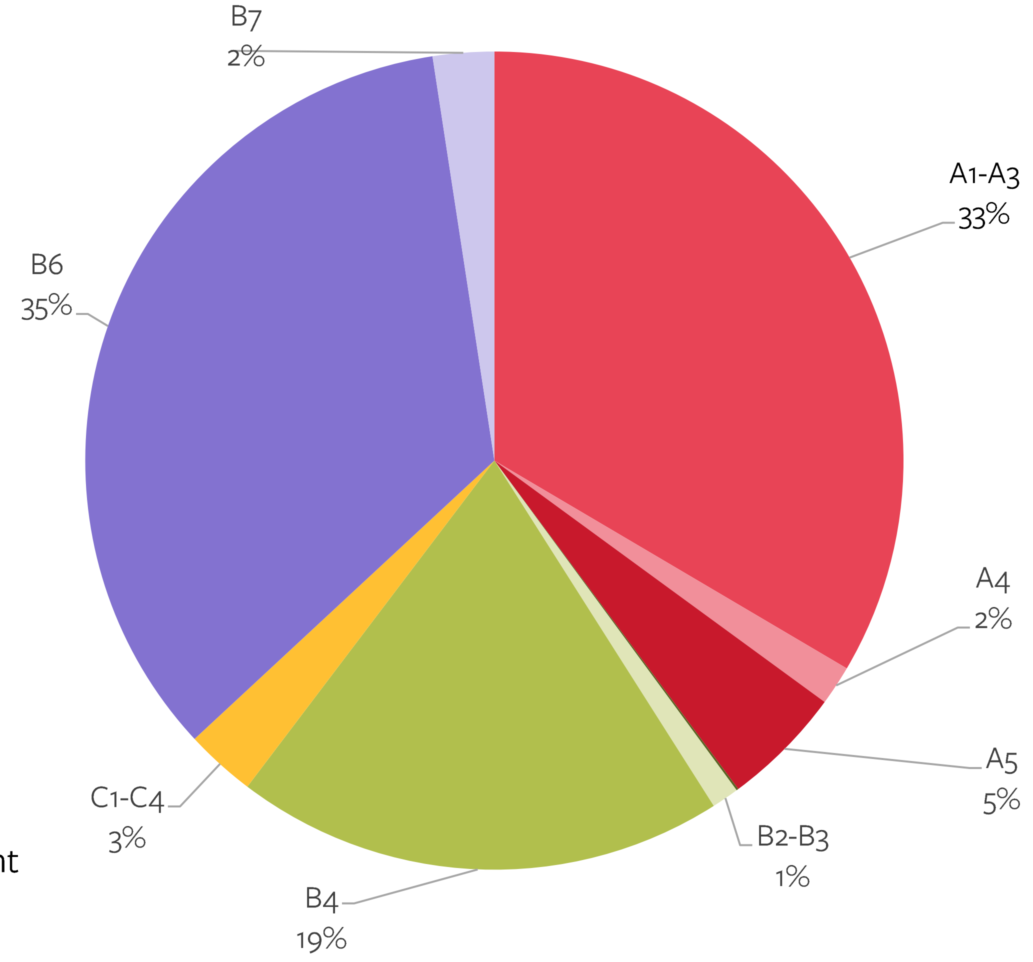
Table 7: Overview of project's whole life carbon performance

Lifecycle Module		Project Performance			GLA Benchmark	% against benchmark
		% of WLC	tCO$_2$e*	kgCO$_2$e/m²	kgCO$_2$e/m²	%
Whole Life Carbon		-	10,000	1,450	1,735	-
Embodied Carbon		63%	6,300	915	1,200	-24%
Upfront carbon	A1-A5	40%	3,990	578	850	-32%
In-use, EoL	B1-B5, C1-C4	23%	2,320	337	350	-4%
Operational carbon		37%	3,700	535	N/A	N/A
Energy	B6	35%	3,460	500	500	
Water	B7	2%	250	35	35	
Biogenic carbon		-	-190	-28		
Beyond the Boundary		-	-970	-141		

*tCO$_2$e: tonnes of carbon dioxide equivalent

Whole Life Carbon

1,450 kgCO$_2$e/m²



A1-A5: Upfront
B1-5: In-use
B6: Energy
B7: Water
C1-C4: End-of-life

Figure 8: Contribution of life cycle modules to the project's whole life carbon emissions

Results
Embodied Carbon Overview

The City House development's life cycle embodied carbon emissions are estimated to be 915 kgCO_2e/m², outperforming the GLA's benchmark for residential development (1,200 kgCO_2e/m²) by 24%.

Figure 9 and Table 9 illustrate the breakdown of embodied carbon in the proposed City House development by building element, compared against the GLA's typical building element breakdown for residential developments. The breakdown of embodied carbon for the proposed City House development differs from the GLA typical breakdown mostly in terms of substructure, façade, MEP services and FFE.

The poor performance of the City House substructure compared to the GLA benchmarks is likely due to the extensive use of concrete with (assumed) low levels of cement replacement in the piled foundations and ground floor slab. Furnishings, fittings and equipment in the proposed City House development also perform poorly against the GLA typical breakdown – this is due to the generic specification which was generated from QSetc's cost plan to reflect expected FF&E provision. Short expected services lifetimes (as per RICS WLC guidance) were applied, increasing the rate of replacement and adding lifetime embodied carbon.

The improved performance of the City House façade against a typical development is mainly attributed to the building's compact form and low façade to floor area ratio (0.5 façade m²/ m² GIA) and the balanced approach to window size (25% on average of the total façade area). The project's average façade intensity is 185 kgCO_2e/m².facade for A-C. The lower carbon intensity of MEP services is attributed to the very low global warming potential (GWP) of the specified refrigerant used for space heating and hot water generation (R454, GWP of 146, compared to a more typical R410 refrigerant with a GWP of 2088), and the fact that the strategy comprises a centralised system of 5 ASHP units rather than a split system of individual units per dwelling. It should be acknowledged though, that industry benchmarks were used for some components of MEP services and that the calculation cannot be considered as accurate or complete as other elements. The availability of product-specific or industry-average EPDs for MEP elements is also very limited, further increasing the uncertainty of early-stage estimates.

Table 8: Embodied carbon performance split per lifecycle stage

Life cycle Embodied Carbon	915 kgCO_2e/m² -24% to GLA benchmark	
Lifecycle Stage	kgCO_2e/m².GIA	% Embodied Carbon
Upfront carbon	578	63%
In-use	297	33%
End-of-life	40	4%

