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Whole Life Carbon Assessment

Understanding the impact and benefits of new construction

41 Sheldon Avenue

For

Mark Tognolini and Eva Stengaard

June 2024



Revisions schedule**Issue Date:****19th June 2024****Report prepared by:**

Han-Chieh Lee, Consultant, Carbon Plan Engineering

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Alan Calcott, Director, Carbon Plan Engineering

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Amended to include Design Team Comments

B**18th September 2024**Updated with planning responses and the design update
All changes highlighted in **blue****C****27th September 2024**

Section 1.1.5 (B6 and B7) updated

Please do not print unless necessary

Please note that the results in this document are high level only and should not be relied upon for financial forecasting as every business will use the building differently.

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Executive Summary

Introduction / context

This document presents the Life-cycle Carbon Assessment (LCA) – the combined Embodied Carbon – for the 41 Sheldon Avenue located in the Haringey Council area. The primary reason for developing the LCA is to enable the design team to understand and report on the impacts of the proposed development.

The LCA is provided to enable the design team with information that will assist in identifying choices when finalising design solutions to reduce the impacts that we have identified.

- ❑ the **Lifecycle Carbon Assessment** (LCA) measures embodied carbon and is based upon the Stage 3 designs
- ❑ any future potential carbon savings post end-of-life, including savings from reuse and recycling of building structure and materials

The document was originally submitted in June 2024 to address the request from the London Borough of Haringey (LBH) to evaluate the impacts of the building and the various options. Subsequently we received the following commentary from LBH.

The WLCA has demonstrated when comparing to the baseline, the embodied carbon of the new building proposal has been reduced by 9.2% overall (and 20.5% in module A1-A5 only). This is achieved by selecting high recycled content materials including:

- *Ready-mix concrete with 50% GGBS cement replacement and aggregate with up to 20% recycled content.*
- *Reinforcement steel with 97% recycled content*
- *Structural hollow steel sections, cold rolled with 40 % recycled content*

The new building proposal's embodied carbon is 679.569 kgCO₂e/m² for module A1—A5 and a total of 872.297 kgCO₂e/m² for modules A-C. Both figures are below the benchmark from WLCA London Plan Guidance which are 850 kgCO₂e/m² and 1200 kgCO₂e/m² correspondingly.

However, they fall short of achieving lower embodied carbon targets of the aspirational WLC benchmarks which are 500 kgCO₂e/m² and 800 kgCO₂e/m². – See Section 3.1.3

In addition, there is no comparison of the WLC of a retention and retrofit scenario. – See Section 3.1

The CE report has explained the new proposed design will use steel frame as the main structure, this allows flexibility for future changes. Applicant should ensure the design of the steel frame to be as efficient as possible as steel has high embodied carbon. – See Section 3.1.3

The revision to this document addresses these comments in detail through the provision of Section 3 and with changes to text throughout the document. In doing this we have generally left in place the work originally submitted for context and as an audit trail of how the design has evolved.

In particular please note that Sections 1 and 2 remain largely unchanged with all new work being presented in Section 3.

Project Description

Two options have been presented to LBH one with the front façade retained and one with a fully new building.

The proposals are for the construction of a new 4 storey property of GIA 837.6m², included a new basement, ground, first and loft floors – two side wings, and ground floor extensions to the side and rear with swimming pool in the garden.

New exterior walls are to be of red/brown brick construction to match the materiality and detailing of the existing front façade. Double storey bays to the front facade comprising faceted joinery and curved masonry.

New roof, with tiles to match the existing, lead flat roofs and six dormer windows detailed to match the existing. Flat roofs to pavilion, side extension and rear terrace.

There are new services throughout as designed by GMS Engineering.

Figure 1 Rendering image from MWA report



Summary of Original results

The **Baseline** modelling included **Superstructure, Sub-structure, Hard Landscaping, Services, and operational energy and water us** initially had a GWP impact of 1,582,400 kgCO₂eq over its lifespan of 60 years.

At the end of the **initial** options analysis – with most measures proposed by the design team included – the impact of the building was reduced to 1,435,589 kgCO₂eq over its lifespan of 60 years. The improved option provided a reduction in the impact over 60 years of **146,811 kgCO₂eq – equivalent to a saving of 9.2%, and a 20.5% reduction in module A1-A5 only**. This was achieved by the selecting materials as follows:

- ☐ Ready-mix Concrete – 50% GGBS cement replacement with specification of natural aggregates with up to 20% of recycled content. (proposed by structure engineer)
- ☐ Reinforcement steel – 97% recycled content (typical UK) (proposed by structure engineer)
- ☐ Structural hollow steel sections (HSS), cold rolled, 40 % recycled content

Baseline

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	715,407 kg CO ₂ e	206,484 kg CO ₂ e	876,662 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	855.034	246.784	1047.761
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Initial Option with Recycled Content

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	568,596 kg CO ₂ e	206,484 kg CO ₂ e	729,851 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	679.569	246.784	872.297
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Two further consideration option were also included – 1) reuse existing brick in good condition. 2) lower impact blockwork. The option of reusing existing brick was proposed by the design team and for this assessment we assumed a 40% of brick would be reused brick. However, the exact percentage would need to confirm at As-build Stage.

- ☐ Reuse existing brick in good condition (40%): **WLC saving of 1.5% from Baseline, 3.3% reduction in module A1-A5.**
- ☐ Lower impact blockwork: **WLC saving of 0.3% from Baseline, 0.7% reduction in module A1-A5.**

Updated Design Scheme

There are some minor changes since last planning submission which have been incorporated as follows:

- ☐ Reduce the amount of chimney from 4 chimneys to 2 chimneys.
- ☐ Change the front façade according to the existing building, the bay window elements only present on ground floor.
- ☐ Bay window to the ground floor drawing room (rear)
- ☐ Slight adjustment to roof rear pitch / added hips. – minor changes not included in this update.
- ☐ GIA amended to 870.8 m²

Result Summary of the updated design

The result below is demonstrate the updated design and reusing 40% the brick of the existing building with high recycled content as well as using the low impact blockwork.

New Design Scheme with optimisations

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	533,079 kg CO₂e	217,162 kg CO ₂ e	705,129 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	612.17	249.38	809.75
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Retained façade Option

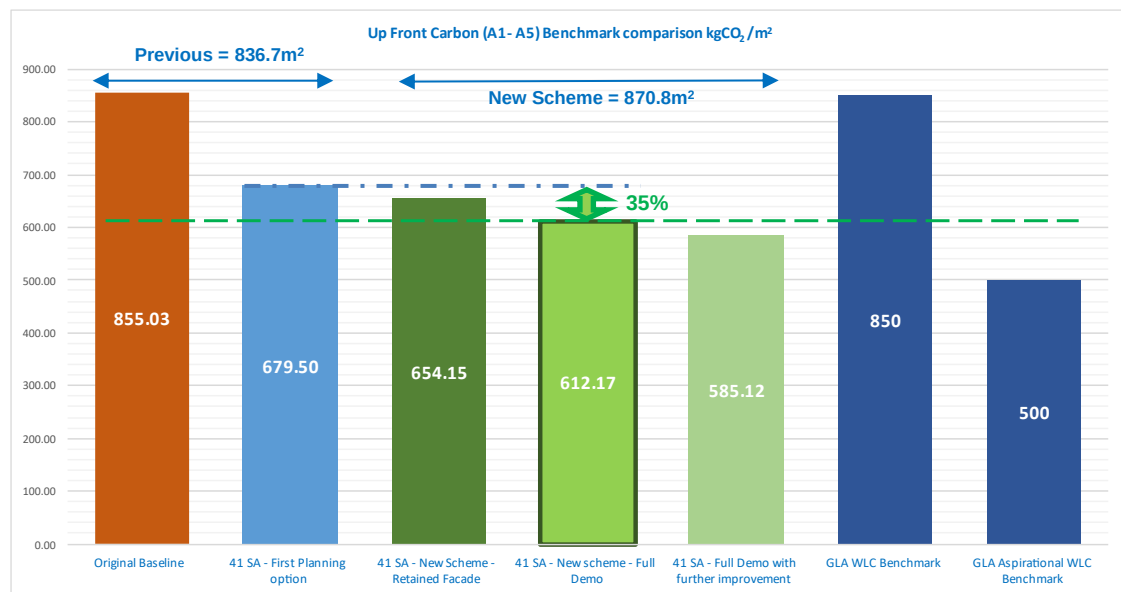
	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	569,634 kg CO₂e	217,737 kg CO ₂ e	742,150 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	654.15	250.04	852.26
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Potential New Design Scheme – further improvements

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	509,519 kg CO₂e	217,055 kg CO ₂ e	681,472 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	585.12	249.26	782.58
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Overall Comparison

The Chart below show the result of A1-A5 upfront carbon for each option and compares with the baseline, the original scheme and the GLA benchmark.



- ☐ **First Planning option:** This is the option previously presented in Section 2.2.
- ☐ **Retained Façade Option:** Retained the front façade.
- ☐ **Updated Full Demo Option:** Full demolition with some design changes made for this submission .
- ☐ **Further Improvement Options:** Optimisation of design for further potential reduction of impacts.

The three additional options presented use the **same low impact Ready-mix concrete** with **Steel frame optimised for a 5% reduction** and apart from the retained option all have **reused 40% of the existing bricks**.

All blockwork is Enviroblock low impact blockwork and all services are identical in these three options.

1 Detailed Analysis

1.1 Methodology

This section sets out the detailed results of the WLCA along with assumption and qualifications on the data quality. WLCA Inputs and assumptions

1.1.1 Building elements

Table 1.1 – Building Elements included in assessment

RICS #	BUILDING ELEMENTS	Coverage %
0	0.1 temporary work	N/A
1	1.1 Substructure	95%
2	2.1 Superstructure: Frame	100%
	2.2 Superstructure: Upper Floors	100%
	2.3 Superstructure: Roof	100%
	2.4 Superstructure: Stair and ramps	100%
	2.5 Superstructure: External wall	100%
	2.6 Superstructure: Windows and External Door	100%
	2.7 Superstructure: Internal Walls and Partitions	100%
	2.8 Superstructure: Internal Doors	100%
3	3.1 Wall Finishes	95%
	3.2 Floor Finishes	100%
	3.3 Ceiling finishes	95%
4	4. Fittings, furnishings, and equipment	N/A
	4.1.2 Domestic Kitchen fitting and equipment	95%
5	5.1. Sanitary installations	95%
	5.4 Water installation	100%
	5.5 Heat source	95%
	5.6 Space heating and air conditioning	95%
	5.8 Lighting installation	95%
	5.11 Fire and Lightning Protection	95%

1.1.2 EN 15978 Module Coverage and life span

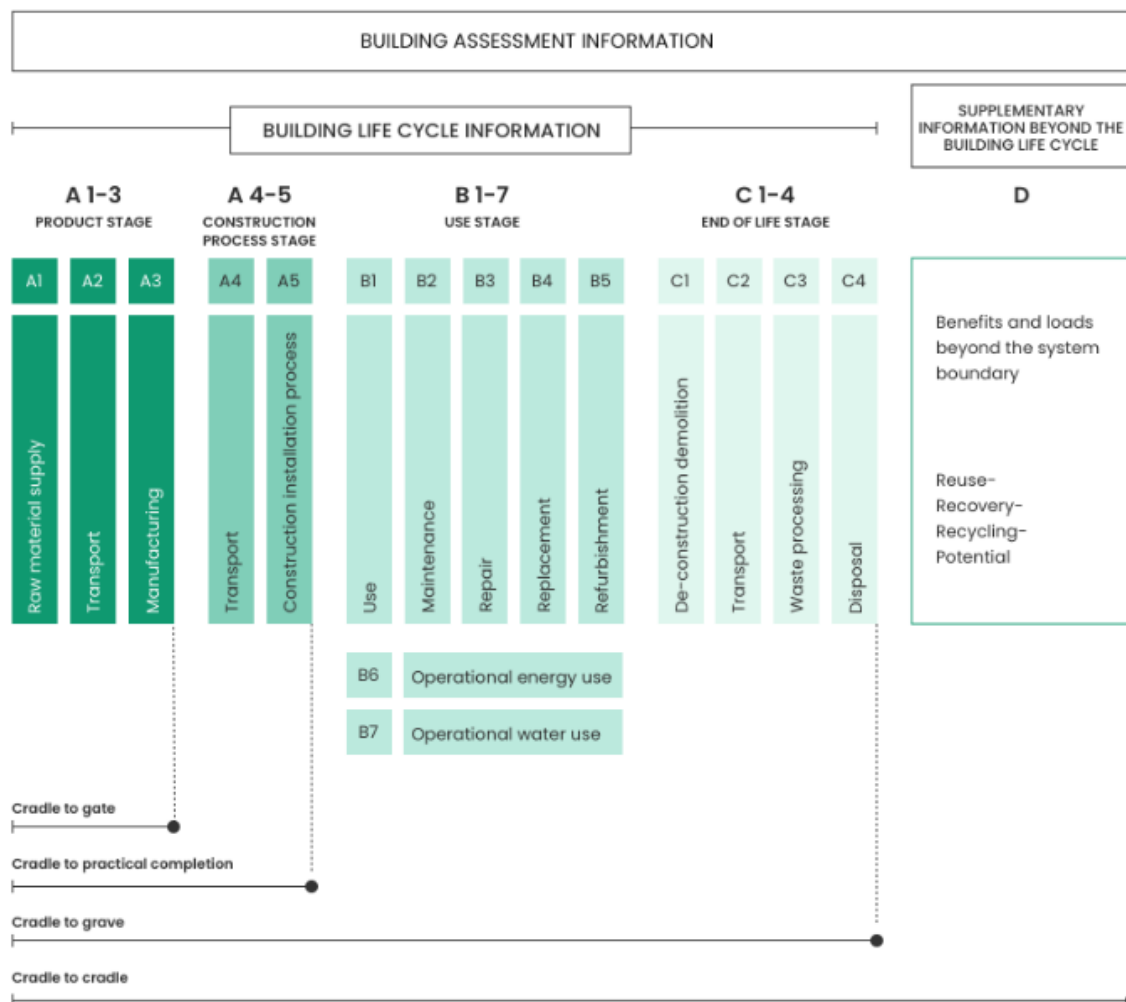
BS EN15978:3011 is the basis for this assessment in alignment with the RICS guidance for Whole life Carbon Assessment for the built environment (2017); utilising One click LCA software.

