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Whole Life Cycle Carbon Emissions Assessment

Richmond Housing Partnership

Sheldon House

Final

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Executive Summary

This Whole Life Cycle Carbon Emissions (WLCCE) Assessment for the proposed development at Sheldon House in the London Borough of Richmond upon Thames, has been prepared by Hodkinson Consultancy, a specialist energy and environmental consultancy for planning and development, appointed by Richmond Housing Partnership.

The purpose of this assessment is to demonstrate that the proposed development at Sheldon House (hereafter known as the Site), has undertaken an initial assessment based on the information available to date which will need to be updated as the project progresses. This report also identifies the carbon that will be emitted from two options; demolition/rebuild and a refurbishment to determine which one generate the least amount of carbon.

The proposed development will comprise demolition of an existing block of flats from the 1970's and replacement of 27 affordable dwellings with the provision of cycle/refuse/recycling storage, 6 parking spaces, a delivery bay, and associated amenity space.

National Building Regulations and the Mayor's net zero-carbon target for new development account for a building's operational carbon emissions. As methods and approaches for reducing operational emissions have become better understood, and as targets have become more stringent, these emissions are now beginning to make up a declining proportion of a development's carbon emissions. Attention now needs to turn to WLCCE to incorporate embodied carbon emissions, enabling a better understanding of the environmental impact of the proposed development.

WLCCE are the carbon emissions resulting from the construction and the use of a building over its entire life, through four stages described as life-cycle modules, as shown in Figure i;

Figure i: Life cycle modules included within WLCCE assessment

They capture a building's operational carbon emissions from both regulated and unregulated energy use, as well as its embodied carbon emissions. Embodied emissions are those associated with raw material extraction, manufacture and transport of building materials, construction and the emissions associated with maintenance, repair, and replacement as well as dismantling, demolition, and eventual material disposal. The assessment provides a picture of a building's carbon impact on the environment.

This WLCCE assessment is being undertaken in compliance with London Plan 2021 Policy (SI 2), the methodology has followed the principles of BS EN 15978 and has used both the GLA guidance and RICS as the methodology for assessment. This has been facilitated through the use of GLA approved One Click LCA software.

The following table outlines the assumptions made within this WLCCE assessment:

Table i: WLCCE assumptions

Data	Data source
Material types and volumes (A1-A3)	Material types were provided by the applicant in the Pre-application document and drawings. Where material types and volumes were not available from these sources, the One Click LCA Carbon tool was used to estimate values. 95% of the cost allocated to each building element category has been accounted for in the assessment.
Transport data (A4)	Default values provided by One Click.
Construction site impacts (A5)	Construction value provided by applicant and baseline target provided by BRE. Waste estimates were provided by the Applicant.
Refrigerants (B1)	Refrigerant quantity has been estimated based on the use of R32 within the Ground Source Heat Pumps with an annual leakage rate of 5% and 10% end of life leakage (One Click defaults).
Maintenance (B2)	An assumption has been made regarding the ongoing water use for the window cleaning and roof maintenance. For module B2 emissions, a total figure of 10 $kgCO_2$ e/m^2 (GIA) has been used to cover all building element categories.
Repair and Replacement data (B3-B4)	Default values provided by RICS and One Click EPD database for products inputted into software.
Refurbishment (B5)	At present One Click does not have ways to consider B5 emissions. However, based on the information provided for B3 and B4 it is likely that these have emissions have been accounted for.

Data	Data source
Operational energy (B6)	Energy calculations based on Energy calculations by Clive Chapman Architects (November, 2022).
Operational water (B7)	Water consumption based on Building Regulations Part G 'Enhanced Consumption' of 110 l/pp/d and multiplied by the intended full occupancy of the development.
End of life (C1-C4)	Default values provided by One Click based on the information within the EPD database.
Building areas	Building areas were provided by the architect in the drawings- 1,510 m^2
Number of occupants	70 occupants- per Accommodation Schedule
Assessment period	60 years

To support Richmond upon Thames Council in fully understanding the impacts of this proposed development, this report has identified the carbon that will be emitted from the following options:

> **Option 1:** Demolition and Rebuild.

> > This option involves the demolition and rebuild of the proposed development to facilitate an additional 3 dwellings on the site. Including the re-use of brick slips and concrete (crushed) from demolition into the new construction.