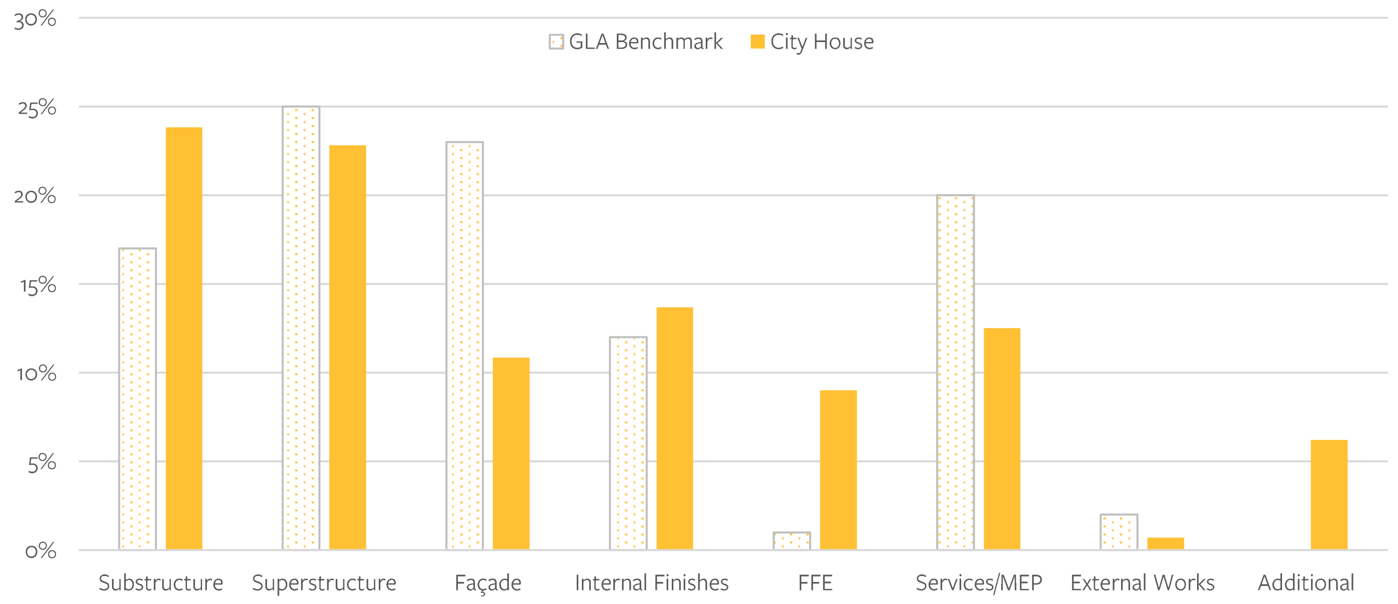


Figure 9 / Table 9: Contribution of building elements to embodied carbon, City House against GLA benchmark

Building Element	GLA Benchmark	City House	Performance relative to benchmark
Substructure	17%	24%	+7%
Superstructure	25%	23%	-2%
Façade	23%	11%	-12%
Internal finishes	12%	14%	+2%
FF&E	1%	9%	+8%
Services/MEP	20%	13%	-7%
External works	2%	1%	-1%
[Additional]	N/A	6%	N/A

Note that the 6% of emissions labelled 'Additional' in the City House performance covers an allowance for repairs, maintenance in-use (B2,B3) and energy use during construction (A5-energy) assigned to the project as a whole, therefore not attributable to individual building elements

Results
Embodied Carbon Hotspots

The primary building element embodied carbon hotspot for the proposed City House scheme is the reinforced concrete substructure, followed by the often-replaced internal finishes and mechanical, electrical and plumbing (MEP) service components.

Figure 10 illustrates the breakdown of embodied carbon (modules A-C) by building element and lifecycle module.

The most significant contributor to embodied carbon in the proposed scheme is the substructure (reinforced concrete pile foundations and slabs), comprising 24% of the total. Of the carbon embodied in the substructure, 95% is upfront carbon associated with raw materials extraction, transport and processing for product manufacture, transport to site and construction wastage. The substructure is a permanent, inaccessible part of the building and therefore has no embodied carbon associated with repair, maintenance or replacement.

The proposed City House building structure includes the substructure (24% of A-C), the upper floors (10% of A-C), frame (7%) and roof structure (1%), together contributing 42% of embodied carbon emissions.

The substructure and structural frame, due to the extensive use of concrete with (assumed) low cement replacement is therefore a focal point for further carbon saving opportunities such as lean design and low carbon concrete specification, to be implemented where possible.

Internal finishes and mechanical, electrical and plumbing (MEP) services and fittings, furnishing and equipment (FF&E) have expected service lifetimes shorter than the expected life of the building and require multiple replacement cycles. Most of the emissions associated with these building elements occur during the in-use stage (module B4 - replacement).

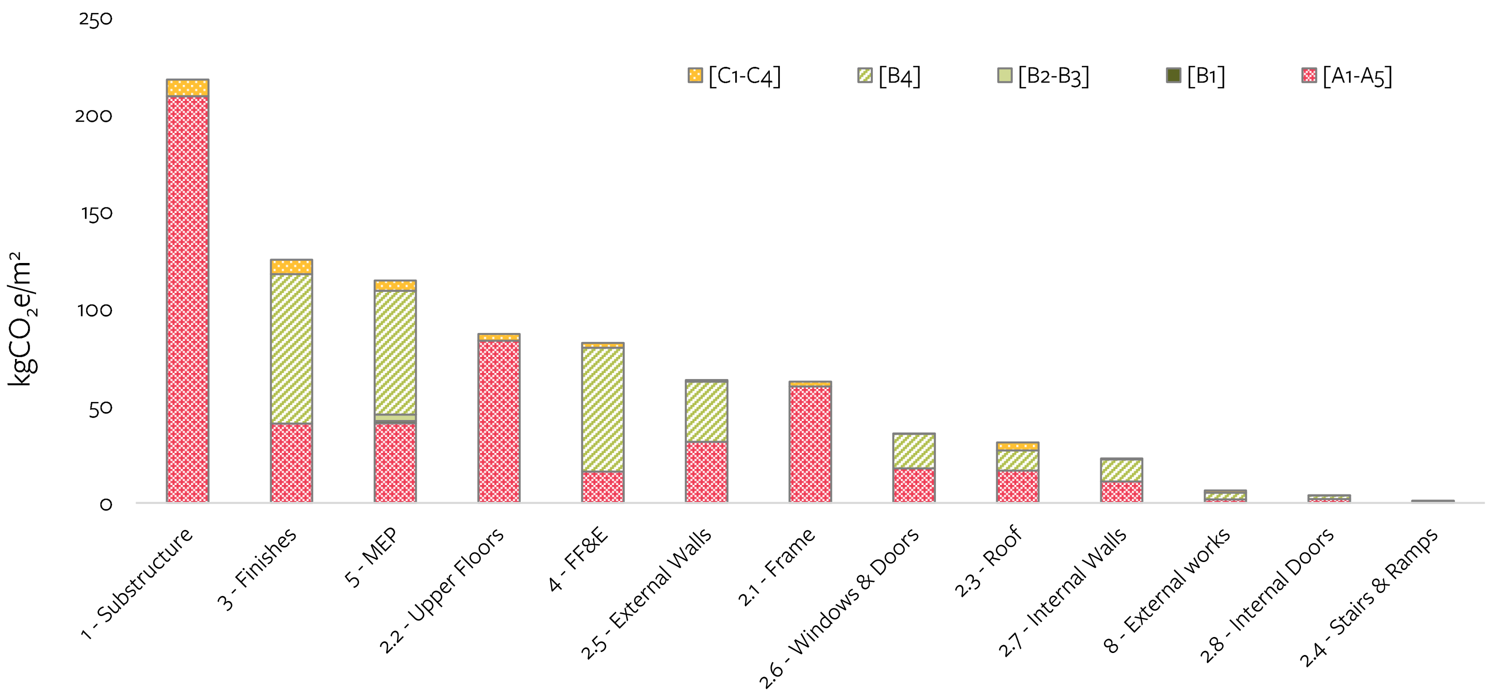


Figure 10/Table 10: Building elements ordered by their contribution to City House upfront carbon

Top 10 most carbon intensive elements – embodied carbon		
Element	**$kgCO_2e/m^2$**	**% of embodied carbon**
Substructure	218	24%
Finishes	125	14%
MEP	114	13%
Upper floors	87	10%
FF&E	82	9%
External walls	63	7%
Frame	62	7%
Windows & doors	57	4%
Roof	36 (10 for structure)	3% (1% structure)
Internal walls	31	3%
All other	91	7%

Results
Embodied Carbon Hotspots

Concrete and steel combined are responsible for 50% of the total embodied carbon of the proposed City House development.