Life-cycle modules

- ☐ Module A1 – A5 (product sourcing and construction stage)
- ☐ Module B1 – B5 (use stage); B6-B7 (Operation stage)
- ☐ Module C1 – C4 (end-of-life stage)
- ☐ Module D (benefits and loads beyond the system boundary)

This assessment has included the A1-A5, B1, B3, B4, C1-C4, and D (not included in the result).

Figure 1 – Building life-cycle module according to the EN-15978



Assumed building life span

The reference study period for the purposes of the assessment is **60 years**. Where the design life of the project exceeds or is less than 60 years, the assessment should still be done to 60 years but with an accompanying explanation of the life cycle and end-of-life scenarios for the actual design life.

1.1.3 Data, measurement source and assumption

As per EN15978-2011 section 9.1 stated that ...” *The quantification of all material and products is determined based upon the design description of the object of assessment (new building or refurbishment of an existing building) or with the actual quantities (existing buildings, post-refurbishment) and the scenarios for each module of the life cycle of the object of assessment.*”

Floor area

The assessment has taken the floor area from Stage 3 outline specification.

Materials quantity, selection and assumptions

Please see table in Appendix A for detail information, however, the data source for materials quantity and selection can be summarised as follows:

- ☐ Revit Model: Architectural, structural (MWA, Symmetrys)
- ☐ Stage 3 Design drawings/report (Architectural, MEP)
- ☐ Stage 3 Outline Specification
- ☐ Energy strategy (Edward Pearce)

Further work – data quality

There is further work to be done in terms of refining the accuracy of the prediction made at this time and in particular:

- ☐ the timber floor and roof supporting structure has been estimated – timber joist.
- ☐ the recycled content in steel frame – currently all assumed as 40% recycled content which can be taken into consideration while procurement as improvement strategy.
- ☐ the recycled content in concrete – structure engineer proposed a 50% GGBS cement replacement and Specification of natural aggregates with up to 20% of recycled content.
- ☐ some services distribution assumptions have been made using standard software criteria and these can be refined at the As Built stage

1.1.4 Tools and embodied carbon data

To assess the embodied carbon for the project, a Life Cycle Assessment (LCA) tool – One Click LCA – has been used to make allocations for the anticipated materials quantities. Material carbon data is based on One Click LCA database which utilises EPDs in accordance with EN 15804, and Material specification, transport assumptions, lifespan assumption and end-of-life scenarios is based on RICS Professional Statement.

Unless noted below we have used standard values for service lifespans and transport.

Module B2 Maintenance Assumptions

The assessment currently is under the design stage 3, therefore the Module B2 is difficult to estimate. According to the GLA WLCA Guidance section 2.5.12 state that "... for module B2 emissions, a total figure of 10 kgCO₂e/m² gross internal area (GIA) may be used to cover all building element categories, or 1 per cent of modules A1-A5, whichever is greater."

Module B3 Repair Assumptions

The assessment is using the Repair scenario which is compliance with the GLA Guidance which may be estimated as 25 per cent of module B2, as per the RICS PS (item 3.5.3.3).

- ❑ All MEP materials repair rate will be updated at As-Build stage.

Module B4 Service Life Assumptions

RICS whole life carbon assessment for the built environment guidance state that ...*"It should be assumed that items are being replaced on a like-for-like basis and full replacement (100 per cent) of the items is assumed once the specified lifespan is reached."*

Carbon Plan Engineering did not change any One Click LCA datapoints' default value (RICS Professional Statement Table 9) except all the cabinets would have a 20-year life span instead of 12 years, due to the improvements compared to 2017.

However, this will have to be updated at As-Build stage with more accurate figure with the manufacturer/supplier O&M Manual or specified product EPD.

1.1.5 Operational Impacts – B6 and B7

Module B6 Operational Energy Use

This project proposed renewable energy – solar panel as low carbon energy strategy. As RISC 2nd edition table H2 below shows that the onsite renewables (used onsite/ exported to grid) are excluded in the B6 calculation.

	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3	C4	D1	D2
Electricity grid																			
Onsite renewables* actually used onsite																			
Onsite renewables* exported to the grid but to be used again by the building in the same year (match annual consumption)																			
Onsite renewables for export only – x%																			
Gas																			
Biomass																			
District heating																			

Key	
Embodied carbon	A, B, C
Operational energy	in B6
Beyond the life cycle	D1
	D2

In this project, there is **589.87 kg CO₂/year** of carbon emission would be offsetting by PV panel, **35393.4 kg CO₂/year** within the 60 of the building lifetimes.

The simulation has been carried out in two scenarios: Retained façade and demolition with Full New Build.

The Regulated energy is based on the updated SAP output report which carried out by the certified energy assessor and consultancy – GMS engineering Design. Please see the screenshot of the SAP Output Report below:

Regulated energy consumption (Electricity) :

Retained Façade Option: 0.3

Figure 3 SAP output report by GMS Engineering Design

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP			
	Energy kWh/year	Emission factor kg CO ₂ /kWh	Emissions kg CO ₂ /year
Space heating - main system 1	9198.6091	0.1549	1425.3005 (261)
Total CO ₂ associated with community systems			0.0000 (373)
Water heating (other fuel)	2030.9338	0.1411	286.6639 (264)
Space and water heating			1711.9644 (265)
Space cooling	16.7267	0.1139	1.9044 (266)
Pumps, fans and electric keep-hot	5124.6190	0.1387	710.8478 (267)
Energy for lighting	1014.9267	0.1443	146.4853 (268)
Energy saving/generation technologies			
PV Unit electricity used in dwelling	-2713.6434	0.1330	-360.9810
PV Unit electricity exported	-1897.4514	0.1206	-228.8219
Total			-589.8029 (269)
Total CO ₂ , kg/year			1981.3990 (272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			2.2800 (273)

Space heating + Water heating + Pumps, fan + Lighting =

$1,425.3 \text{ kg CO}_2 + 286.66 \text{ kg CO}_2 + 710.85 \text{ kg CO}_2 + 146.49 \text{ kg CO}_2 = 2,569 \text{ kg CO}_2 / \text{year}$

$60 \text{ years building life} = 2,569 \text{ kg CO}_2 / \text{year} \times 60 \text{ years} = 154,158 \text{ kg CO}_2 \text{e}$

Full New Build Option:

Figure 4 SAP output report by GMS Engineering Design

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP			
	Energy kWh/year	Emission factor kg CO ₂ /kWh	Emissions kg CO ₂ /year
Space heating - main system 1	8436.7639	0.1553	1310.1479 (261)
Total CO ₂ associated with community systems			0.0000 (373)
Water heating (other fuel)	2066.0528	0.1411	291.4385 (264)
Space and water heating			1601.5863 (265)
Space cooling	15.6669	0.1137	1.7809 (266)
Pumps, fans and electric keep-hot	5067.2424	0.1387	702.8890 (267)
Energy for lighting	1002.4814	0.1443	144.6890 (268)
Energy saving/generation technologies			
PV Unit electricity used in dwelling	-2695.5053	0.1330	-358.4936
PV Unit electricity exported	-1915.5895	0.1208	-231.3784
Total			-589.8720 (269)
Total CO ₂ , kg/year			1861.0733 (272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			2.1700 (273)

Space heating + Water heating + Pumps, fan + Lighting =

$1,310.15 \text{ kg CO}_2 + 291.44 \text{ kg CO}_2 + 702.89 \text{ kg CO}_2 + 144.69 \text{ kg CO}_2 = 2449 \text{ kg CO}_2 / \text{year}$

$60 \text{ years building life} = 2449 \text{ kg CO}_2 / \text{year} \times 60 \text{ years} = 146,950 \text{ kg CO}_2 \text{e}$

Unregulated energy consumption:

GMS has made provision in the new design to connect the pool to the ASHP system. The low temperature heat required by the pool means that a high ScOP of 4.5 can be utilised.

$$\text{Pool Energy Required} = 5,000 / 4.5 \text{ (ScOP of ASHP)} = 1,111 \text{ kWh}$$

$$\text{Pool (Electricity): } 1,111 \text{ kWh/year} \times 60 \text{ years} = 66,660 \text{ kWh}$$

$$66,660 \text{ kWh} \times 0.1552 \text{ kg CO}_2\text{e} = \mathbf{10,345.63 \text{ kg CO}_2\text{e}}$$

No assessment was made by GMS engineering design on unregulated energy use in the dwelling and so we have made an assumption of 30kWh/m² based upon other – smaller- residential dwellings.

$$30 \text{ kWh/m}^2\text{/year (unregulated energy)} \times 870.8 \text{ m}^2 \text{ (GIA)} = 26,124 \text{ kWh}$$

$$26,124 \text{ kWh/year} \times 60 \text{ years} = 1,567,440 \text{ kWh}$$

$$1,506,060 \text{ kWh} \times 0.136 \text{ kg CO}_2\text{e} = \mathbf{213,171.84 \text{ kg CO}_2\text{e}}$$

Total of unregulated energy emission:

$$\mathbf{10,345.63 \text{ kg CO}_2\text{e} + 213,171.84 \text{ kg CO}_2\text{e} = 223,517.47 \text{ kg CO}_2\text{e}}$$

Module B7 Operational Water Use

The Operational Water Use have assumed this project as a 6-people living household with the water usage of 115 litre/person/day to compliance with the regulation minimum.

$$\text{Total water use} = (\text{WUI} \times \text{no. of occupants}) \times \text{home days in a year} \times \text{building life cycle}$$

$$\text{Water use} = ((125 \times 6+) \times 365 \times 60) \div 1000 + 20 \text{ m}^3 \times 60 \text{ (swimming pool)} = 17,625 \text{ m}^3 \text{ of water consumed over development life.}$$

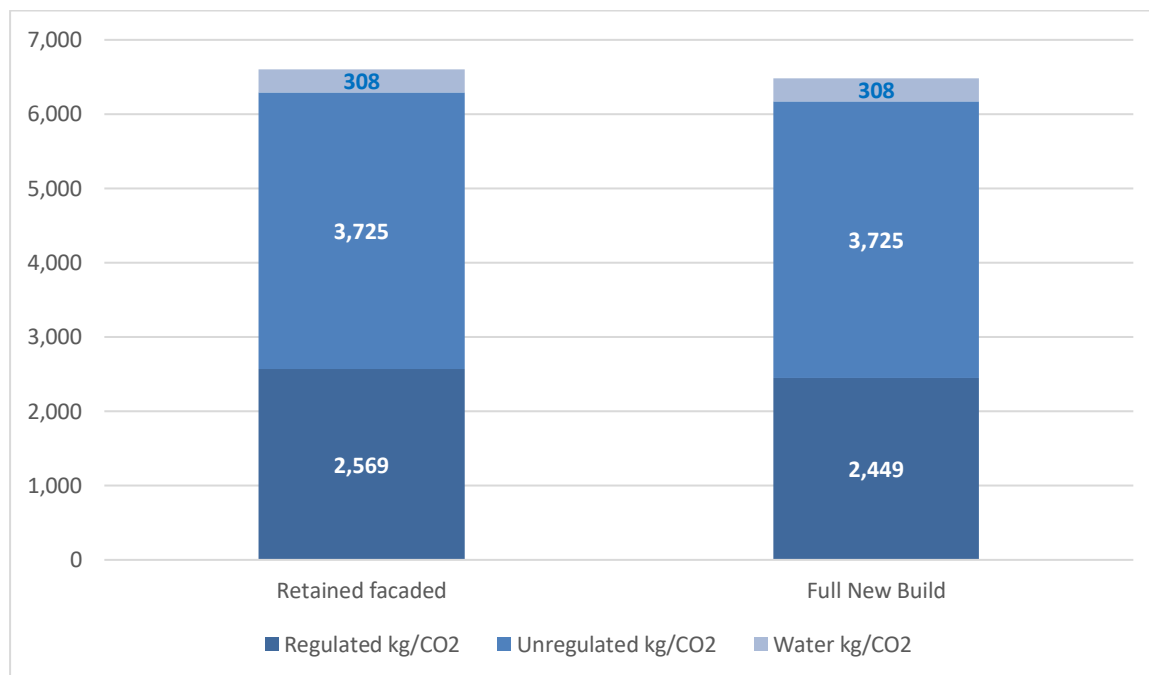
$$\text{Supply} = 17,625 \times 0.34 = 5,993 \text{ kgCO}_2\text{e}$$

$$\text{Treatment} = (17,625 \times 0.9) \times 0.71 = 12,514 \text{ kgCO}_2\text{e}$$

$$\mathbf{\text{Total water emissions} = 18,506 \text{ kgCO}_2\text{e}}$$

Module B6 & B7 Option Comparison

The above figures are brought together in the following table to show the operational impacts of the proposals. The Regulated CO₂ figures circa 38.72% of the total operational impact per year for the full new build proposal and are 1.14% lower than the façade retnrtion option.



Over the 60 year lifespan of the project these can be compared as:

- ❑ Retained façade = 396.16 Tonnes CO₂
- ❑ Full New Build = 388.96 Tonnes CO₂

Therefore the façade retention option emits approximately 7.2 Tonnes more CO₂ than the full new build assuming the current CO₂ factor for electricity.

1.2 Baseline Building

1.2.1 Baseline LCA impacts

The top 15 Materials make up 77.2% of total materials impact, and the MEP materials have 11.1% of total materials impact.