> > The total expected emissions for Option One are **1,083 $kgCO_2/m^2$ GIA over 60 years (excluding sequestered carbon);** 637 $kgCO_2/m^2$ for modules A1-A5 and 446 $kgCO_2/m^2$ for modules B – C. When operational energy and water emissions are included in the calculation above the total emissions are expected to be **1,246 $kgCO_2/m^2$ GIA over 60 years.**

> **Option 2:** Refurbishment of existing building.

> > This option involves a refurbishment of all areas of the development, including new fittings, furnishes and basic elements of mechanical and electrical equipment.

> > The total expected emissions for Option Two are **819 $kgCO_2/m^2$ GIA over 60 years (excluding sequestered carbon);** 378 $kgCO_2/m^2$ for modules A1-A5 and 441 $kgCO_2/m^2$ for modules B – C. When operational energy and water emissions are included in the calculation above the total emissions are expected to be **2,200 $kgCO_2/m^2$ GIA over 60 years.**

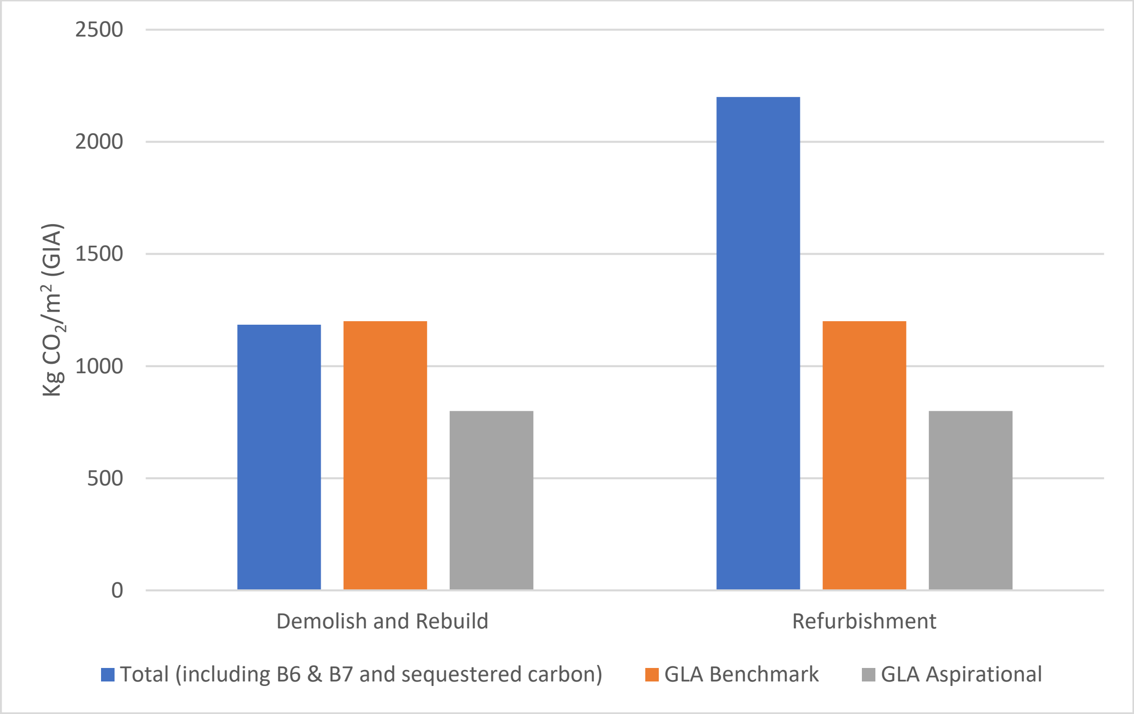

Figure ii: Total $kgCO_2$ /m^2 Gross Internal Floor Area (GIA) performance compared to GLA Benchmarks

A series of high-level opportunities to further reduce carbon emissions post planning have also been made. These measures will be looked at in detail in the next stage of the design development process and included, where possible.

CONTENTS

1. INTRODUCTION

1.1 This Whole Life Cycle Carbon Emissions (WLCCE) Assessment for the proposed development at Sheldon House within the London Borough of Richmond upon Thames has been prepared by Hodkinson Consultancy, a specialist energy and environmental consultancy for planning and development, appointed by Richmond Housing Partnership.