Across the proposed scheme, concrete is the most used material by mass, followed by plasterboard and steel (as outlined in Useful Project's Circular Economy Statement).

Concrete and steel used in the building's structure contribute 42% of emissions (see Figure 04 - substructure, frame, upper floors, roof), whilst the steel framing of suspended ceiling systems is the third most carbon intensive material of the scheme (6%). Steel used in structural framing SFS components used in external and internal walls contributes another 2% of embodied carbon.

The other material hotspots (brick, windows, plasterboard, rockwool, screed and paint) are contained in the façade and internal finishes. Bricks and glass have high upfront carbon due to energy-intensive processing. The other material hotspots are finishing materials (screed, paint), with short service lives and frequent replacement cycles.

Table 11: Top 10 most carbon intensive materials in the proposed City House development

Top 10 materials – embodied carbon		
Material	$kgCO_2e/m^2$	% of embodied carbon
Concrete	288	32%
Rebar (steel)	89	10%
Suspended ceiling frame (steel)	55	6%
Windows	36	4%
Brick	24	3%
Plasterboard	22	2%
Rockwool	19	2%
Screed	17	2%
SFS (steel)	16	2%
Paint	15	2%
All other	334	36%

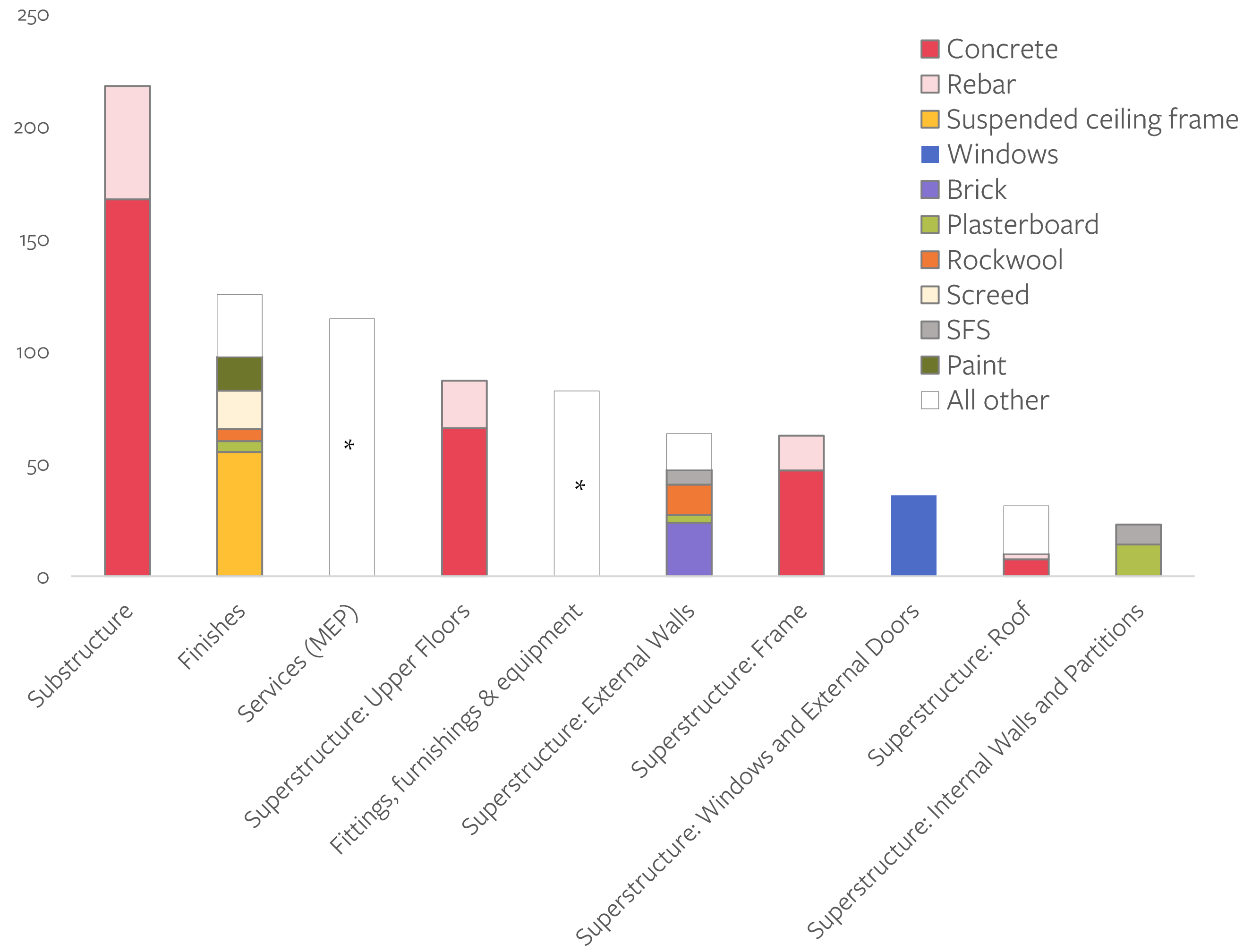


Figure 11: Embodied carbon intensity of building elements, split by material hotspots

**Note: due to a lack of detailed materials specifications for MEP services and fittings, furnishings and equipment (FF&E), a materials breakdown is unavailable, and these building elements are included in the 'all other' category. Since a broad variety of materials are expected to comprise these elements (noting that MEP services mostly comprise metals), the materials hotspots presented are likely to be representative of the as-built scheme, but a further embodied carbon assessment upon construction would confirm this.*

Results
Upfront Carbon Overview

The proposed City House development's upfront carbon emissions are estimated to be 578 $kgCO_2e/m^2$, outperforming the GLA's benchmark for residential development (850 $kgCO_2e/m^2$) by 32%.

Figure 13 shows the relative contribution to upfront carbon of the different building elements, comparing the performance of the proposed development to the breakdown provided in the GLA WLCA guidance, assumed to be representative of typical developments. Similar observations are made on the differences between City House performance and GLA benchmark breakdown as for embodied carbon emissions (page 18).

The centralised ASHP plant, the compact form of the building and the façade design and specification are the factors contributing to the improved performance of the MEP services and façade against the benchmark.

The project's substructure is found to make a much larger contribution to the project's upfront carbon compared to what would be expected in a typical residential development. The substructure stands out as a key focus area for further upfront carbon reduction action during later design stages, where possible.

The upfront carbon performance for the proposed development approaches the GLA's aspirational benchmark for upfront carbon of 500 $kgCO_2e/m^2$. A 15% further reduction in embodied carbon would place the proposed City House scheme in the aspirational bracket.