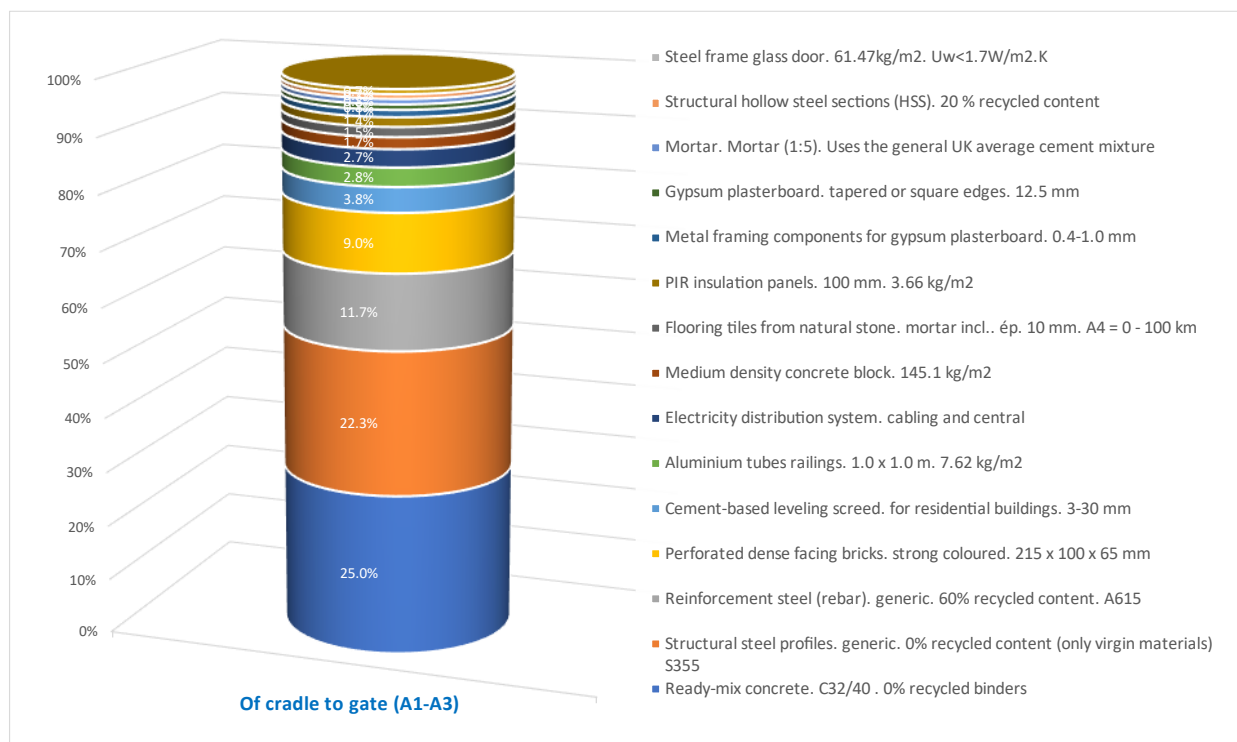
Table 1.2 – The top 25 materials

	Resource / Material / Product	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1	Ready-mix concrete. C32/40 . 0% recycled binders	158.00	25.0%
2	Structural steel profiles. generic. 0% recycled content (only virgin materials) S355	141.00	22.3%
3	Reinforcement steel (rebar). generic. 60% recycled content. A615	74.00	11.7%
4	Perforated dense facing bricks. strong coloured. 215 x 100 x 65 mm	57.00	9.0%
5	Cement-based levelling screed. for residential buildings. 3-30 mm	24.00	3.8%
6	Aluminium tubes railings. 1.0 x 1.0 m. 7.62 kg/m2	18.00	2.8%
7	Electricity distribution system. cabling and central	17.00	2.7%
8	Medium density concrete block. 145.1 kg/m2	11.00	1.7%
9	Flooring tiles from natural stone. mortar incl.. ép. 10 mm. A4 = 0 - 100 km	9.40	1.5%
10	PIR insulation panels. 100 mm. 3.66 kg/m2	8.90	1.4%
11	Metal framing components for gypsum plasterboard. 0.4-1.0 mm	6.70	1.1%
12	Gypsum plasterboard. tapered or square edges. 12.5 mm	5.00	0.8%
13	Mortar. Mortar (1:5). Uses the general UK average cement mixture	5.00	0.8%
14	Structural hollow steel sections (HSS). 20 % recycled content	4.30	0.7%
15	Steel frame glass door. 61.47kg/m2. Uw<1.7W/m2.K	4.60	0.7%
16	5.24 kW air-to-air heat pump heating only for individual housing.	4.30	0.7%
17	Masonry mortars.	3.60	0.6%
18	Clay roofing tiles. 40 kg/m2	3.80	0.6%
19	Wooden and engineered wood interior doors. 1.23 m x 2.18 m. 72.8 kg/m2	3.60	0.6%
20	Facing bricks. clay pavers and brick slips. 900-2500 kg/m3	3.50	0.6%
21	Electric water heater (water cylinder). 200 litre capacity	3.60	0.6%
22	XPS insulation board. 0.033 W/mK. 31 kg/m3	3.10	0.5%
23	Softwood plywood. uncoated. 480 kg/m3. 8% moisture content	3.10	0.5%
24	Exterior wooden door and windows. double glazed.. 36.8kg/m2	2.90	0.5%
25	Fan coil unit. 41.4 kg/unit	2.90	0.5%

The top 15 materials are represented in the chart below.



Figure 4 – WLCA – Top 15 materials – Baseline



1.2.2 Baseline LCA impact breakdown

The detailed results of the WLCA are compared to the GLA benchmark shown in the section 2.5 and the total saving of the embodied carbon is around 70% compared to these WLCA benchmarks.

Table 1.3a – WLCA Breakdown

A1-A5 Embodied Carbon Emission		
A1-A3	Product Stage	632.20 tCO2e
A1-A3	Biogenic	-45.20 tCO2e
A4	Transport to site	14.60 tCO2e
A5	Construction and installation	68.50 tCO2e
Total A1-A5		670.10 tCO2e

B1-B5 Embodied Carbon Emission		
B1-B2	Use and Maintenance	8.40 tCO2e
B3	Repair	2.10 tCO2e
B4	Replacement	122.70 tCO2e
B5	Refurbishment	0.00 tCO2e
Total B1-B5		133.20 tCO2e

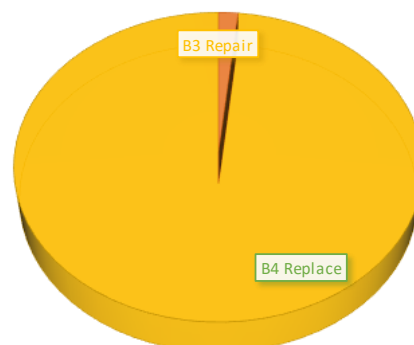
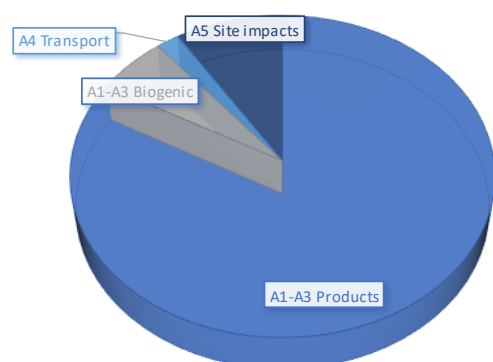
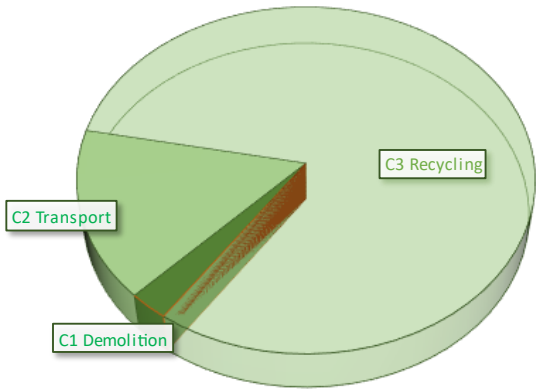
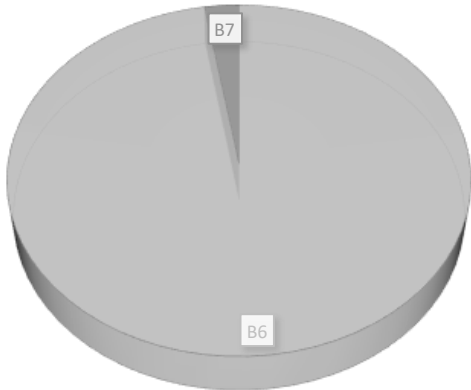


Table 1.3b – WLCA Breakdown

C1-C4 Embodied Carbon Emission		
C1	Demolition	1.90 tCO2e
C2	Transport to disposal	11.60 tCO2e
C3	Waste processing for reuse, recovery or recycle	59.90 tCO2e
C4	Refurbishment	0.00 tCO2e
Total C1-C4		73.40 tCO2e



B6-B7 Operational Carbon Emission		
B6	Operational Energy Use	687.23 tCO2e
B7	Operational Water Use	18.51 tCO2e
Total B6-B7		705.74 tCO2e



Recommendation

The above charts and the following images both confirm that the impact of Product stage (A1-A3) and replacement (B1-B5) is significant. Therefore, the recycled content in concrete or metal and the lifespan of all materials should be considered in detail going forward.

1.3 Options Considered

1.3.1 Recycled Content in concrete, rebar and steel frame

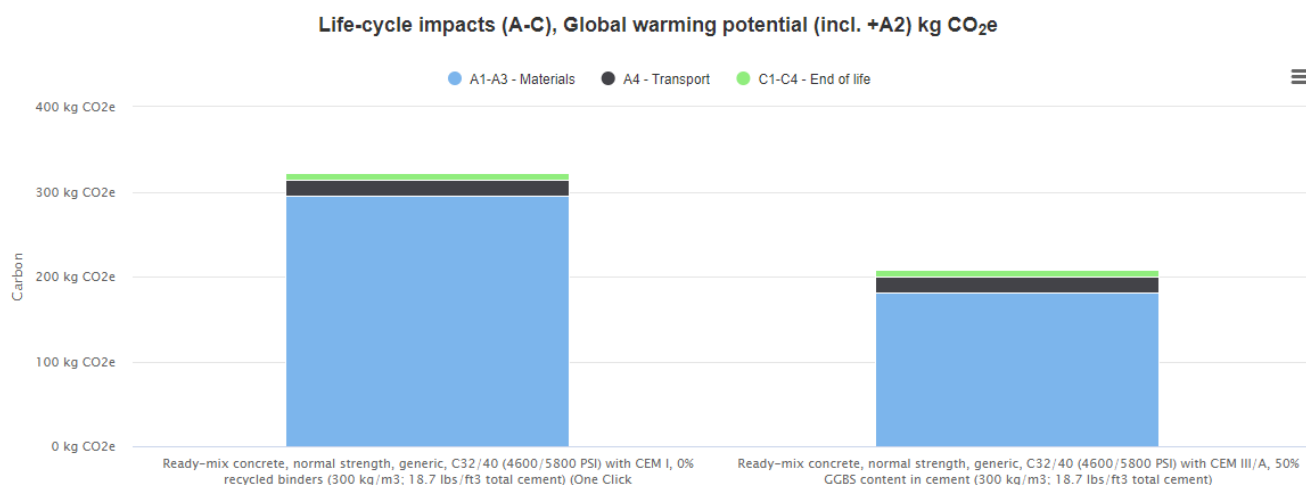
Recycled content in materials is a critical measure of reducing embodied carbon emissions, in this section we demonstrate the saving by comparing the materials with and without recycled content.

Recycled content in Concrete

As the following table and chart shows that there is a 114 kg CO_{2e} (38.6%) of carbon saving if the project used 1 m³ of the ready-mix concrete with 50% GGBS instead of the ready-mix concrete with no recycled content.

Resource name	Quantity	A1-A3 - Materials (kg CO _{2e})	A4 - Transport (kg CO _{2e})	C1-C4 - End of life (kg CO _{2e})
Ready-mix concrete, normal strength, generic, C32/40 (4600/5800 PSI) with CEM I, 0% recycled binders (300 kg/m ³ ; 18.7 lbs/ft ³ total cement) (One Click LCA) - 1.0 m ³	1.0 m ³	295.18	18.72	7.85
Ready-mix concrete, normal strength, generic, C32/40 (4600/5800 PSI) with CEM III/A, 50% GGBS content in cement (300 kg/m ³ ; 18.7 lbs/ft ³ total cement) (One Click LCA) - 1.0 m ³	1.0 m ³	181.18	18.72	7.85

Figure 5 LCA Options – Concrete

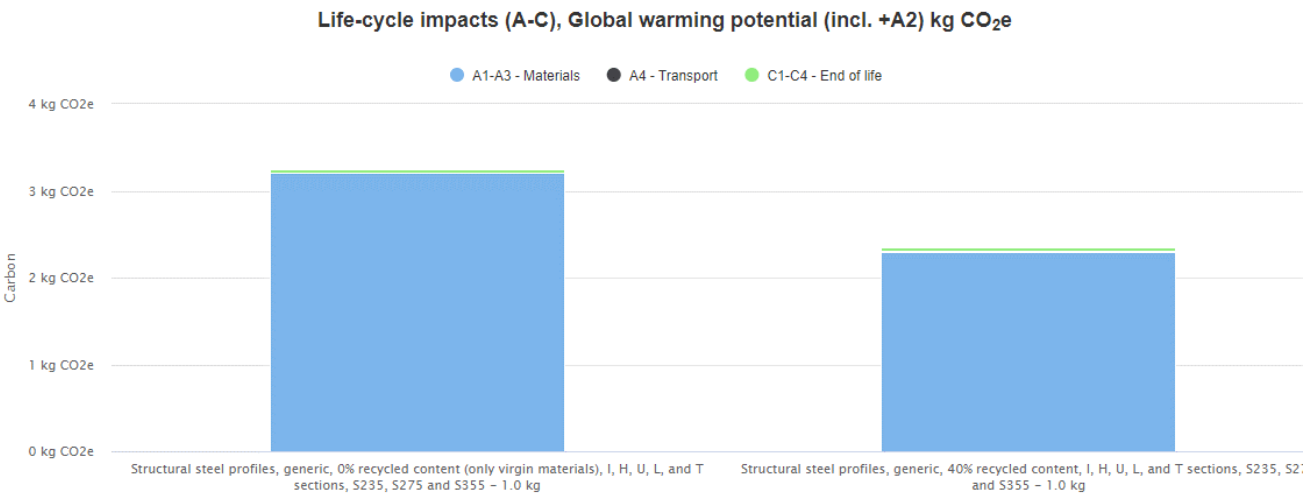


Recycled content in Steel Frame

As the following table and chart shows that there is a 0.91kg CO₂e (28.35%) of carbon saving if the project used 1 kg of the steel profiles with 40% recycled content instead of the steel with no recycled content.

Resource name	Quantity	A1-A3 - Materials (kg CO ₂ e)	A4 - Transport (kg CO ₂ e)	C1-C4 - End of life (kg CO ₂ e)
Structural steel profiles, generic, 0% recycled content (only virgin materials), I, H, U, L, and T sections, S235, S275 and S355 - 1.0 kg	1.0 kg	3.21	0	0.04
Structural steel profiles, generic, 40% recycled content, I, H, U, L, and T sections, S235, S275 and S355 - 1.0 kg	1.0 kg	2.3	0	0.04

Figure 6 LCA Options – Steel



Reinforcement (Rebar)

The recycled content in rebar will be maximised to 97% from 60% which also reduce a significant amount of the module A1-A5 embodied Carbon impact.