1.2 The proposed development will comprise demolition of an existing block of flats from the 1970's and replacement of 27 affordable dwellings with the provision of cycle/refuse/recycling storage, 6 parking spaces, a delivery bay, and associated amenity space.

1.3 The purpose of this WLCCE assessment is to demonstrate that the proposed development at Sheldon House has undertaken an initial assessment based on the information available to date which will need to be updated as the project progresses. This report also identifies the carbon that will be emitted from two options; demolition/rebuild and a refurbishment to determine which one generates the least amount of carbon.

1.4 National Building Regulations and the Mayor's net zero-carbon target for new development account for a building's operational carbon emissions. As methods and approaches for reducing operational emissions have become better understood, and as targets have become more stringent, these emissions are now beginning to make up a declining proportion of a development's carbon emissions. Attention now needs to turn to WLCCE to incorporate embodied carbon emissions, enabling a better understanding of the environmental impact of the proposed development.

1.5 The assessment of the proposed development endeavours to help the design team understand, at concept design stage, the lifetime consequences of their design decisions. This report should be read in conjunction with the '*GLA Whole Life Carbon Assessment Template*' which has been submitted alongside this application.

2. DEVELOPMENT OVERVIEW

Site Location

2.1 The site at Sheldon House lies on the southwest corner of the junction with Cromwell Road and Fairfax Road, within Teddington. The site location is shown in Figure 1 below.

Figure 1: Site Location – Map data © 2022 Google

2.2 The site currently comprises a block of flats with 24 residential units, 14 parking spaces and 7 garages used for storage.

Proposed Development

2.3 The proposed development comprises a 5-storey building providing 27 residential units, to be 100% affordable. Associated landscaping, car parking and cycle parking will also be provided.

2.4 Figure 2 overleaf illustrates the proposed site layout.

Figure 2: Proposed Site Layout- Clive Chapman Architects (2022)

2.5 The total Gross Internal Floor Area (GIA) for the proposed development is 1,510 m^2. The principles noted within this report apply to this GIA.

3. POLICY AND REGULATIONS

Regional Policy: The London Plan

London Plan (2021)

3.1 The London Plan sets out an integrated economic, environmental, transport and social framework for the development of London. The following policies are considered relevant to the proposed development and this Statement:

3.2 **Policy SI 2 Minimising Greenhouse Gas Emissions, states:**

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

Operational carbon emissions will make up a declining proportion of a development's whole life-cycle carbon emissions as operational carbon targets become more stringent. To fully capture a development's carbon impact, a whole life-cycle approach is needed to capture its unregulated emissions (i.e., those associated with cooking and small appliances), its embodied emissions (i.e., those associated with raw material extraction, manufacture and transport of building materials and construction) and emissions associated with maintenance, repair and replacement as well as dismantling, demolition and eventual material disposal). Whole life-cycle carbon emission assessments are therefore required for development proposals referable to the Mayor. Major non-referable development should calculate unregulated emissions and are encouraged to undertake whole life-cycle carbon assessments. The approach to whole life-cycle carbon emissions assessments, including when they should take place, what they should contain and how information should be reported, will be set out in guidance'.

London Borough of Richmond upon Thames Draft Local Plan

3.3 A Draft Local Plan is currently under consultation by the Richmond upon Thames Borough Council. The third public consultation is expected to begin in March of 2023, with the new Local Plan projected to be adopted in Winter 2024. Though not yet in effect, the following Draft Local Plan policy is considered relevant to this assessment:

3.4 **Policy 3- Tackling the climate emergency**

'The Council will promote zero carbon development, with the aim that all building and infrastructure projects in the borough will be net-zero carbon by 2050. This will require substantial reductions in greenhouse gas emissions and will also reduce fuel poverty and improve long term energy security for Richmond's residents and businesses. Development must not exacerbate climate change. Development should increase local resilience to current and future impacts of climate changes, especially for the most vulnerable people and property. This will be achieved by requiring development to:

> *Reuse and refurbishment in preference to demolition and new construction;*

> *Adopt a circular economy approach and minimise embodied carbon; and*

> *Promote retrofitting of existing buildings, through low-carbon measures.'*

Guidance Documents

3.5 Guidance has been released by the Greater London Authority *"Whole Life-Cycle Carbon Assessments guidance – March 2022"*. It outlines how to prepare a WLCCE assessment which should accompany all referable planning applications in line with London Plan Policy SI 2 *'Minimising Greenhouse Gas Emissions'*. This document is now out of consultation but is yet to be formally approved. It has however been used and referenced throughout this assessment.