Table 12: Upfront carbon performance split by life cycle module

Upfront Carbon	578 $kgCO_2e/m^2$ -32% to GLA benchmark	
Lifecycle Module	$kgCO_2e/m^2$	% Upfront Carbon
A1-A5	578	100%
A1-A3	485	84%
A4	23	4%
A5	69	12%

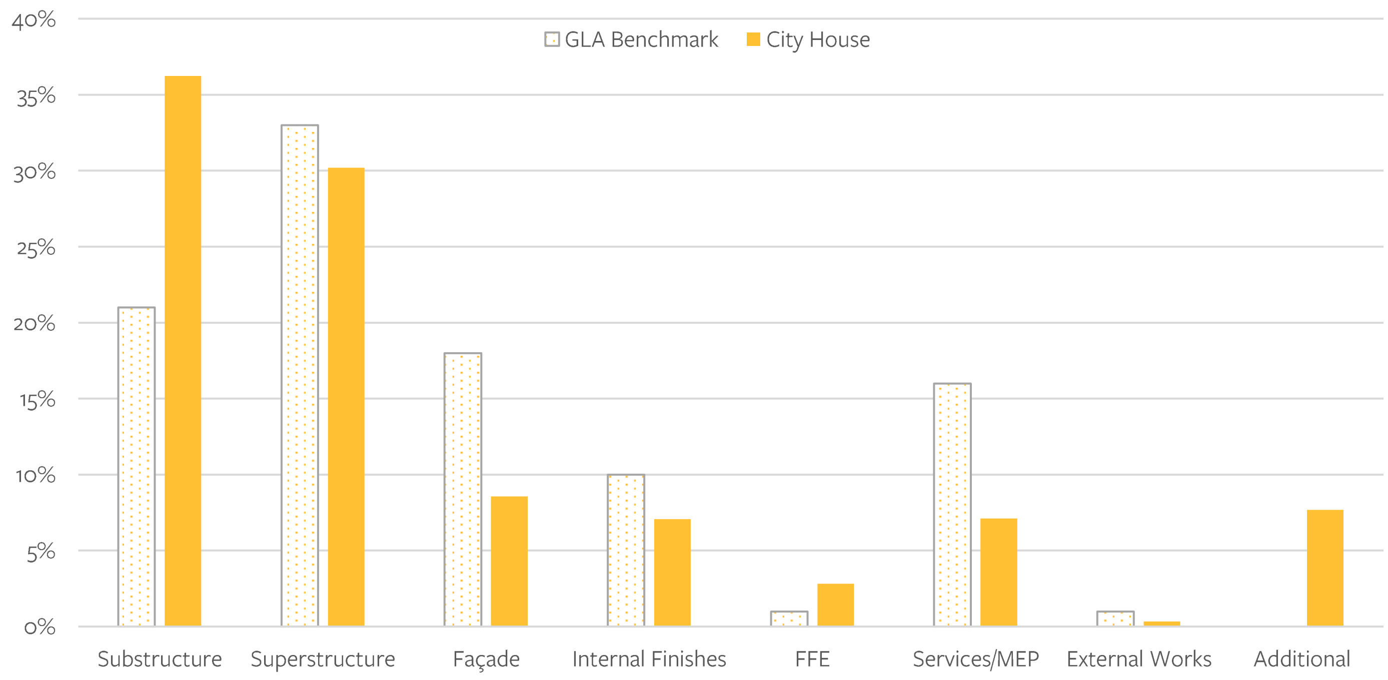


Figure 12/ Table 13: Contribution of building elements to upfront carbon, City House against GLA benchmark

Building Element	GLA Benchmark	City House	Performance relative to benchmark
Substructure	21%	36%	+16%
Superstructure	33%	30%	-3%
Façade	18%	9%	-9%
Internal finishes	10%	7%	-3%
FF&E	1%	3%	+2%
Services/MEP	16%	7%	-9%
External works	1%	0%	-1%
[Additional]	N/A	8%	N/A

Note that the 8% of emissions labelled 'Additional' in the City House performance covers an allowance for repairs, maintenance in-use (B2,B3) and energy use during construction (A5-energy) assigned to the project as a whole, therefore not attributable to individual building elements

Results

In-use & end-of-life Carbon Overview

The City House development's in-use and end-of-life (EoL) carbon emissions are estimated to be 337 $kgCO_2e/m^2$, outperforming the GLA's benchmark for residential development (350 $kgCO_2e/m^2$) by 4%.

Figure 13 shows the relative contribution to the in-use and end-of-life carbon emissions of the different building elements, comparing the performance of the proposed development to the breakdown provided in the GLA WLCA guidance.

Due to the many replacement cycles of products comprising internal finishes, FF&E and MEP services, these three elements contribute the largest portion of emissions at the in-use stage. The contribution of the substructure and superstructure reflects the transport emissions associated with taking heavy concrete off-site for waste management at end-of-life.

The difference between the performance of the proposed City House development and GLA benchmarks during use and at end-of-life are related to the upfront carbon intensity of these elements (page 21), as replacement emissions (B4) are estimated by multiplying the upfront emissions of the component by the number of times it is expected to be replaced. No allowance has been made to account for the ongoing decarbonisation of materials production (A1-A3), as this is not part of the currently adopted methodology.

Table 14: In-use and end-of-life carbon performance split by lifecycle module

In-use & EoL Carbon	337 $kgCO_2e/m^2$	
	-4% to GLA benchmark	
Lifecycle Module	**$kgCO_2e/m^2$**	**% In-use, EoL Carbon**
B1-B4	297	88%
B1	1	0%
B2-B3	16	5%
B4	280	83%
C1-C4	40	12%

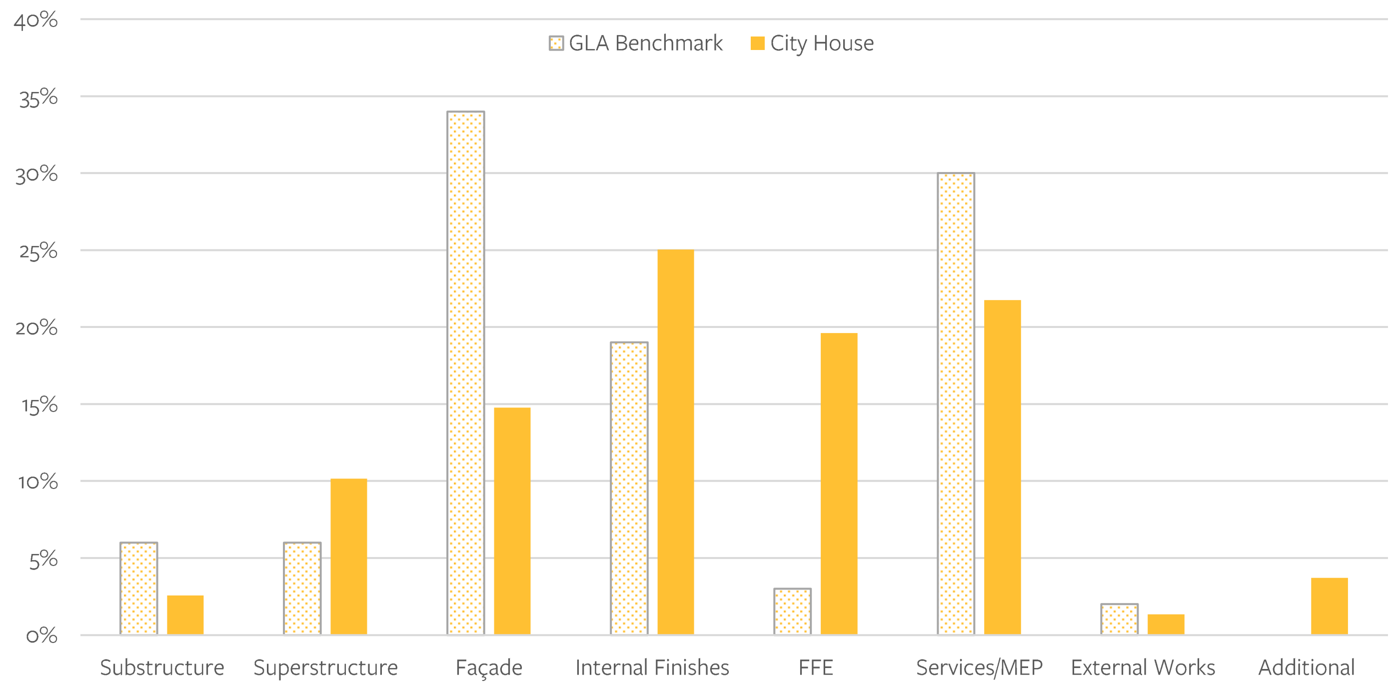


Figure 13/Table 15: Contribution of building elements to in-use and EoL carbon, City House against GLA benchmark