1.3.2 Further improvement to be considered

Reuse Brick on site

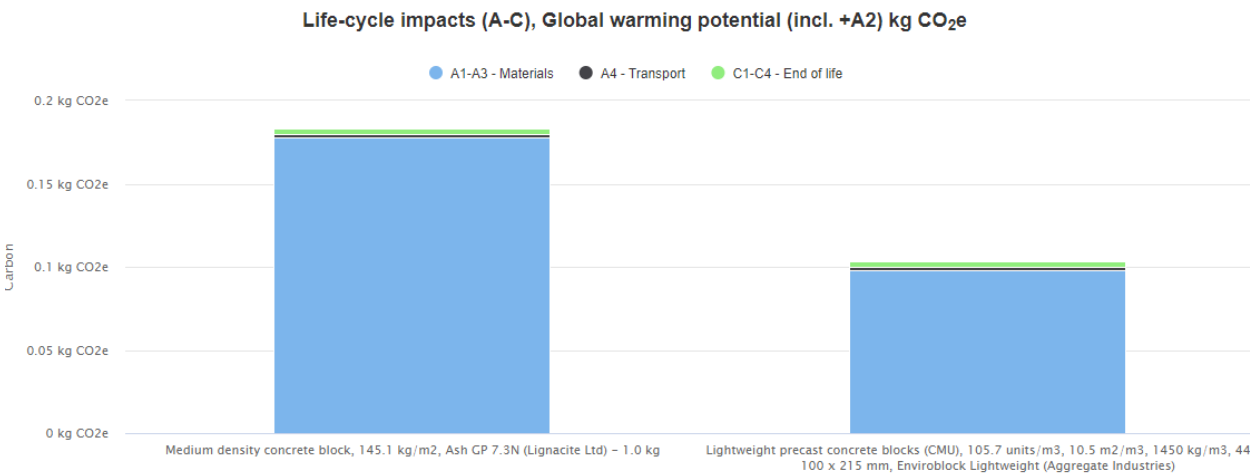
The project proposed to maximise the potential of reusing the brick in good condition from existing building. This measure will be beneficial to reduce the module A1-A5 embodied carbon emission (up-front carbon).

Choosing lower impact blockwork

As the following table and chart shows that there is a 0.08 kg CO₂e (44.4%) of carbon saving if the project used 1 kg of the lower impact product.

Resource name	A1-A3 - Materials (kg CO2e)	A4 - Transport (kg CO2e)	C1-C4 - End of life (kg CO2e)
Medium density concrete block, 145.1 kg/m ² , Ash GP 7.3N (Lignacite Ltd) - 1.0 kg	1.0 kg	0.18	0
Lightweight precast concrete blocks (CMU), 105.7 units/m ³ , 10.5 m ² /m ³ , 1450 kg/m ³ , 440 x 100 x 215 mm, Enviroblock Lightweight (Aggregate Industries) - 1.0 kg	1.0 kg	0.1	0

Figure 7 LCA Options – Blockwork



1.4 LCA Results – Original As Designed building

1.4.1 Original As Designed LCA impacts

The top 15 Materials make up 77.2% of total materials impact, and the MEP materials have 11.1% of total materials impact.

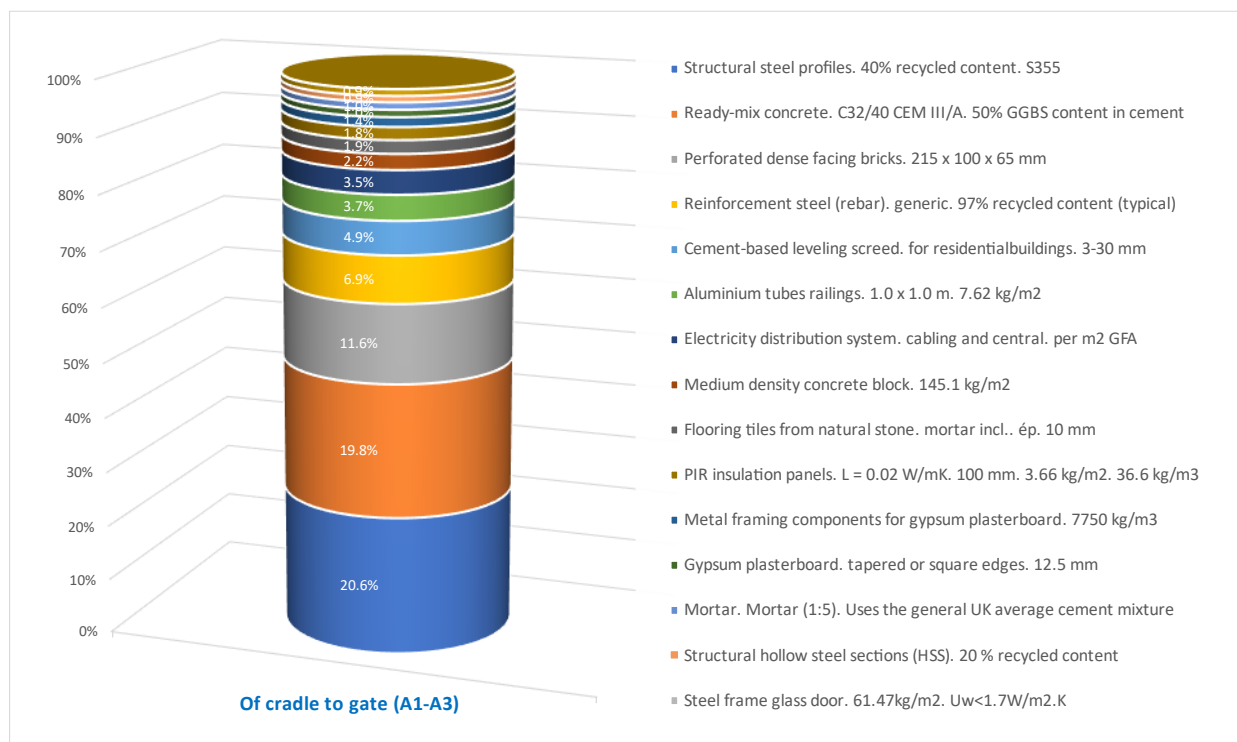
Table 1.4 – The top 25 materials

	Resource / Material / Product	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1	Structural steel profiles. 40% recycled content. S355	101.00	20.6%
2	Ready-mix concrete. C32/40 CEM III/A. 50% GGBS content in cement	97.00	19.8%
3	Perforated dense facing bricks. 215 x 100 x 65 mm	57.00	11.6%
4	Reinforcement steel (rebar). generic. 97% recycled content (typical)	34.00	6.9%
5	Cement-based levelling screed. for residential buildings. 3-30 mm	24.00	4.9%
6	Aluminium tubes railings. 1.0 x 1.0 m. 7.62 kg/m2	18.00	3.7%
7	Electricity distribution system. cabling and central. per m2 GFA	17.00	3.5%
8	Medium density concrete block. 145.1 kg/m2	11.00	2.2%
9	Flooring tiles from natural stone. mortar incl.. ép. 10 mm	9.40	1.9%
10	PIR insulation panels. L = 0.02 W/mK. 100 mm. 3.66 kg/m2. 36.6 kg/m3	8.90	1.8%
11	Metal framing components for gypsum plasterboard. 7750 kg/m3	6.70	1.4%
12	Gypsum plasterboard. tapered or square edges. 12.5 mm	5.00	1.0%
13	Mortar. Mortar (1:5). Uses the general UK average cement mixture	5.00	1.0%
14	Structural hollow steel sections (HSS). 20 % recycled content	4.30	0.9%
15	Steel frame glass door. 61.47kg/m2. $U_w < 1.7 \text{ W/m}^2 \cdot \text{K}$	4.60	0.9%
16	5.24 kW air-to-air heat pump heating only for individual housing	4.30	0.9%
17	Clay roofing tiles. 40 kg/m2	3.80	0.8%
18	Masonry mortars.	3.60	0.7%
19	Wooden and engineered wood interior doors. 72.8 kg/m2	3.60	0.7%
20	Facing bricks. clay pavers and brick slips. 900-2500 kg/m3	3.50	0.7%
21	Electric water heater (water cylinder). 200 litre capacity	3.60	0.7%
22	XPS insulation board. 0.033 W/mK. 31 kg/m3	3.10	0.6%
23	Softwood plywood. uncoated. 480 kg/m3. 8% moisture content	3.10	0.6%
24	Exterior wooden door and windows. double glazed. 24mm. 36.8kg/m2	2.90	0.6%
25	Fan coil unit. 41.4 kg/unit	2.90	0.6%

The top 15 materials are represented in the chart below.



Figure 8 – WLCA – Top 15 materials – As Designed



1.4.2 Original As Designed LCA impact breakdown

The detailed results of the WLCA are compared to the GLA benchmark shown in the section 2.5 and the total saving of the embodied carbon is around 70% compared to these WLCA benchmarks.

Table 1.5a – WLCA Breakdown

A1-A5 Embodied Carbon Emission		
A1-A3	Product Stage	491.10 tCO2e
A1-A3	Biogenic	-45.20 tCO2e
A4	Transport to site	14.60 tCO2e
A5	Construction and installation	62.80 tCO2e
Total A1-A5		523.30 tCO2e

B1-B5 Embodied Carbon Emission		
B1-B2	Use and Maintenance	8.40 tCO2e
B3	Repair	2.10 tCO2e
B4	Replacement	122.70 tCO2e
B5	Refurbishment	0.00 tCO2e
Total B1-B5		133.20 tCO2e

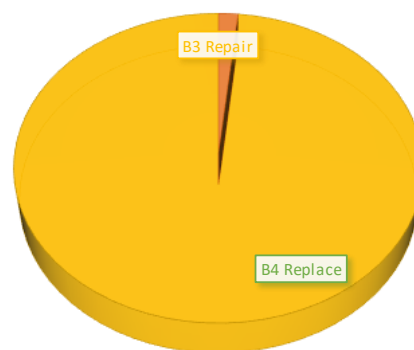
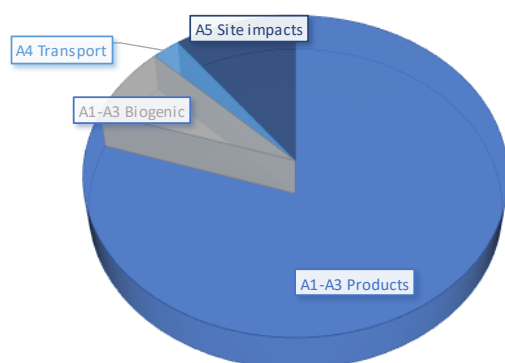
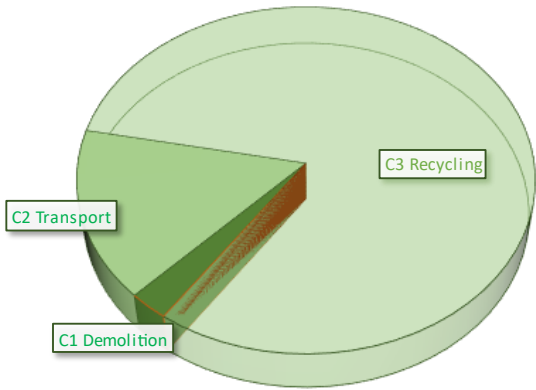
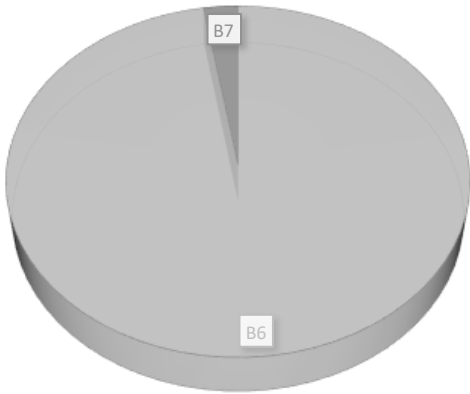


Table 1.5b – WLCA Breakdown

C1-C4 Embodied Carbon Emission		
C1	Demolition	1.90 tCO2e
C2	Transport to disposal	11.60 tCO2e
C3	Waste processing for reuse, recovery or recycle	59.90 tCO2e
C4	Refurbishment	0.00 tCO2e
Total C1-C4		73.40 tCO2e



B6-B7 Operational Carbon Emission		
B6	Operational Energy Use	687.23 tCO2e
B7	Operational Water Use	18.51 tCO2e
Total B6-B7		705.74 tCO2e



Recommendation

The above charts and the following images both confirm that the impact of Product stage (A1-A3) and replacement (B1-B5) is significant. Therefore, the recycled content in concrete or metal and the lifespan of all materials should be considered in detail going forward.

There follows a series of charts which present the outcomes of the analysis in different formats. These show the various breakdowns of materials across modules, categories and sub-categories.