3.6 In addition, the following guidance is available to conduct assessments:

> **BS EN 15978:2011 -** *Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.*

> **ISO 14040:2006 -** *Environmental management — Life cycle assessment — Principles and framework.*

> **RICS Professional Statement Whole life carbon assessment: 2017 -** *Whole life carbon assessment for the built environment.*

3.7 The above documents are used to complete the WLCCE assessment, further planning reports submitted alongside this report will also be used and/or referenced within this assessment, including:

> Energy Statement- Clive Chapman Architects (November, 2022).

> Design and Access Statement- Clive Chapman Architects (November, 2022).

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4. WHOLE LIFE CYCLE CARBON EMISSIONS ASSESSMENT

4.1 Undertaking WLCCE assessments is a way to fully understand and minimise the carbon emissions associated with building designs over the entire life cycle of the building. This will be done at the proposed development to quantify the WLCCE that will be released, considering not only operational and embodied emissions but also demolition, construction, and refurbishment and replacement cycles.

4.2 The London Plan has introduced a requirement (Policy SI 2 *'Minimising Greenhouse Gas Emissions'*) for all new referable developments to calculate and reduce WLCCE, this is both embodied and operational carbon:

> **Operational carbon** is the energy required to heat and power a building;

> **Embodied carbon** is the carbon that is released in the manufacturing, production, and transportation of the building materials used.

4.3 In addition to the two metrics above there are additional life cycle stages that are considered during WLCCE assessments, these include demolition, end of life and refurbishment/replacement cycles.

4.4 The two metrics (operational and embodied) and the additional life cycle stages, as noted above, have been included in this WLCCE assessment as per GLA guidance.

4.5 Undertaking a WLCCE assessment provides a full overview of the material and construction of a building using science-based metrics whilst also identifying the overall best combined opportunities for reducing lifetime emissions, and also helps to avoid any unintended consequences of focusing on operational emissions alone.

Methodology

4.6 To support Richmond upon Thames Council in fully understanding the impacts of this proposed development:

> **Option 1:** Demolition and Rebuild.

> > This option involves the demolition and rebuild of the proposed development to facilitate an additional 3 dwellings on the site. Including the re-use of brick slips and concrete (crushed) from demolition into the new construction.

> **Option 2:** Refurbishment of existing building.

> > This option involves a refurbishment of all areas of the development, including new fittings, furnishes and basic elements of mechanical and electrical equipment.

4.7 WLCCE assessments are sensitive to changes in design and specification and therefore detailed design will impact the results as the scheme progress. As noted in the GLA guidance, WLCCE assessments should be conducted at the following stages in order to maximise design efficiencies:

> Pre application;

> Stage 1 submission (RIBA 2/3);

> Post construction (RIBA 6).

4.8 This assessment is considered to be the Stage 1 submission and has been completed for the proposed development using the drawings provided by Clive Chapman and energy calculations from the Energy Statement submitted for planning (Clive Chapman- November, 2022).

4.9 A set of WLCCE benchmarks have been developed by the GLA in which applicants are required to compare against their own results as part of the assessment and which the GLA will refer to in its review of these assessments. An ‘aspirational’ set of benchmarks have also been devised for applicants that wish to go further. Both sets of benchmarks are included in this assessment and are being reported on.

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Study Period

4.10 The reference study period (RSP) is 60 years, this is based on the principles outlined in BS EN 15978: 2011, section 7.3 and the RICS guidance. RSPs are fixed to enable comparability between whole life carbon results for different projects. It ensures that the assessment is representative of typical service life of different building elements.

Operational Carbon

4.11 Operational energy is the inputted energy required for all heating and power needs. It can be split into two variants:

> **Regulated emissions** are assessed using the Government's approved methodology for Building Regulations Part L compliance, the Standard Assessment Procedure (SAP) for residential units; and

> **Unregulated emissions** are energy use as a direct result of user behaviour. This includes cooking, white goods (fridges, washing machines, etc), and plug-in electrical loads (televisions, laptops, lamps, etc).