Building Element	GLA Benchmark	City House	Performance relative to benchmark
Substructure	6%	3%	-3%
Superstructure	3%	10%	+7%
Façade	34%	15%	-19%
Internal finishes	19%	25%	+6%
FF&E	3%	20%	+17%
Services/MEP	30%	22%	-8%
External works	2%	1%	-1%
[Additional]	N/A	4%	N/A

Note that the 4% of emissions labelled 'Additional' in the City House performance covers an allowance for repairs, maintenance in-use (B2,B3) and energy use during construction (A5-energy) assigned to the project as a whole, therefore not attributable to individual building elements

Results
Operational energy & water

Operational energy use emissions (B6)

Operational energy use emissions contribute **37% of the project's whole life carbon** (A-C incl. B6-B7).

Table 16 summarises the estimated annual energy use intensity (EUI), annual and lifecycle energy emissions for City House. The EUI and annual emissions figures have been confirmed by the project's Building Services engineers (Integration) and align with the emissions reported in the Energy Statement submitted for planning. Lifecycle impacts have been estimated taking the annual emissions and multiplying it by 60 years of service life.

Table 16: Energy use intensity (EUI), annual and lifecycle operational energy emissions

Energy Use emissions (B6)	EUI (kWh/m².GIA.annum)				Annual Energy Emissions	Lifecycle Energy Emissions (B6)	
	Regulated energy	Unregulated energy	On-site renewables	Total EUI			
Residential	38	52	-	90	56 tCO_2e/yr	3,360 tCO_2e	500 $kgCO_2e/m^2$
Non-residential	31	36	-	67	1.5 tCO_2e/yr	91 tCO_2e	

Operational water use emissions (B7)

Operational water use emissions contribute **3% of the project's whole life carbon** (A-C incl. B6-B7).

Estimates of anticipated water consumption have been made using Table 22 of the BSRIA Rules of Thumb – guidelines for the building services (fifth edition). This is in line with the recommendation of the GLA's Guidance on WLCAs (2.5.15), in the absence of project-specific figures. The 2022 UK Government's carbon factors for water supply (0.149 $kgCO_2e/m^3$) and wastewater treatment (0.272 $kgCO_2e/m^3$) have been used to calculate the water use emissions.

Table 17: Annual and lifecycle water use and associated operational water emissions (B7)

Water Use emissions (B7)	Annual Water use (m³/annum)	Lifecycle Water use	Annual Water Emissions	Lifecycle Water Emissions (B7)	
Residential	9,578 m3/yr	574,680 m3	4.0 tCO_2e/yr	242 tCO_2e	35 $kgCO_2e/m^2$

4/ Key carbon saving measures

Key carbon saving measures

Applying the carbon hierarchy | substructure and superstructure

The tables in this section present an overview of the key design measures and approaches embedded in the proposals for City House that are considered to improve upon BAU/typical performance and thereby contribute to its good practice embodied carbon performance.

The carbon saving measures are organised by the three whole life carbon hierarchy principles adopted in the design development ('Need Less', 'Use Less', 'Use Better') and by building layer, so that it corresponds to the accompanying Circular Economy Statement, which can be read in conjunction with this report for a complete context of materiality decisions.

Table 18: Design measures embedded in the substructure and superstructure proposals for City House that contribute to achieving embodied carbon savings and a low carbon performance

	Building Layer:			
	Structure		Skin	Space
	Building Element:			
	Substructure	**Superstructure** 2.1 Frame 2.2 Upper floors incl. balconies 2.3 Roof 2.4 Stairs and ramps	**Superstructure – Façade** 2.5 External walls 2.6 External windows & doors	**Superstructure – Internal** 2.7 Internal Walls & Partitions 2.8 Internal Doors
'Need Less' / Principles	• There are no basements planned for the scheme. • Reuse on-site materials (e.g. hardstanding) for site levelling.		• The building form is compact to minimise façade area. • Reduced corner columns to reduce weight of building and bricks needed • Glazing ratio (20%) balanced to minimize fabrication emissions related to glass and metal, whist achieving the façade's other performance objectives	• Rationalisiation of plan and dwellings' layout leading to reduced requirement for partition walls
'Use Less' / Principles	• Piled foundations, spacing optimised with grid spacing for materials efficiency	• Grid spacing is optimised to use material efficiently • Eliminate transfer structures		
'Use Better' / Principles	• 25% cement replacement (GGBS) for foundations	• 25% cement replacement (GGBS) for concrete frame	• Low carbon, rockwool insulation specified across all elements apart from the roof • Durable brick specification for cladding material • Timber framed, aluminium clad windows	

Key carbon saving measures

Applying the carbon hierarchy | finishes, building services, external works

Table 18 (continued): Design measures embedded in the proposals for City House that contribute to a low embodied carbon design

	Building Layer:			
	Space	Stuff	Services	Site
	Building Element:			
	Finishes 3.1 Wall finishes 3.2 Floor finishes 3.3 Ceiling finishes	**Fittings, furnishings & equipment** 4.1 Fittings, Furnishings & Equipment – Building-related	**Building services/MEP** 5.1–5.14 Services – Building-related	**External Works** 8.1–8.14
'Need Less' / Principles			• Low space heating demand through high quality fabric performance - reduced design loads • Centralised, highly efficient ASHP units • High diversity to reduce kit size and duct sizes (material efficiency)	• Existing utilities and drainage will be retained and used wherever possible. • Reuse of site won material for site levelling.
'Use Less' / Principles	• Minimal finishes prior to tenant agreements.	• Avoid overspecification of FF&E prior to tenant agreements.	• Air-source heat pumps for improved energy efficiency.	• The site's current levels will be kept the same as much as possible, minimising the need for cut and fill. • Minimise hardstanding areas.
'Use Better' / Principles	• Build to rent therefore selection of robust, low-maintenance specification to reduce in-use emissions	• Specify white goods with high energy efficiency ratings • Specify high-quality, durable appliances	• Heat pumps with low GWP (Global Warming Potential) refrigerants (R454C, GWP=146).	• Low carbon materials such as cold asphalt will be utilised.

Key carbon saving measures
Estimated carbon savings

A selection of the key carbon saving measures identified on the preceding pages have been analysed to estimate their carbon-savings compared to a business-as-usual (BAU) scenario.

The potential carbon savings associated with the use of supplementary cementitious materials (SCM) for cement replacement has been modelled in OneClick LCA. The total volume of C32/40 specified in the early-stage bill of materials (BOM) was input to the OneClick Whole Life Carbon model with environmental product declarations (EPD) for both C32/40 concrete with 0% recycled content, and with 25% GGBS as specified in the design. This material replacement analysis returned an estimated saving of 444tCO_2e across the scheme.

Comparing virgin aluminum framed windows with a 50% recycled aluminum framed option returned an estimated potential saving of 102tCO_2e across the scheme.

Analysis of the benefits of using a refrigerant with lower global warming potential (GWP) in air-source heat pumps was also carried out, to compare R454C refrigerant (146 GWP) with commonly used R410a refrigerant (2088 GWP). The TM65 calculation methodology was applied, and the analysis returned a saving of 107tCO_2e in the B1 lifecycle module.