Figure 9 – Material Flows

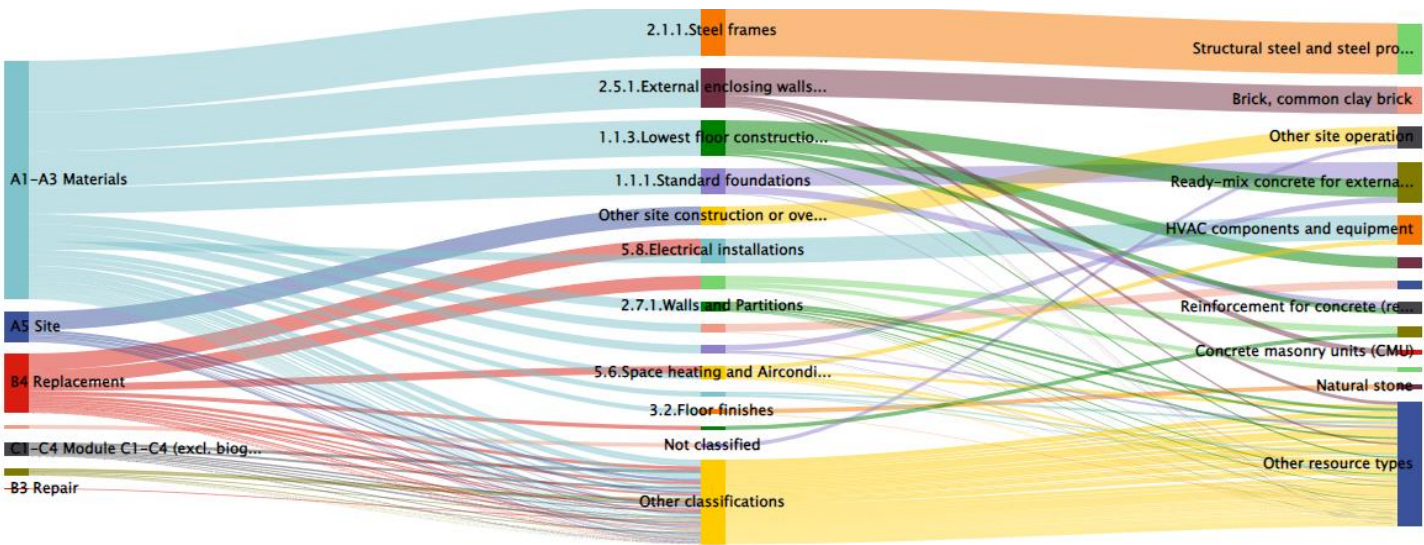


Figure 10a – Subtype breakdown – Lifecycle Stages

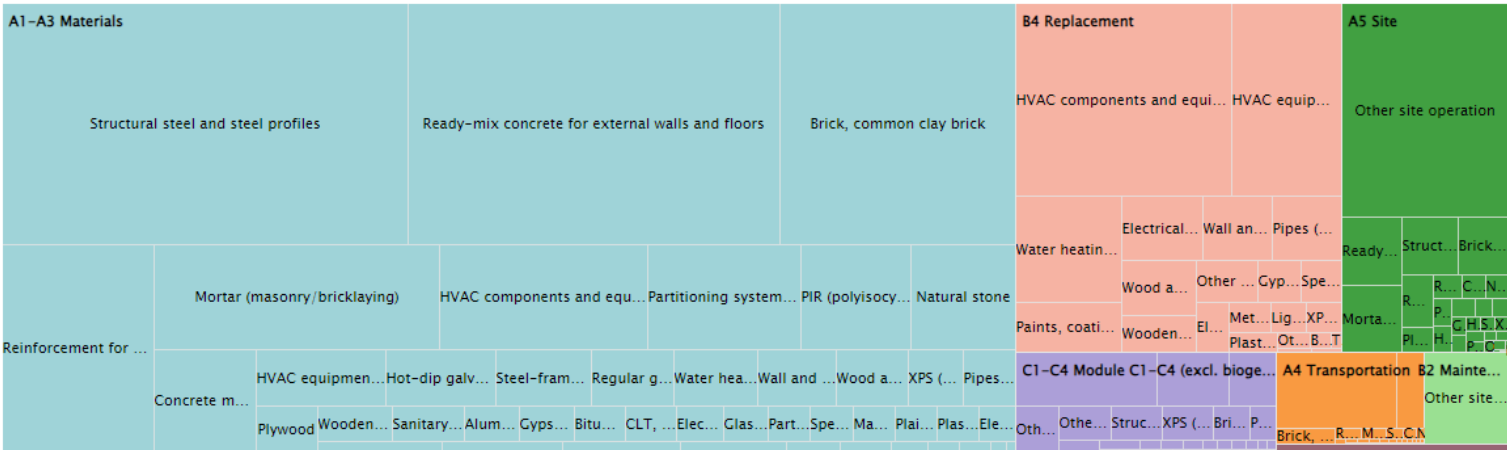


Figure 10b – Subtype breakdown – Subtype over lifecycle

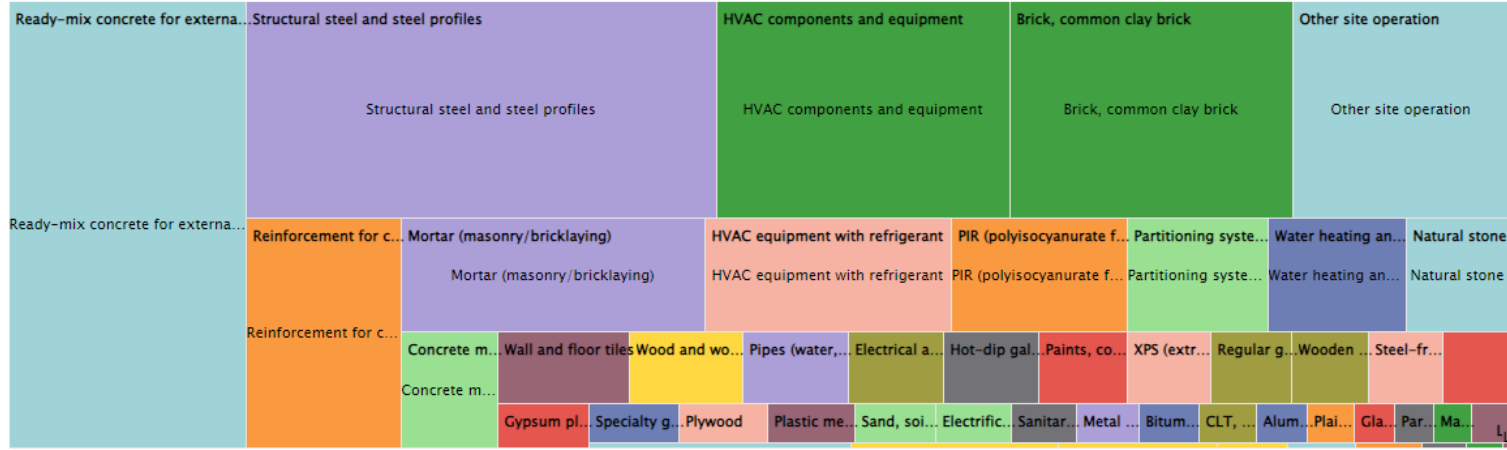


Figure 10c – Subtype breakdown – By Lifecycle Stage

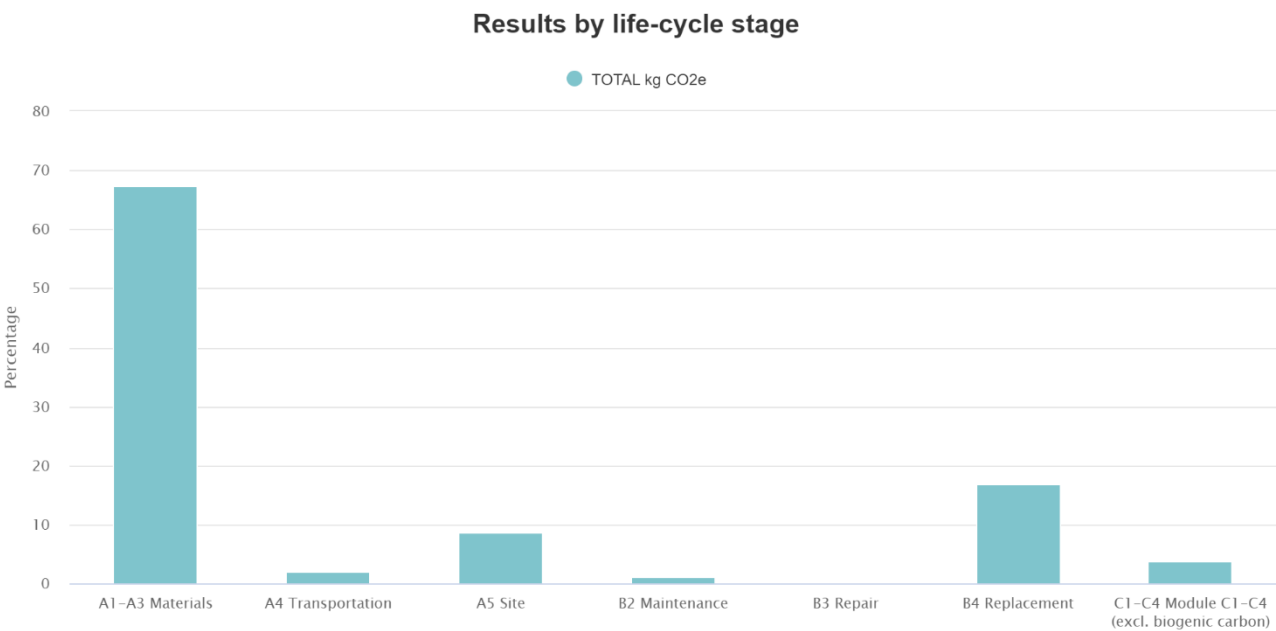
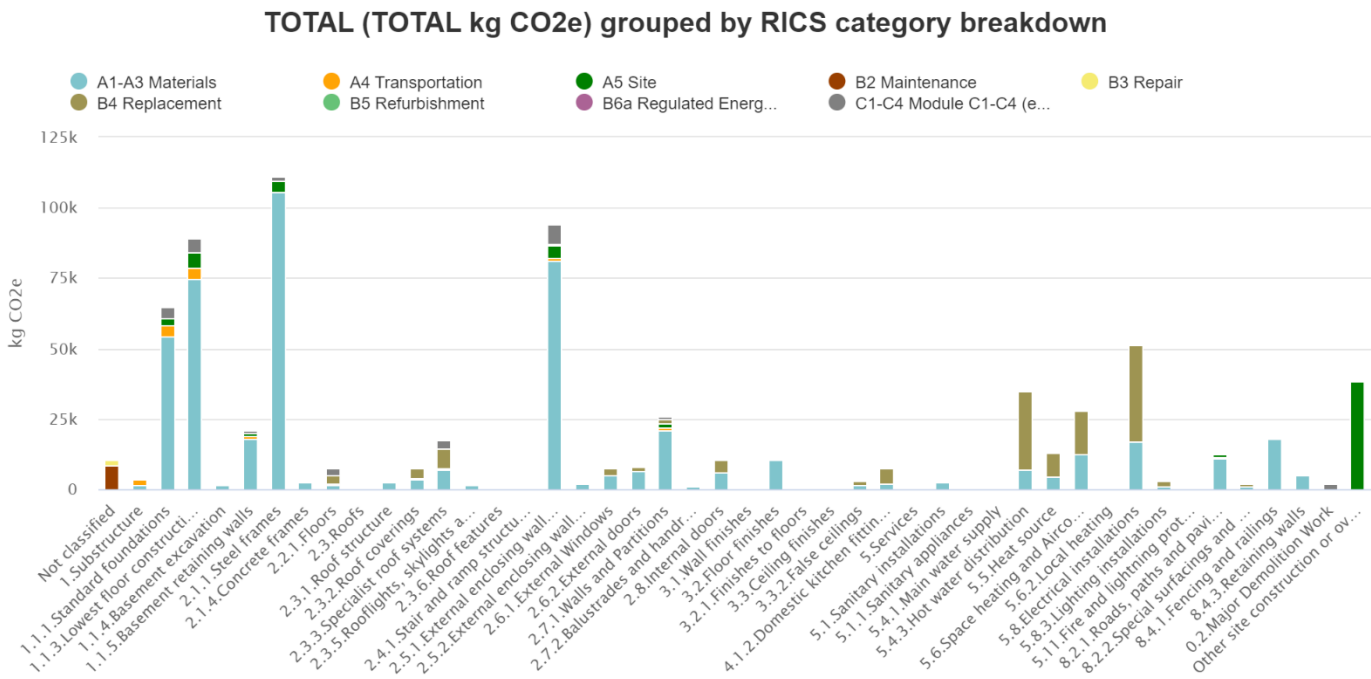


Figure 10d – Subtype breakdown – Total kg CO₂e by category



2 LCA Results Summary – Original

2.1 Baseline Summary

The overall WLC result (including all modules of WLC) are shown in the table and chart below.

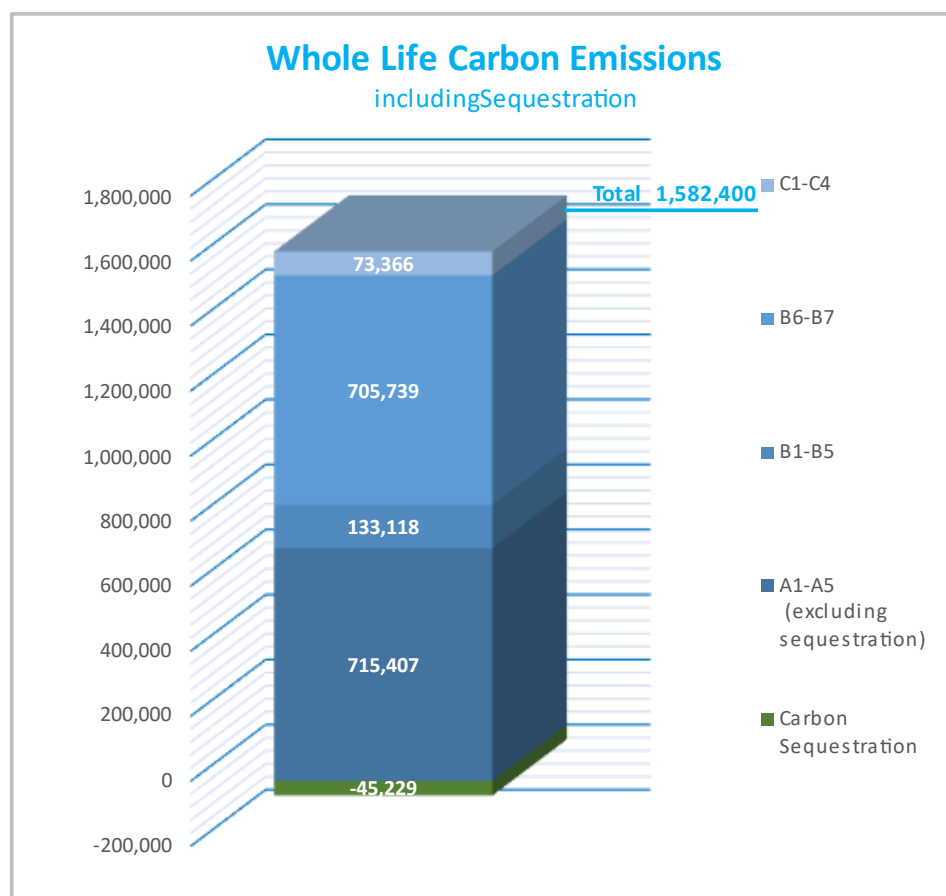
In the tables, all carbon emissions are listed by WLC modules, to demonstrate the specific elements that can be improved or for the future reference.