4.12 Both of the above elements have been accounted for in this WLCCE assessment, these were provided by the calculations completed for the Energy Statement submitted for planning (Clive Chapman Architects- November, 2022). For clarity, as unregulated energy demands are largely reliant on the behaviour of occupants, they have been considered a fixed entity in the calculations in accordance with the guidance.

Energy Calculations

4.13 **Option 1-** Demolition and Rebuild:

> These have been modelled using the approved SAP 10 methodology. The calculations include both PV panels for energy generation and ground source heat pumps for space and water heating.

4.14 **Option 2-** Refurbishment of existing building:

> These have also been modelled using the approved SAP 10 methodology, however the specification is more limited than the one proposed in Option 1. Also, no low or zero carbon technologies are provided for space and water heating.

Embodied Carbon

One Click LCA

4.15 OneClick LCA is the software that has been used to conduct the WLCCE assessment. This is a web-based piece of design software for buildings and infrastructure approved for use by the GLA.

4.16 OneClick LCA consists of a large database of generic and average Life Cycle Indicator (LCI) data, and global Environmental Product Declaration (EPDs). The most suitable option for each material (where available) was chosen from the database in OneClick. The material LCI data has been chosen to be representative of the typical UK supply chain.

4.17 The life cycle stages (or modules) included within the WLCCE assessment as standard are shown in Figure 3 below.

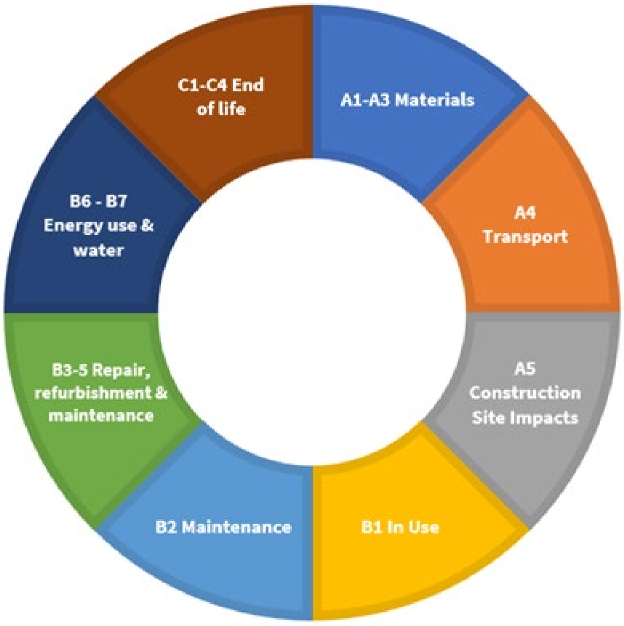

Figure 3: Life cycle modules

4.18 At this stage it is not expected that all the information will be available. Where this is the case, One Click has been used to calculate the required values for the assessment. As the design develops, we will update and refine the tool to reflect the quantity and types of materials being used.

Construction Impacts

4.19 In addition to embodied carbon in the materials used for construction, greenhouse gas (GHG) emissions will be created by transportation of materials to site and operation of onsite plant and machinery. Guidance from RICs indicates 1.4 tonnes of CO_2e per £100,000 of project value, this is further referenced and approved by the BRE.

4.20 The project value has been provided by the Applicant, which would result in construction transport GHG emissions of:

> **Option 1:** 28 tonnes of CO_2 (includes demolition works and other construction site impacts, such as wastage).

> **Option 2:** 35 tonnes of CO_2 (does not include demolition works but does include temporary structural works and wastage).

Potable Water Use

4.21 The carbon impact associated with water use during the operation of the proposed development is also required to be reported, in accordance with the RICS guidance. Water consumption is based on Building Regulations Part G 'enhanced consumption' of 110 litres/per person/per day (including external water use) and multiplied by the intended full occupancy of the development annually.

4.22 70 occupants have been assumed based upon the expected number of residents on site as per the Accommodation .This gives an estimated **annual water consumption of 2,810.5 m^3** for the entire development for 60 years. An additional allowance has been added to the calculations for the ongoing water required for maintenance. This has been assumed to be the same in both assessments.