At least 95kgCO_2e/m² of whole life carbon emissions is expected to have been saved by the design choices embedded in the City house proposal compared to typical design features not driven by carbon reduction.

Table 19: Estimated carbon savings for a selection of the key design choices embedded in the City House proposal

Carbon hierarchy principle	Business-as-usual specification	Carbon-saving measure embedded in design	Estimated carbon saving (tCO_2e)	Estimated carbon saving (kgCO_2e/m²)	Estimated carbon saving compared to business-as-usual design element (%)	% of City House whole life carbon
'Use less'	0% cement replacement with GGBS	25% cement replacement with GGBS.	444	64.3	18%	4%
'Use better'	0% recycled content aluminium frame for windows	50% recycled content aluminium frame for windows.	102	14.8	41%	1%
'Use better'	Use of R454C refrigerant in ASHP systems	Use of R410a refrigerant in ASHP systems.	107	15.6	93%	1%

5/ Further carbon saving opportunities

Further carbon saving opportunities

Applying the carbon hierachy | substructure and superstructure

The tables in this section present an overview of suggested additional design measures and approaches for City House that are considered to improve upon the current design specification and further improve embodied carbon performance. These measures should be explored with relevant members of the design teams in later stages.

The carbon saving measures are organised by the three whole life carbon hierarchy principles adopted in the design development ('Need Less', 'Use Less', 'Use Better') and by building layer, so that it corresponds to the accompanying Circular Economy Statement, which can be read in conjunction with this report for a complete context of materiality decisions.

Table 20: Design measures proposed to be explored at future project stages, towards further carbon savings

	Building Layer:			
	Structure		Skin	Space
	Building Element:			
	Substructure	**Superstructure** 2.1 Frame 2.2 Upper floors incl. balconies 2.3 Roof 2.4 Stairs and ramps	**Superstructure – Façade** 2.5 External walls 2.6 External windows & doors	**Superstructure – Internal** 2.7 Internal Walls & Partitions 2.8 Internal Doors
'Need Less' / Principles	• Reduce the volume of concrete required in foundations through lean design principles	• Reduce the volume of concrete required in the superstructure through lean design principles (optimised column spacing)	• Incorporate reclaimed bricks in the façade specification	• Incorporate more open-plan areas to reduce need for partition walls in the communal and commercial areas
'Use Less' / Principles		• Explore alternatives to flat slabs (e.g. waffle slab)	• Further compact the building form to reduce façade area	
'Use Better' / Principles	• Further increase cement replacement (e.g 70% GGBS) in the foundations	• Further increase cement replacement (e.g 50% GGBS) in the frame	• Increase the recycled content of façade materials • Specify timber framed windows	• Specify biogenic materials palette

Further carbon saving opportunities
Applying the carbon hierarchy | finishes, building services, external works

Table 20 (continued): Design measures proposed to be explored at future project stages, towards further carbon savings

	Building Layer:			
	Space	Stuff	Services	Site
	Building Element:			
	Finishes 3.1 Wall finishes 3.2 Floor finishes 3.3 Ceiling finishes	**Fittings, furnishings & equipment** 4.1 Fittings, Furnishings & Equipment – Building-related	**Building services/MEP** 5.1–5.14 Services – Building-related	**External Works** 8.1–8.14
'Need Less' / Principles	• Incorporate more open-plan areas to reduce wall finishes • Incorporate more areas of exposed ceiling to reduce need for finishing materials (and expose thermal mass)	• Establish a dedicated space and service to support a sharing economy	• Further centralise the MEP architecture and optimise distribution networks to minimise material requirements	• Further minimise hardstanding areas
'Use Less' / Principles	• Further minimise initial finishing materials specification prior to tenant agreement	• Further minimise initial FF&E specification prior to tenant agreement	• Utilise heat recovery from cooling systems	• Specify paving buildups (subsurface layers) to be made from site-won crushed aggregate • Utilise existing materials / utilities/ drainage from the existing City House site
'Use Better' / Principles	• Specify biogenic materials palette	• Utilise reclaimed and refurbished appliances and furnishings • Specify biogenic materials palette	• Utilise reclaimed and refurbished MEP components	• Incorporate above-ground sustainable drainage systems (SUDS)

Further carbon saving opportunities
Estimated carbon savings

A selection of the further opportunities for carbon saving identified on the preceding pages have been analysed to estimate their carbon-savings compared to the proposed design specification.

The potential carbon savings associated with the use of reclaimed brick in the City House façade has been modelled. The total mass of bricks specified in the early-stage bill of materials (BOM) was assessed for both virgin bricks as specified in the design, and with reclaimed bricks. This material replacement analysis returned an estimated potential saving of 120 tCO_2e across the scheme.

A similar process was followed to assess the whole life carbon of window fittings, comparing aluminum framed windows with a timber and aluminum framed option. This materials replacement analysis returned an estimated saving of 124 tCO_2e across the scheme.

Analysis of the benefits of lean design of the foundations through design optimization in RIBA 3/4 returns an estimated potential carbon saving of 110 tCO_2e with 10% material savings. Similarly, through by reducing the area covered by suspended ceiling systems by 15% returns a 102 tCO_2e carbon saving.

The option for increasing the proportion of recycled industry waste materials (e.g ground granulated blast furnace slag, GGBS) from 25% to 50% across the scheme's concrete specification has also been explored, showing a 355 tCO_2e carbon saving was estimated. It may be unlikely that all the ready-mix concrete across the scheme can be replaced with 50% GGBS concrete, but this figure illustrates the significant carbon savings achievable through cement replacement. It should be noted, however, that cement replacement is increasingly seen as a less viable option for global decarbonization due to the high emissions of the industrial practices producing the by-products used for cement replacement (blast furnaces, coal power plants), and the ongoing phase-out of these industrial areas. The preferred option for reducing the whole life carbon associated with cementitious materials is to incorporate lean design where possible to reduce the amount of cement poured.

Based on these models, 111 $kgCO_2e/m^2$ of whole life carbon emissions is potentially achievable by implementing the design opportunities previously discussed in the City house proposal. These approaches will be explored in later design stages and pursued where possible.

Table 21: Estimated carbon savings for a selection of future opportunities for the City House proposal

Carbon hierarchy principle	Opportunity	Estimated carbon saving (tCO^2e)	Estimated carbon saving ($kgCO_2e/m^2$)	Estimated carbon saving compared to proposed design element (%)	% of City House whole life carbon
'Need less'	Use reclaimed bricks from the existing City House structure in the new façade.	120	17.4	27%	
'Use less'	Lean design of foundations to reduce volume by 10%	110	15.9	10%	
'Use less'	Reduce area covered by suspended ceiling systems by 15%	57	8.3	15%	
'Use better'	Specify combination timber/aluminium frame windows	124	18	50%	
'Use better'	Increase cement replacement in concrete specification from 25% to 50%	355	51.4	18%	

6/ Conclusions

Conclusions

The proposed development at City House, Sutton, has been analysed and reported against the London Plan's Whole Life Carbon Statement Guidance (2022). Based on an early-stage bill of materials (BOM) provided by the design teams and covering external works, structural elements, mechanical, electrical and plumbing (MEP) and architectural components, a Whole Life Carbon Assessment model was built in OneClick LCA. This model has informed the information entered in the GLA Whole Life Carbon template (Appendix A) and the analysis in the preceding sections.

The proposed City House development is expected to exceed the GLA benchmarks as described in Table 21.

Whole life carbon minimisation strategies have been identified according to the 'building in layers' approach, which separates the proposed City House development into discrete sections for targeted carbon reduction while retaining a consideration of the entire structure. Various strategies have been taken forward in the design proposal, including the use of supplementary cementitious material for cement replacement, designing a compact structure and designing out basements and transfer structures.