Table 2.1 – Overall WLCA results showing sequestration

Modules	WLC Result					
	A1-A5 (excluding sequestration)	B1-B5	B6-B7	C1-C4	Carbon Sequestration	Total (included sequestration)
kgCO ₂ e	715,407	133,118	705,739	73,366	-45,229	1,582,400
kgCO ₂ e/m ²	855.03	159.10	843.48	87.68	-54.06	1891.24

The chart below gives a visualisation of the WLC breakdown for the building, with module A1-A5, B1-B5, and C1-C4.

Figure 11 – Baseline – Overall Whole Life Carbon showing sequestration



2.2 Original As Designed Summary

The overall WLC result (including all modules of WLC) are shown in the table and chart below.

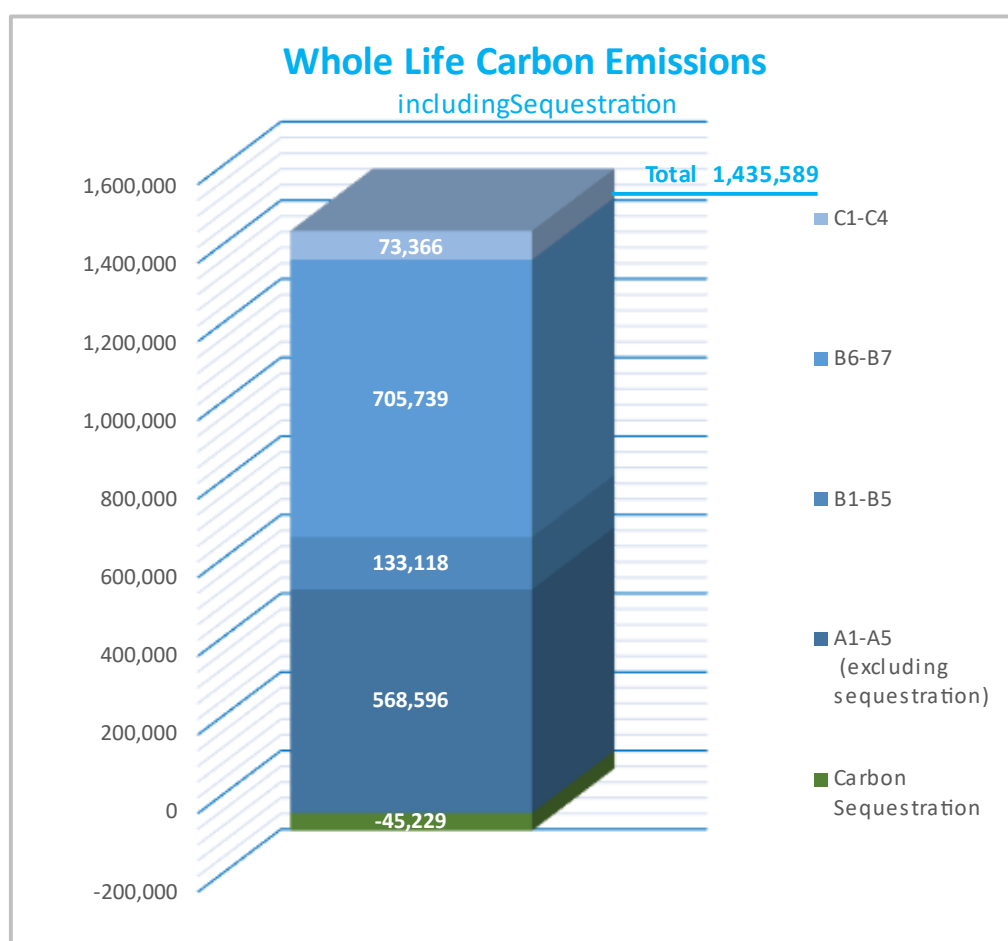
In the tables, all carbon emissions are listed by WLC modules, to demonstrate the specific elements that can be improved or for the future reference.

Table 2.2 – Overall WLCA results showing sequestration

Modules	WLC Result					
	A1-A5 (excluding sequestration)	B1-B5	B6-B7	C1-C4	Carbon Sequestration	Total (included sequestration)
kgCO ₂ e	568,596	133,118	705,739	73,366	-45,229	1,435,589
kgCO ₂ e/m ²	679.57	159.10	843.48	87.68	-54.06	1715.78

The chart below gives a visualisation of the WLC breakdown for the building, with module A1-A5, B1-B5, and C1-C4.

Figure 12 – As Designed – Overall Whole Life Carbon showing sequestration



2.3 Original Options Comparison

Please see below tables for the summary result for each option compare with the GLA WLA benchmark for residential development.

Table 2.3 – WLCA Results and Options – Details

Baseline

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	715,407 kg CO ₂ e	206,484 kg CO ₂ e	876,662 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	855.034	246.784	1047.761
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Recycled Content

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	568,596 kg CO ₂ e	206,484 kg CO ₂ e	729,851 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	679.569	246.784	872.297
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Reused 40% of brickwork

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	691,612 kg CO ₂ e	206,484 kg CO ₂ e	852,867 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	826.595	246.784	1019.323
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

Lower Impact Blockwork – Envirobloc

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	710,074 kg CO ₂ e	201,539 kg CO ₂ e	871,329 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	848.660	240.874	1041.387
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

The following bar chart shows the A1-A5 impact between Baseline, as design and two further consideration option with the WLCA benchmark.

Figure 13 – WLCA Results and Options – Summary

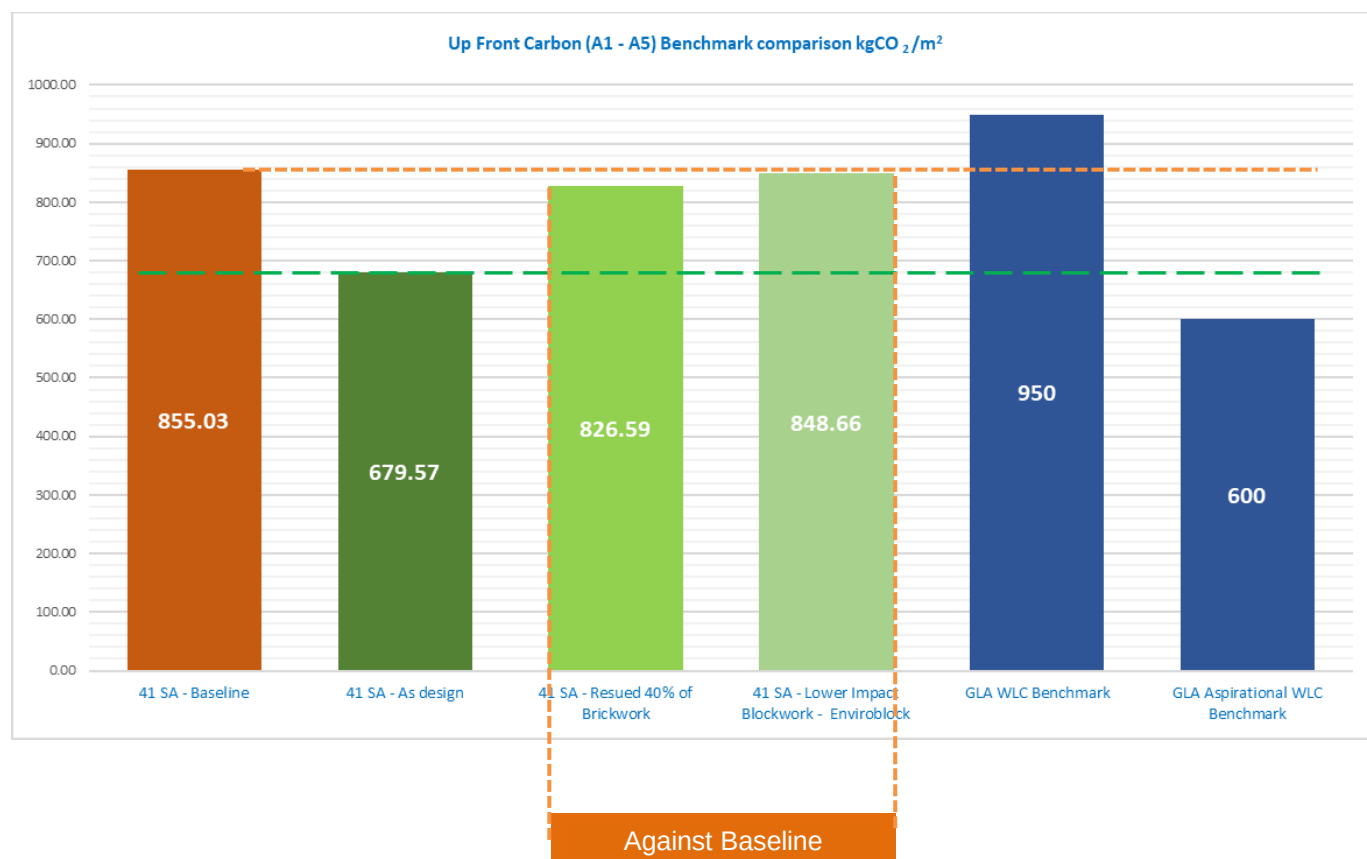


Table 2.4 – WLCA Results and Options – Summary

	kg/CO ₂ /m ²	Compare to baseline
41 SA - Baseline	855.03	
41 SA - As design	679.57	-175.47
41 SA - Resued 40% of Brickwork	826.59	-28.44
41 SA - Lower Impact Blockwork - Enviroblock	848.66	-6.37
GLA WLC Benchmark	850	-5.03
GLA Aspirational WLC Benchmark	500	-355.03

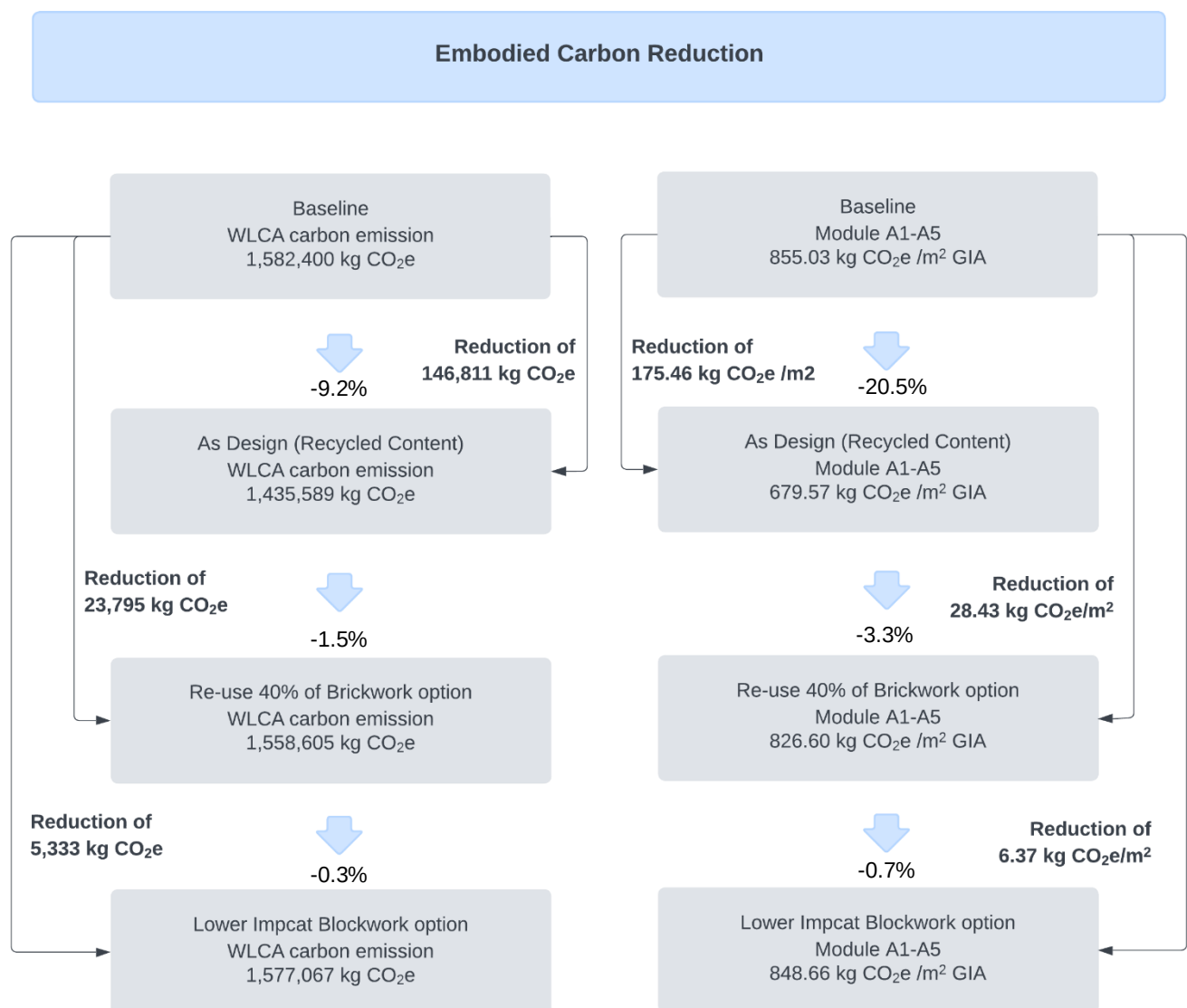
2.3.2 Summary

The flow chart below has shown that the potential reduction figure by each measure, as the bottom line the project would have a carbon saving around 146,811 kg CO₂e throughout the design building life (60 years) by procuring high recycled content materials.

For the option of reusing 40% brickwork is based on the architect proposal (reuse good condition brick) and the percentage is assumed for the purpose of the exercise to demonstrate the potential future reduction. It is difficult to have an accurate figure at stage 3 therefore the percentage of reusing existed brick will be report at as build stage assessment.

The option of lower impact block work only shows a little reduction due to the little amount of the blockwork present on site.