Carbon Sequestration

4.23 Sequestered carbon in timber has been included in the WLCCE assessment as all timber is assumed to be sustainably sourced.

Data Sources

4.24 The assessment has utilised multiple data sources described above and is based on the level of detail available at the current stage of design. The following data sources have been used:

Table 1: Data Sources

Data	Data source
Material types and volumes (A1-A3)	Material types were provided by the applicant in the Pre-application document and drawings. Where material types and volumes were not available from these sources, the One Click LCA Carbon tool was used to estimate values. 95% of the cost allocated to each building element category has been accounted for in the assessment.
Transport data (A4)	Default values provided by One Click.

Data	Data source
Construction site impacts (A5)	Construction value provided by applicant and baseline target provided by BRE. Waste estimates were provided by the Applicant.
Refrigerants (B1)	Refrigerant quantity has been estimated based on the use of R32 within the Air Source Heat Pumps with an annual leakage rate of 5% and 10% end of life leakage (One Click defaults).
Maintenance (B2)	An assumption has been made regarding the ongoing water use for the window cleaning and roof maintenance. For module B2 emissions, a total figure of 10 $kgCO_2e/m^2$ (GIA) has been used to cover all building element categories.
Repair and Replacement data (B3-B4)	Default values provided by RICS and One Click EPD database for products inputted into software.
Refurbishment (B5)	At present One Click does not have ways to consider B5 emissions. However, based on the information provided for B3 and B4 it is likely that these have emissions have been accounted for.
Operational energy (B6)	Energy calculations based on Energy calculations by Clive Chapman Architects (November, 2022).
Operational water (B7)	Water consumption based on Building Regulations Part G 'Enhanced Consumption' of 110 l/pp/d and multiplied by the intended full occupancy of the development.
End of life (C1-C4)	Default values provided by One Click based on the information within the EPD database.
Building areas	Building areas were provided by the architect in the drawings- 1,510 m^2
Number of occupants	70 occupants- per Accommodation Schedule
Assessment period	60 years

4.25 For clarity, all assumptions made within the WLCCE assessment have been noted within this report. The assessment and comments made throughout should be taken within the context of carbon and energy use only.

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5. WHOLE LIFE CYCLE CARBON RESULTS

5.1 The following results are an initial assessment based on the best available information, which will need to be updated as the project progresses, in line with GLA Guidance.

Option 1

5.2 This option involves demolition of the existing building followed by a complete rebuild.

5.3 Table 2 below demonstrates the A1-A5 and B-C emissions compared to the GLA Benchmarks.

Table 2: Option 1 Whole Life Carbon Baseline (GLA Guidance)

	Project kg CO_2/m^2	WLC Benchmark	Aspirational Benchmark
Modules A1 – A5	**637 kg CO_2e/m^2 GIA**	<850 kg CO_2e/m^2 GIA	<500 kg CO_2e/m^2 GIA
Modules B – C (excluding B6 and B7)	**446 kg CO_2e/m^2 GIA**	<350 kg CO_2e/m^2 GIA	<300 kg CO_2e/m^2 GIA

5.4 The total emissions, based on the GLA guidance is **1,083 kgCO_2/m^2 GIA over 60 years excluding sequestered carbon or 1,024 kgCO_2/m^2 when sequestered carbon is included.**

> 637 kgCO_2/m^2 for modules A1-A5 (excluding sequestered carbon).

> 446 kgCO_2/m^2 for modules B-C.

5.5 When operational energy and water emissions are included in the calculation above the total emissions are expected to be **1,185 kgCO_2/m^2 GIA over 60 years.**

5.6 Option 1 is performing better than GLA benchmark for modules A1-A5. For modules B-C, the proposed development has higher emissions than the GLA benchmark but given that assumptions have been made for all M&E and replacement/repair cycles, this figure represents a worst case scenario.