Opportunities for more ambitious carbon reduction strategies have been put forward in this report and during workshops with the design team, including alternative slab designs to minimise concrete use, the increased use of biogenic materials and the direct reuse of site-won aggregates and façade materials in buildups for the new development. These opportunities will be explored at later design stages and pursued where possible.

Following a successful planning application, the City House development will be required to further report on the outcome of the whole life carbon targets and strategies outlined in this report.

Upon commencement of RIBA Stage 6 and no more than three months post-construction, an as-built whole life carbon is required to demonstrate performance against the projected whole life carbon performance outlined in Table 21. This will require an update of the GLA whole life carbon template with a new model considering the as-built bill of materials and an accompanying written report describing key achievements and lessons learnt.

Table 21: Performance of the proposed City House development against GLA Carbon Benchmarks

Whole Life Carbon	**1,450 $kgCO_2e/m^2$**		
Embodied Carbon [A-C, excl. B7, B7]	**915 $kgCO_2e/m^2$**	**63% of whole life carbon**	**-24% to GLA benchmark**
Upfront Carbon [A1-A5]	578 $kgCO_2e/m^2$	40% of whole life carbon	-32% to GLA benchmark
In-use, end-of-life carbon [B1-B4, C1-C4]	337 $kgCO_2e/m^2$	23% of whole life carbon	-4% to GLA benchmark
Operational carbon [B6, B7]	**535 $kgCO_2e/m^2$**	**37% of whole life carbon**	-

Appendix A/ GLA template

GLA Whole Life Carbon Template

The GLA's Whole Life Carbon Template, which forms the supporting evidence to this statement, has been submitted alongside the planning documentation.

The whole life carbon input section of the GLA template, with results from the WLC analysis of the City House early-stage bill of materials, has been included here as supporting information to the preceding report.

The GLA WLC template contains further information on materials quantities used in the WLC analysis, with details on refrigerants and the TM54 calculation, service lifetimes and end-of-life scenarios for the materials used in the model.

GWP POTENTIAL FOR ALL LIFE-CYCLE MODULES [kgCO2e] (See Note 1 below if you selected a reference study period in cell C12)		Sequestered (or biogenic) carbon (negative value) [kgCO2e]	Product stage [kgCO2e]	Construction process stage [kgCO2e]		Use stage [kgCO2e]							End of Life (EoL) stage [kgCO2e]				TOTAL Modules A-C kgCO2e	Benefits and loads beyond the system boundary [kgCO2e]
			Module A			Module B							Module C					Module D
Building element category			[A1] to [A3]	[A4]	[A5]	[B1]	[B2]	[B3]	[B4]	[B5]	[B6]	[B7]	[C1]	[C2]	[C3]	[C4]		
0.1	Demolition: Toxic/Hazardous/Contaminated Material Treatment												0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
0.2	Major Demolition Works												25,425 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	25,425 kg CO2e	0 kg CO2e
0.3	Temporary Support to Adjacent Structures	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
0.4	Specialist Ground Works	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
0.5	Temporary Diversion Works	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
1	Substructure	0 kg CO2e	1,287,335 kg CO2e	84,445 kg CO2e	74,683 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	54,625 kg CO2e	4,388 kg CO2e	0 kg CO2e	1,589,661 kg CO2e	-284,721 kg CO2e
2.1	Superstructure: Frame	0 kg CO2e	363,515 kg CO2e	29,752 kg CO2e	28,534 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	15,978 kg CO2e	1,456 kg CO2e	0 kg CO2e	434,245 kg CO2e	-81,835 kg CO2e
2.2	Superstructure: Upper Floors	0 kg CO2e	514,192 kg CO2e	53,240 kg CO2e	28,574 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	22,187 kg CO2e	1,356 kg CO2e	0 kg CO2e	638,848 kg CO2e	-113,842 kg CO2e
2.3	Superstructure: Roof	0 kg CO2e	184,872 kg CO2e	4,823 kg CO2e	7,338 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	71,441 kg CO2e	0 kg CO2e			0 kg CO2e	2,848 kg CO2e	25,833 kg CO2e	0 kg CO2e	215,538 kg CO2e	-37,863 kg CO2e
2.4	Superstructure: Stairs and Ramps	0 kg CO2e	6,857 kg CO2e	151 kg CO2e	72 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	285 kg CO2e	24 kg CO2e	0 kg CO2e	7,239 kg CO2e	-2,362 kg CO2e
2.5	Superstructure: External Walls	-284 kg CO2e	284,549 kg CO2e	2,223 kg CO2e	18,353 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	215,145 kg CO2e	0 kg CO2e			0 kg CO2e	5,684 kg CO2e	2,613 kg CO2e	79 kg CO2e	437,832 kg CO2e	-43,518 kg CO2e
2.6	Superstructure: Windows and External Doors	0 kg CO2e	121,366 kg CO2e	114 kg CO2e	1,238 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	122,375 kg CO2e	0 kg CO2e			0 kg CO2e	878 kg CO2e	5 kg CO2e	12 kg CO2e	247,188 kg CO2e	-483 kg CO2e
2.7	Superstructure: Internal Walls and Partitions	-851 kg CO2e	74,627 kg CO2e	335 kg CO2e	2,213 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	78,255 kg CO2e	0 kg CO2e			0 kg CO2e	3,188 kg CO2e	113 kg CO2e	0 kg CO2e	157,872 kg CO2e	-58,915 kg CO2e
2.8	Superstructure: Internal Doors	-27,818 kg CO2e	12,475 kg CO2e	58 kg CO2e	1,275 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	12,756 kg CO2e	0 kg CO2e			0 kg CO2e	58 kg CO2e	156 kg CO2e	0 kg CO2e	-1,822 kg CO2e	0 kg CO2e
3	Finishes	-78,365 kg CO2e	262,363 kg CO2e	5,443 kg CO2e	15,885 kg CO2e	0 kg CO2e	54,588 kg CO2e	8,625 kg CO2e	538,632 kg CO2e	0 kg CO2e			0 kg CO2e	6,632 kg CO2e	44,878 kg CO2e	286 kg CO2e	835,832 kg CO2e	-329,383 kg CO2e
4	Fittings, furnishings & equipment	-36,828 kg CO2e	188,314 kg CO2e	661 kg CO2e	3,878 kg CO2e	0 kg CO2e	54,588 kg CO2e	8,625 kg CO2e	455,615 kg CO2e	0 kg CO2e			0 kg CO2e	3,118 kg CO2e	631 kg CO2e	55 kg CO2e	433,178 kg CO2e	0 kg CO2e
5	Services (MEP)		272,484 kg CO2e	2,211 kg CO2e	3,126 kg CO2e	8,882 kg CO2e	0 kg CO2e	21,616 kg CO2e	448,454 kg CO2e	0 kg CO2e	296,408 kg CO2e 3,330,000 kg CO2e	241,348 kg CO2e	35,764 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	4,557,813 kg CO2e	0 kg CO2e
6	Prefabricated Buildings and Building Units	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
7	Work to Existing Building	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e			0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e
8	External works	0 kg CO2e	18,121 kg CO2e	2,884 kg CO2e	1,267 kg CO2e	0 kg CO2e	0 kg CO2e	0 kg CO2e	24,885 kg CO2e	0 kg CO2e			0 kg CO2e	-188 kg CO2e	7,864 kg CO2e	0 kg CO2e	44,847 kg CO2e	-11,817 kg CO2e
Other site construction impacts or overall construction stage (A5) carbon emissions not specific to an individual building element category					385,732 kg CO2e												385,732 kg CO2e	
TOTAL kg CO_2e		-135,856 kg CO2e	3,343,451 kg CO2e	156,683 kg CO2e	478,328 kg CO2e	8,882 kg CO2e	63,888 kg CO2e	38,866 kg CO2e	1,933,324 kg CO2e	0 kg CO2e	3,626,408 kg CO2e	241,348 kg CO2e	60,883 kg CO2e	118,724 kg CO2e	83,731 kg CO2e	338 kg CO2e	9,368,256 kg CO2e	-375,226 kg CO2e
TOTAL - kg CO_2e/m^2 GIA		-20 kg CO2e/m2 GIA	485 kg CO2e/m2 GIA	23 kg CO2e/m2 GIA	69 kg CO2e/m2 GIA	1 kg CO2e/m2 GIA	10 kg CO2e/m2 GIA	6 kg CO2e/m2 GIA	288 kg CO2e/m2 GIA	0 kg CO2e/m2 GIA	526 kg CO2e/m2 GIA	35 kg CO2e/m2 GIA	9 kg CO2e/m2 GIA	16 kg CO2e/m2 GIA	13 kg CO2e/m2 GIA	0 kg CO2e/m2 GIA	1,445 kg CO2e/m2 GIA	-161 kg CO2e/m2 GIA