Figure 14 – Embodied Carbon process map



3 Planning Responses – Updated Design

This section is the response to the Planning comment related to the WLCA, as follows:

“However, they fall short of achieving lower embodied carbon targets of the aspirational WLC benchmarks which are 500 kgCO₂e/m² and 800 kgCO₂e/m². – Section 3.1.3

In addition, there is no comparison of the WLC of a retention and retrofit scenario. – Section 3.1

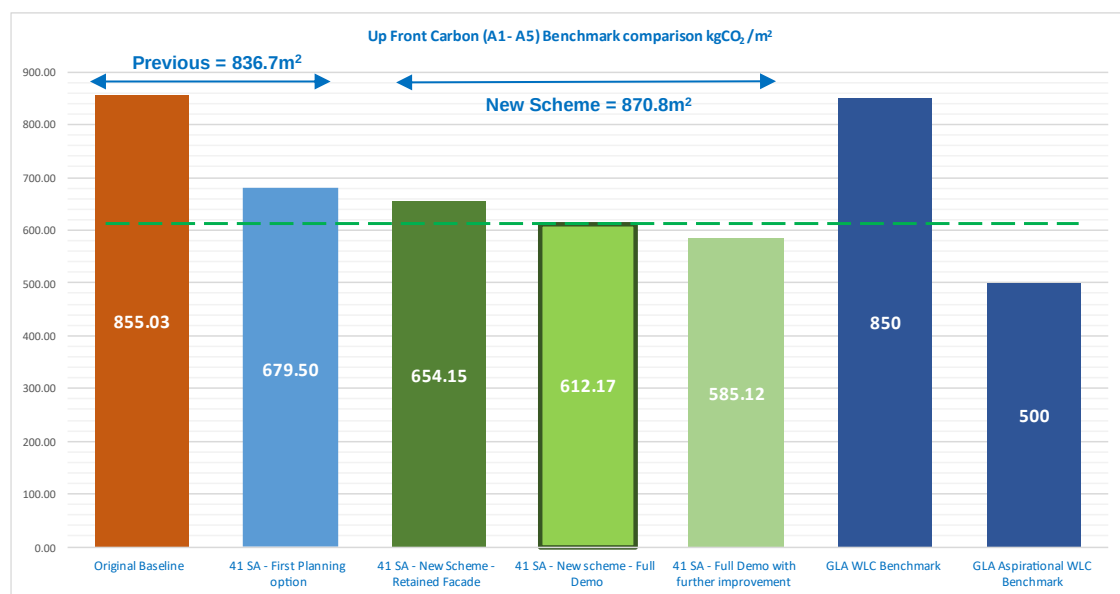
The CE report has explained the new proposed design will use steel frame as the main structure, this allows flexibility for future changes. Applicant should ensure the design of the steel frame to be as efficient as possible as steel has high embodied carbon.” – Section 3.1.3

The section 3.1 below has included the result and comparison of the retained option and current proposal.

3.1 Options Comparison

This Section set out the options and compare among the first planning submission scheme, retained front façade option and updated design option.

The Chart below show the result of A1-A5 upfront carbon for each option and compares with the baseline, the original scheme and the GLA benchmark.



- ☐ **First Planning option:** This is the option previously presented in Section 2.2
- ☐ **Retained Façade Option:** Retained the front façade
- ☐ **Updated Full Demo Option:** Full demolition with some design changes made for this submission
- ☐ **Further Improvement Options:** Optimisation of design for further potential reduction of impacts

All additional options presented use the **same low impact Ready-mix concrete** with **Steel frame optimised for a 5% reduction** and apart from the retained option all have **reused 40% of the existing bricks**. All blockwork is Enviroblock low impact blockwork and all services are identical.

3.1.1 Retained Front Façade Option



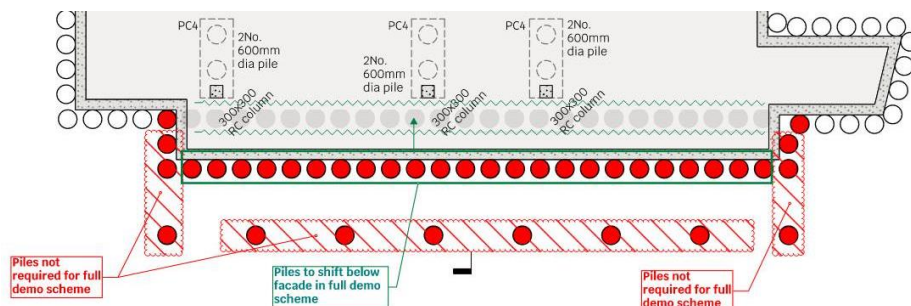
This option explores the carbon impacts of retaining the front façade. The result of this option is an impact of **569,634 kgCO₂eq** in module A1-A5 only. This has a slightly higher impact when compared to the full demolition scheme in the First Planning option and significantly higher than the improved proposals for full demolition below; increasing the A1-A5 impacts by **36,555 kgCO₂eq**.

Retained façade Option

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	569,634 kg CO₂e	217,737 kg CO ₂ e	742,150 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	654.15	250.04	852.26
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

The following lists the factors that make the retained façade option have higher embodied impact:

- ☐ The retained façade needs to be supported by temporary steel frame.
- ☐ The new ground floor slab area needed for the supported temporary steel frame
- ☐ 12 more piles needed for the new scheme, please see the drawing below provided by Symmetry.



- ☐ There is minimal of brick can be reused as the brick on the rear façade is painted and the front façade is retained.

3.1.2 Updated Scheme (New Proposed Option)



Figure 3 rendering image from Response to Conservation Design by WMA

This option includes the following changes to the design with no additional changes to the data inputs.

- ☐ Bay window on the front façade and ground floor only
- ☐ Reduce the chimney amount from 4 to 2.
- ☐ Change the window for drawing room to Bay window
- ☐ Roof adjustment – minimal change hence ignored at this update.
- ☐ Inclusion of the Photovoltaic panels, MVHR and amended ASHP

This new scheme provides a reduction in the impact of the building of **24,722kgCO₂eq – equivalent to a saving of 3.4%** compared to First Planning option. When compared to the façade retention option we see that there is a saving of **36,555 kgCO₂eq – equivalent to a saving of 5%**. (Mouldes A-C result comparison)

New Design Scheme with optimisations

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	533,079 kg CO₂e	217,162 kg CO ₂ e	705,129 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	612.17	249.38	809.75
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

3.1.3 Updated Scheme with Further Improvements

Following the above option a number of further interventions have been proposed to further reduce the impacts. We cannot commit to full delivery of these until the stage 4 design is well underway and procurement has been commenced, however they will be pursued as far as is possible:

- Materials Optimised: 10% quantity reduction of steel frame by structure engineering
- Reclaimed steel frame: target 20% of the steel frame will procure reclaimed steel frame

This option provides a reduction in the impact of the proposed option in Section 3.1.2 of **23,657 kgCO₂eq – equivalent to a saving of 3.3%.**(Mouldes A-C result comparison) This also demonstrates that the Design Team have attempted to get closer to the aspirational WLC benchmark by exploring the potential to reduce the impact further.

Currently the Module A-C have achieve the target <800 kg CO₂e/m² (GIA) by resulting in 782.58 kg CO₂e/m² (GIA).

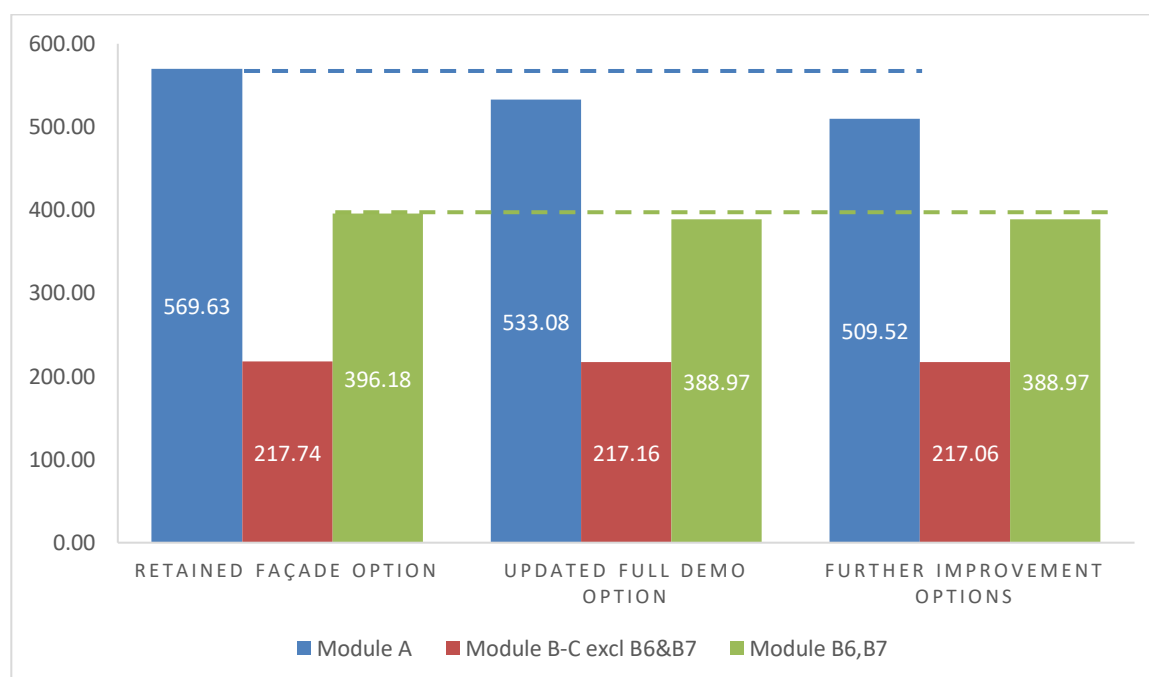
Potential New Design Scheme – further improvements

	Module A1-A5 (excluding sequestered carbon)	Modules B-C (excl B6 & B7)	Modules A-C (excl B6 & B7; including sequestered carbon)
TOTAL kg CO ₂ e	509,519 kg CO ₂ e	217,055 kg CO ₂ e	681,472 kg CO ₂ e
TOTAL kg CO ₂ e/m ² GIA	585.12	249.26	782.58
WLC Benchmark	<850	<350	<1200
Aspirational WLC Benchmark	<500	<300	<800

3.2 WLCA comparison summary

This Section set out the options and compare among the retained front façade option and updated design option.

The Chart below show the result of WLC for each option to compare and demonstrate the effect of the Module B6 difference cause by the worse u value in the retained front façade option.



- ☐ **Retained Façade Option:** Retained the front façade
- ☐ **Updated Full Demo Option:** Full demolition with some design changes made for this submission
- ☐ **Further Improvement Options:** Optimisation of design for further potential reduction of impacts

	Retained Façade Option	Updated Full Demo Option	Further Improvement Options
WLC Result	1,183,549 kgCO ₂ e	1,139,215 kgCO ₂ e	1,115,548 kgCO ₂ e
Overall Difference		44,334 kgCO ₂ e	68,001 kgCO ₂ e
Difference in kgCO ₂ e/m ²		50.92	78.10

3.3 Proposed Updated Scheme Summary

3.3.1 Updated Scheme LCA Impacts A1 – A3

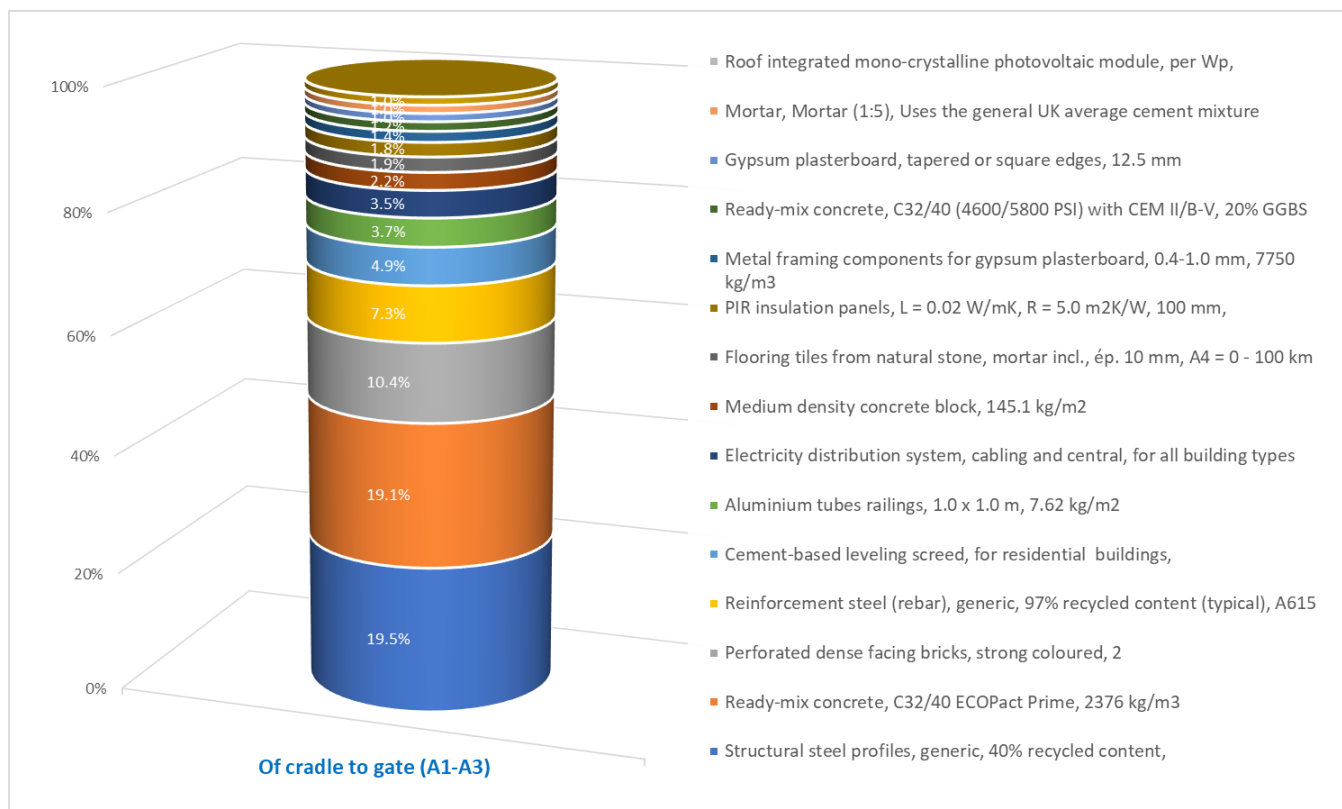
The top 15 Materials make up 84% of total materials impact, and the MEP materials have 10.9% of total materials impact.