5.7 The full results are as follows:

Table 3: Overview WLCCE Results for Option 1

Category	Global warming potential	Total $kgCO_2e$ over 60 years	Total $kgCO_2e/m^2$ GIA over 60 years
A1-A3	Construction Materials	854,119	565.64
A4	Transport	32,361	21.43
A5	Site operations	75,564	50.04
B1	In Use	127,052	84.14
B2	Maintenance	16,079	10.65
B3	Repair	106,901	70.80
B4	Replacement/Refurbishment	295,669	195.81
B6	Operational energy use	243,535	161.28
B7	Operational water use	3,305	2.19
C1-C4	End of life	127,916	-84.71
	Total	**1,882,501**	**1,246.69**
	Carbon Sequestering	-89,984	-59.60
	TOTAL	**1,792,517**	**1,187.10**

5.8 The above results demonstrate that **1,792 tonnes** are expected to be emitted over a 60-year period.

5.9 The operational energy (B6) makes up 13.13% of the overall emissions for the proposed development; 13% for regulated energy use and 0.13% for unregulated use.

5.10 Materials (A1 – A3) make up 45% of the overall emissions. There has already been a big focus on material selection which is why this percentage share is not bigger. Further focus should be given to reduce embodied carbon, especially surrounding the façade and general structure of the building.

5.11 6% of emissions are a result from the transport of materials to site and construction stages (A4 and A5), whilst this is small in comparison to elements it is still important to reduce transport emissions through the local sourcing of materials and to reduce consumption of energy and water during consumption, where possible.

5.12 There are also impacts, with the in-use life-cycle module B1-B5 making up approximately 29% of all embodied carbon emissions. This is primarily due to materials that will need replacing over the 60 year study period.

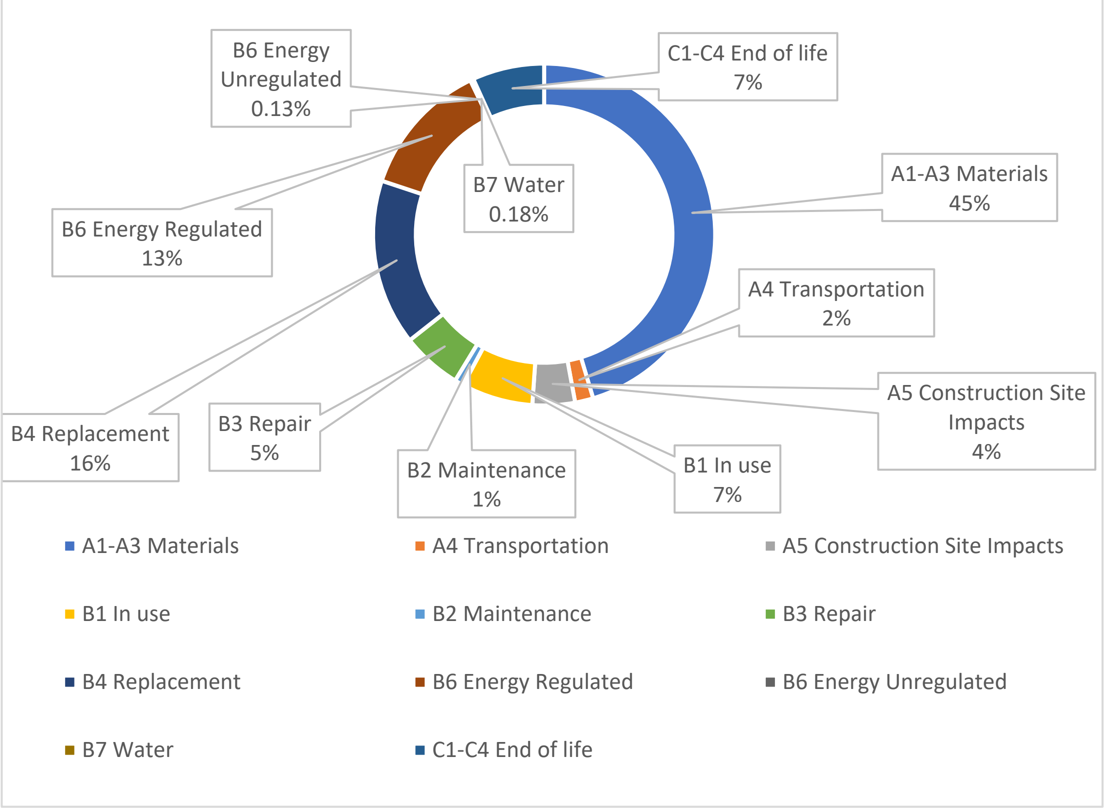

Figure 5: Total kg CO_2/m^2 - Life-cycle stages – Option 1

Analysis of Results

5.13 Through the new construction of Sheldon House, a significant improvement to wall U-values, thermal bridging values, and an overall improvement to the building fabric is achieved.