Notes:

Appendix B/ UKGBC Embodied Carbon QA Tables

UKGBC Embodied Carbon QA
Input Review Table

Step	Consultant Comments *Example comments and supporting are included in italics*	Self-audit?	Auditor Comments	QA Passed?
1. Confirm Scope of assessment	e.g., BREEAM Mat 01, Upfront A1-A5, GLA WLC	GLA WLC	N/A	*Yes*
2. Stage of assessment	*This should be in line with RICS methodology or relevant body (i.e., BRE or Mat 01)*	Aligned with RICS Professional Statement, 1st Edition (2017)		*Yes*
3. Are any options being considered?	*Options appraisals should be discussed early to ensure maximum value is added.*	Limited options appraised (programme and brief did not allow)		*Yes*
4. Confirm sources of information	*e.g., BIM model, BOQ, consultants drawings (note these are in order of preference as per RICS PS rev 02)*	BOQs for key elements provided from key design team members (architect, landscape designer, structural engineer, MEP/Services engineer). *For further details please see Table 06 in Methodology section.*		*Yes*
5. Confirm percentage of materials included in the assessment	*This can be checked through review of an excel sheet confirming all inputs*	Inclusions checked against value in the cost plan to be in excess of 95% across all building elements.		*Yes*
6. Have all assumptions made by the consultant on materials and quantities been audited?	*e.g., detailed within the input excel sheet (noted above) and discussed with the QA consultant, following RICS WLCA PS guidance or other appropriate industry guidance*	Yes		*Yes*
7. Does the level of detail included in the inputs align with the Scope	*e.g. refer to RICS WLCA PS for guidance regarding the level of detail required at each stage.*	Yes		*Yes*
8. What software and parameters are being used	*Do these align with the Scope and Stage of assessment?*	OneClick LCA		*Yes*

QA Software Checklist

Step	Consultant Comments *Example comments and supporting are included in italics*	Self-audit?	Auditor Comments	QA Passed?
9. Is the reference study period appropriate to the scope confirmed in Step 1/2	*e.g. refer to RICS PS Rev 02 for appropriate scope reference periods.*	Yes. 60 years, typical of building projects	N/A	*Yes*
10. Do the quantities entered reflect those in the sources provided, and where calculations have been made (e.g., m² to m³) are the methodology and values appropriate		Yes		*Yes*
11. Have all building materials and quantities been input into the software	*These values should be taken from the input excel sheet and therefore should be consistent.*	Yes, with the exception of Building Services, where CIBSE TM65 assessments were carried out, combined with the use of industry benchmarks. This is due to a lack of EPDs or generic database for such systems, also lacking in the software's database. See Table 06 for further details.		*Yes*
12. Where materials have been excluded, has justification been provided and verified		Yes		*Yes*
13. Have justifiable EPDs been chosen	*Refer to Carbon Factor Hierarchy from RICS and Whole Life Carbon Network*	Yes		*Yes*
14. Transport types and distances?	*e.g. in lieu of product specific data this should be in line with RICS guidance*	Standard assumptions used, as proposed in RICS and built-in as default in OneClick LCA.		*Yes*
15. Appropriate End of Life calculations?		To the extent feasible. C1 has only been assessed for heat pumps (refrigerants' leakage at plant decommissioning). The software used provides C2, C3 and C4 data, based on generic/default assumptions on EoL waste management practices and/or as provided in the EPD selected.		*Yes*
16. Have the RICS categories been correctly allocated?		Yes		*Yes*
17. Is each material clearly referenced to show the correspondence between the input excel sheet and the software entry		Yes		*Yes*
18. Have the service lives been appropriately input for each entry	*e.g. in line with RICS default service lives (where actual data is not known) or alternatively confirmed by the project team?*	Yes, service lives are in line with RICS PS proposed default values.		*Yes*
19. Has the building area been input (GIA)		Yes		*Yes*

UKGBC Embodied Carbon QA
QA Software Checklist

Step	Consultant Comments *Example comments and supporting are included in italics*	Self-audit?	Auditor Comments	QA Passed?
Where applicable to the assessment scope:				
20. Has the Energy Consumption been input, and is the source appropriate	*The source should be appropriate to the scope of the assessment (e.g., TM54 data).*	The Building Services Engineers (Integration) have provided annual energy use and associated carbon emissions values, as estimated and presented in the accompanying Energy Statement submitted for planning. The methodology adopted by Integration was confirmed to be in line with GLA WLCA guidance.	N/A	*Yes*
21. Has the water consumption been input, and is the source appropriate	*The source should be appropriate to the scope of the assessment – refer to RICS PS rev 02*	The Building Services Engineers (Integration) have provided annual water use data.		*Yes*
22. Has the construction site operations tab been completed	*e.g. If no project information is available is this based on the RICS 1400 kgCO₂e/£100k project value rate (where applicable to assessment scope)*	Generic assumption as per RICS PS 1st edition (*1400 kgCO₂e/£100k*). The resulting emissions were compared against those estimated using the recommended value in draft RICS 2nd edition. The value used was the highest of the two.		*Yes*
23. Has the emissions and removals tab been completed	*Have leakage rates been taken from CIBSE TM65? (where applicable to assessment scope?)*	Yes. A CIBSE TM65 calculation was undertaken for B1 and C1 (refrigerant leakage emissions) associated with the use of air source heat pumps.		*Yes*
25. Do the % total impact for all life-cycle stages for each material/ categories look reasonable?	*e.g. are results similar to a previous assessment, do the values meet expectations?*	Yes.		*Yes*
26. Where results fall outside of the typical performance expected for the assessment, has this been investigated	*e.g. discussed with Project Lead/ QA consultant, EPDs checked or discussed with the design team?*	Yes.		*Yes*
27. Have results been compared against industry benchmarks for that building type and scope, and seem reasonable?	*e.g. LETI or RIBA benchmarks or UK NZCBS limits, are benchmarks appropriate for the building type and assessment scope?*	Yes. Performance assessed against GLA benchmarks for residential developments. A rationale has been provided on the underlying causes of identified discrepancies.		*Yes*
28. Have all assessment naming conventions been followed	*e.g. BREEAM requirements for export, internal organisational references*	Yes		*Yes*

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Thank you.

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