Table 1.4 – The top 25 materials

	Resource / Material / Product	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)
1	Structural steel profiles, generic, 40% recycled content,	96.00	19.5%
2	Ready-mix concrete, C32/40 ECOPact Prime, 2376 kg/m3	94.00	19.1%
3	Perforated dense facing bricks, strong coloured, 2	51.00	10.4%
4	Reinforcement steel (rebar), generic, 97% recycled content (typical), A615	36.00	7.3%
5	Cement-based leveling screed, for residential buildings,	24.00	4.9%
6	Aluminium tubes railings, 1.0 x 1.0 m, 7.62 kg/m2	18.00	3.7%
7	Electricity distribution system, cabling and central, for all building types	17.00	3.5%
8	Medium density concrete block, 145.1 kg/m2	11.00	2.2%
9	Flooring tiles from natural stone, mortar incl., ép. 10 mm, A4 = 0 - 100 km	9.40	1.9%
10	PIR insulation panels, L = 0.02 W/mK, R = 5.0 m2K/W, 100 mm,	8.90	1.8%
11	Metal framing components for gypsum plasterboard, 0.4-1.0 mm, 7750 kg/m3	6.70	1.4%
12	Ready-mix concrete, C32/40 (4600/5800 PSI) with CEM II/B-V, 20% GGBS	5.80	1.2%
13	Gypsum plasterboard, tapered or square edges, 12.5 mm	5.00	1.0%
14	Mortar, Mortar (1:5), Uses the general UK average cement mixture	5.00	1.0%
15	Roof integrated mono-crystalline photovoltaic module, per Wp,	5.00	1.0%
16	Steel frame glass door, 61.47kg/m2, Uw<1.7W/m2.K	4.60	0.9%
17	Structural hollow steel sections (HSS), 20 % recycled content,	4.30	0.9%
18	5.24 kW air-to-air heat pump heating only for individual housing,	4.30	0.9%
19	Clay roofing tiles, 40 kg/m2	3.80	0.8%
20	Wooden and engineered wood interior doors, 1,23 m x 2,18 m, 72.8 kg/m2	3.60	0.7%
21	Electric water heater (water cylinder), 200 liter capacity	3.60	0.7%
22	Facing bricks, clay pavers and brick slips, 900-2500 kg/m3	3.50	0.7%
23	Masonry mortars,	3.20	0.7%
24	XPS insulation board, 0.033 W/mK, 31 kg/m3	3.10	0.6%
25	Softwood plywood, uncoated, 480 kg/m3, 8% moisture content	3.10	0.6%

The top 15 materials are represented in the chart below.





3.3.2 Updated Scheme Overall Summary

The overall WLC result (including all modules of WLC) are shown in the table and chart below.

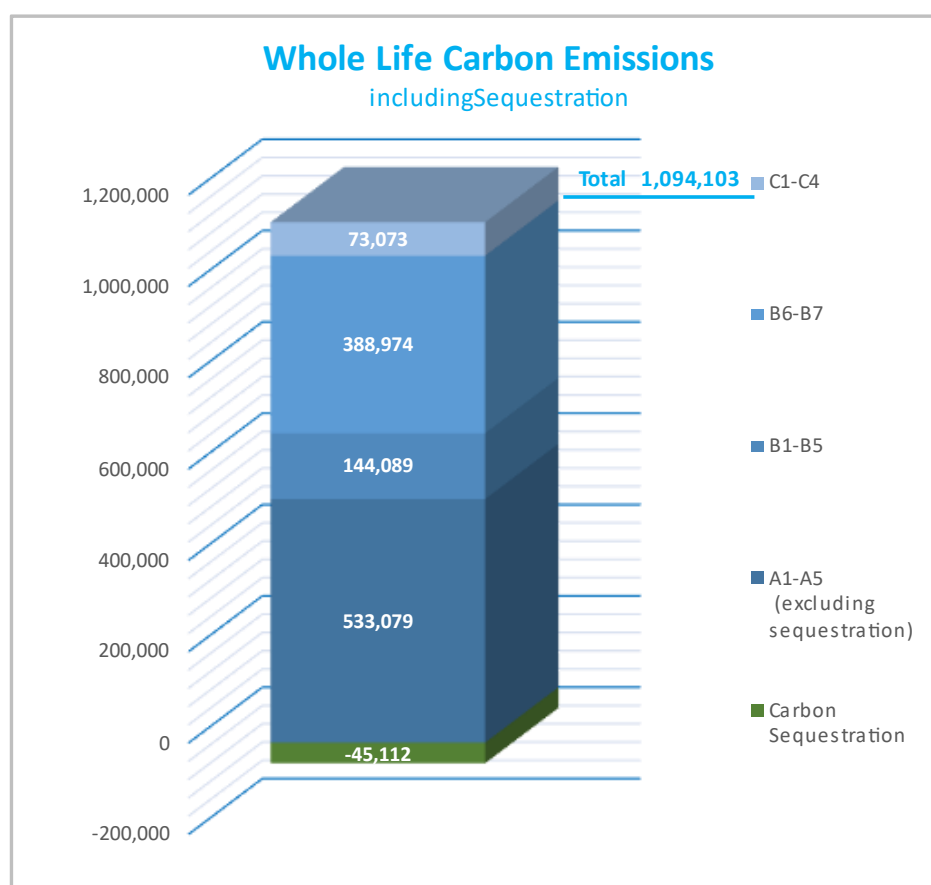
In the tables, all carbon emissions are listed by WLC modules, to demonstrate the specific elements that can be improved or for the future reference.

Table 2.1 – Overall WLCA results showing sequestration

Modules	WLC Result					
	A1-A5 (excluding sequestration)	B1-B5	B6-B7	C1-C4	Carbon Sequestration	Total (included sequestration)
kgCO ₂ e	533,079	144,089	388,974	73,073	-45,112	1,127,429
kgCO ₂ e/m ²	612.17	165.47	446.69	83.91	-51.81	1294.70

The chart below gives a visualisation of the WLC breakdown for the building, with module A1-A5, B1-B5, and C1-C4.

Figure 11 – Baseline – Overall Whole Life Carbon showing sequestration



Appendix A – GLA Spreadsheet extracts

GWP POTENTIAL FOR ALL LIFE CYCLE MODULES (kgCO ₂ e) (See Note 1 below if you entered a reference study period in cell C12)		Sequestered (or biogenic) carbon (negative value) (kgCO ₂ e)	Product stage (kgCO ₂ e)	Construction process stage (kgCO ₂ e)			
			Module A				
			[A1] to [A3]	[A4]	[A5]	[B1]	[B2]
Building element category							
0.1	Demolition: Toxic/Hazardous/Contaminated Material Treatment						
0.2	Major Demolition Works						
0.3	Temporary Support to Adjacent Structures						
0.4	Specialist Ground Works						
0.5	Temporary Diversion Works						
1	Substructure	0 kg CO ₂ e	145,363 kg CO ₂ e	2,935 kg CO ₂ e	8,749 kg CO ₂ e		
2.1	Superstructure: Frame	0 kg CO ₂ e	102,798 kg CO ₂ e	196 kg CO ₂ e	3,488 kg CO ₂ e		
2.2	Superstructure: Upper Floors	-12,699 kg CO ₂ e	1,550 kg CO ₂ e	46 kg CO ₂ e	512 kg CO ₂ e		
2.3	Superstructure: Roof	-14,620 kg CO ₂ e	14,975 kg CO ₂ e	104 kg CO ₂ e	1,465 kg CO ₂ e		
2.4	Superstructure: Stairs and Ramps	-1,247 kg CO ₂ e	674 kg CO ₂ e	5 kg CO ₂ e	125 kg CO ₂ e		
2.5	Superstructure: External Walls	-5,319 kg CO ₂ e	63,824 kg CO ₂ e	836 kg CO ₂ e	3,972 kg CO ₂ e		
2.6	Superstructure: Windows and External Doors	-1,384 kg CO ₂ e	10,879 kg CO ₂ e	22 kg CO ₂ e	0 kg CO ₂ e		
2.7	Superstructure: Internal Walls and Partitions	0 kg CO ₂ e	21,626 kg CO ₂ e	111 kg CO ₂ e	1,527 kg CO ₂ e		
2.8	Superstructure: Internal Doors	-4,992 kg CO ₂ e	5,809 kg CO ₂ e	21 kg CO ₂ e	0 kg CO ₂ e		
3	Finishes	4,850 kg CO ₂ e	12,458 kg CO ₂ e	65 kg CO ₂ e	900 kg CO ₂ e		
4	Fittings, furnishings & equipment	0 kg CO ₂ e	1,838 kg CO ₂ e	5 kg CO ₂ e	0 kg CO ₂ e		
5	Services (MEP)	0 kg CO ₂ e	50,891 kg CO ₂ e	80 kg CO ₂ e	471 kg CO ₂ e		
6	Prefabricated Buildings and Building Units						
7	Work to Existing Building						
8	External works	0 kg CO ₂ e	34,658 kg CO ₂ e	227 kg CO ₂ e	1,373 kg CO ₂ e		
Other site construction impacts or overall construction stage [A5] carbon emissions not specific to an individual building element category					38,502 kg CO ₂ e		
TOTAL kg CO ₂ e		45,112 kg CO ₂ e	467,342 kg CO ₂ e	4,653 kg CO ₂ e	61,084 kg CO ₂ e	0 kg CO ₂ e	0 kg CO ₂ e
TOTAL - kg CO ₂ e/m ² GIA		-52 kg CO ₂ e/m ² GIA	537 kg CO ₂ e/m ² GIA	5 kg CO ₂ e/m ² GIA	70 kg CO ₂ e/m ² GIA	0 kg CO ₂ e/m ² GIA	0 kg CO ₂ e/m ² GIA



Use stage (kgCO ₂ e)					End of Life (EoL) stage (kgCO ₂ e)				TOTAL Modules A-C kgCO ₂ e	Benefits and loads beyond the system boundary (kgCO ₂ e)		
Module B					Module C					Module D		
[B3]	[B4]	[B5]	[B6]	[B7]	[C1]	[C2]	[C3]	[C4]				
					[Where only a single C1-C4 is known, please include it here]				0 kg CO ₂ e			
					1,880 kg CO ₂ e				1,880 kg CO ₂ e			
									0 kg CO ₂ e			
										0 kg CO ₂ e		
										0 kg CO ₂ e		
										0 kg CO ₂ e		
0 kg CO ₂ e												
0 kg CO ₂ e								5,870 kg CO ₂ e	3,558 kg CO ₂ e	3 kg CO ₂ e	166,479 kg CO ₂ e	-33,250 kg CO ₂ e
0 kg CO ₂ e								1,792 kg CO ₂ e	105 kg CO ₂ e		108,378 kg CO ₂ e	-63,604 kg CO ₂ e
0 kg CO ₂ e	2,900 kg CO ₂ e	0 kg CO ₂ e						42 kg CO ₂ e	14,932 kg CO ₂ e		7,283 kg CO ₂ e	-5,871 kg CO ₂ e
0 kg CO ₂ e	10,494 kg CO ₂ e	0 kg CO ₂ e						114 kg CO ₂ e	17,629 kg CO ₂ e	7 kg CO ₂ e	30,167 kg CO ₂ e	-10,157 kg CO ₂ e
0 kg CO ₂ e								4 kg CO ₂ e	1,261 kg CO ₂ e		822 kg CO ₂ e	-824 kg CO ₂ e
0 kg CO ₂ e	348 kg CO ₂ e	0 kg CO ₂ e						1,462 kg CO ₂ e	10,697 kg CO ₂ e	3 kg CO ₂ e	75,821 kg CO ₂ e	-7,969 kg CO ₂ e
0 kg CO ₂ e	4,232 kg CO ₂ e	0 kg CO ₂ e						183 kg CO ₂ e	1,386 kg CO ₂ e	2 kg CO ₂ e	15,320 kg CO ₂ e	-1,513 kg CO ₂ e
0 kg CO ₂ e	1,411 kg CO ₂ e	0 kg CO ₂ e						976 kg CO ₂ e	57 kg CO ₂ e	14 kg CO ₂ e	25,721 kg CO ₂ e	-8,214 kg CO ₂ e
0 kg CO ₂ e	4,442 kg CO ₂ e	0 kg CO ₂ e						30 kg CO ₂ e	5,032 kg CO ₂ e	2 kg CO ₂ e	10,346 kg CO ₂ e	-4 kg CO ₂ e
0 kg CO ₂ e	2,400 kg CO ₂ e	0 kg CO ₂ e				197 kg CO ₂ e	4,916 kg CO ₂ e	8 kg CO ₂ e	16,094 kg CO ₂ e	-2,327 kg CO ₂ e		
0 kg CO ₂ e	5,594 kg CO ₂ e	0 kg CO ₂ e				20 kg CO ₂ e	2 kg CO ₂ e	0 kg CO ₂ e	7,459 kg CO ₂ e	-4,133 kg CO ₂ e		
0 kg CO ₂ e	100,723 kg CO ₂ e	0 kg CO ₂ e	145,950 kg CO ₂ e	223,517 kg CO ₂ e	18,506 kg CO ₂ e		286 kg CO ₂ e	93 kg CO ₂ e	5 kg CO ₂ e	541,521 kg CO ₂ e	-38,690 kg CO ₂ e	
										0 kg CO ₂ e		
											0 kg CO ₂ e	
8,367 kg CO ₂ e	3,179 kg CO ₂ e	0 kg CO ₂ e				450 kg CO ₂ e	53 kg CO ₂ e	3 kg CO ₂ e		48,309 kg CO ₂ e	-2,362 kg CO ₂ e	
									38,502 kg CO ₂ e			
8,367 kg CO ₂ e	135,722 kg CO ₂ e	0 kg CO ₂ e	370,467 kg CO ₂ e	18,506 kg CO ₂ e	1,880 kg CO ₂ e	11,426 kg CO ₂ e	59,720 kg CO ₂ e	46 kg CO ₂ e	1,094,102 kg CO ₂ e	-178,857 kg CO ₂ e		
10 kg CO ₂ e/m ² GIA	156 kg CO ₂ e/m ² GIA	0 kg CO ₂ e/m ² GIA	425 kg CO ₂ e/m ² GIA	21 kg CO ₂ e/m ² GIA	2 kg CO ₂ e/m ² GIA	13 kg CO ₂ e/m ² GIA	69 kg CO ₂ e/m ² GIA	0 kg CO ₂ e/m ² GIA	1,256 kg CO ₂ e/m ² GIA	-295 kg CO ₂ e/m ² GIA		