5.14 The following factors also significantly contribute to the reduction in energy demand during use (B6):

> **Improved envelope performance**- Greater U-values and lower heat loss;

> **Improved air tightness**- Less heat loss through ventilation;

> **Improved thermal bridging**- Less heat loss through construction joints; and

> **Use of low and zero carbon technologies**- Significantly reduces the reliance on fossil fuels.

5.15 The material use in Option 1 is higher than Option 2. This is because all materials are being replaced as opposed to being 'refurbished'. A significant amount of reuse of this material is expected which enables further carbon savings to be made.

Option 2

5.16 This option involves refurbishment of the existing building.

5.17 Table 4 below demonstrates the A1-A5 and B-C emissions compared to the GLA Benchmarks.

Table 4: Option 2 Whole Life Carbon Baseline (GLA Guidance)

	Project kg CO_2/m^2	WLC Benchmark	Aspirational Benchmark
Modules A1 – A5	**379 kg CO_2e/ m^2 GIA**	<850 kg CO_2e/ m^2 GIA	<500 kg CO_2e/ m^2 GIA
Modules B – C (excluding B6 and B7)	**441 kg CO_2e/ m^2 GIA**	<350 kg CO_2e/ m^2 GIA	<300 kg CO_2e/ m^2 GIA

5.18 The total emissions, based on the GLA guidance is **819 $kgCO_2/m^2$ GIA over 60 years excluding sequestered carbon or 757 $kgCO_2/m^2$ when sequestered carbon is included.**

> 379 $kgCO_2/m^2$ for modules A1-A5 (excluding sequestered carbon).

> 441 $kgCO_2/m^2$ for modules B-C.

5.19 When operational energy and water emissions are included in the calculation above the total emissions are expected to be **2,200 $kgCO_2/m^2$ GIA over 60 years.**

5.20 Option 2 is performing better than GLA benchmark for modules A1-A5. For modules B-C, the proposed development has higher emissions than the GLA benchmark but given that assumptions have been made for all M&E and replacement/repair cycles, this figure represents a worst case scenario.

5.21 The full results are as follows:

Table 5: Full WLCCE Results for Option 2

Category	Global warming potential	Total $kgCO_2e$ over 60 years	Total $kgCO_2e/m^2$ GIA over 60 years
A1-A3	Construction Materials	441,558	305.37
A4	Transport	3,122	2.16

Category	Global warming potential	Total $kgCO_2e$ over 60 years	Total $kgCO_2e/m^2$ GIA over 60 years
A5	Site operations	102,163	70.65
B1	In Use	127,052	87.86
B2	Maintenance	16,079	11.12
B3	Repair	106,901	73.93
B4	Replacement/Refurbishment	284,651	196.85
B6	Operational energy use	2,087,264	1,443.47
B7	Operational water use	3,305	2.29
C1-C4	End of life	102,840	71.12
	Total	**3,274,935**	**2,264.82**
	Carbon Sequestering	-89,984	-62.23
	TOTAL	**3,184,951**	**2,202.59**

5.22 The above results demonstrate that **3,184 tonnes** are expected to be emitted over a 60-year period.

5.23 The operational energy (B6) makes up 64.13% of the overall emissions for the proposed development; 64% for regulated energy use and 0.13% for unregulated use.

5.24 Materials (A1 – A3) make up 13% of the overall emissions. Reuse of the existing building materials such as foundations, internal and external walls, and floor slabs, greatly reduce the embodied carbon of the building. Further focus should be put on what additional materials can be reused.

5.25 3.10% of emissions are a result from the transport of materials to site and construction stages (A4 and A5), whilst this is small in comparison to elements it is still important to reduce transport emissions through the local sourcing of materials and to reduce consumption of energy and water during consumption, where possible.

5.26 There are also impacts, with the in-use life-cycle module B1-B5 making up approximately 17% of all embodied carbon emissions. This is primarily due to materials that will need replacing over the 60 year study period.

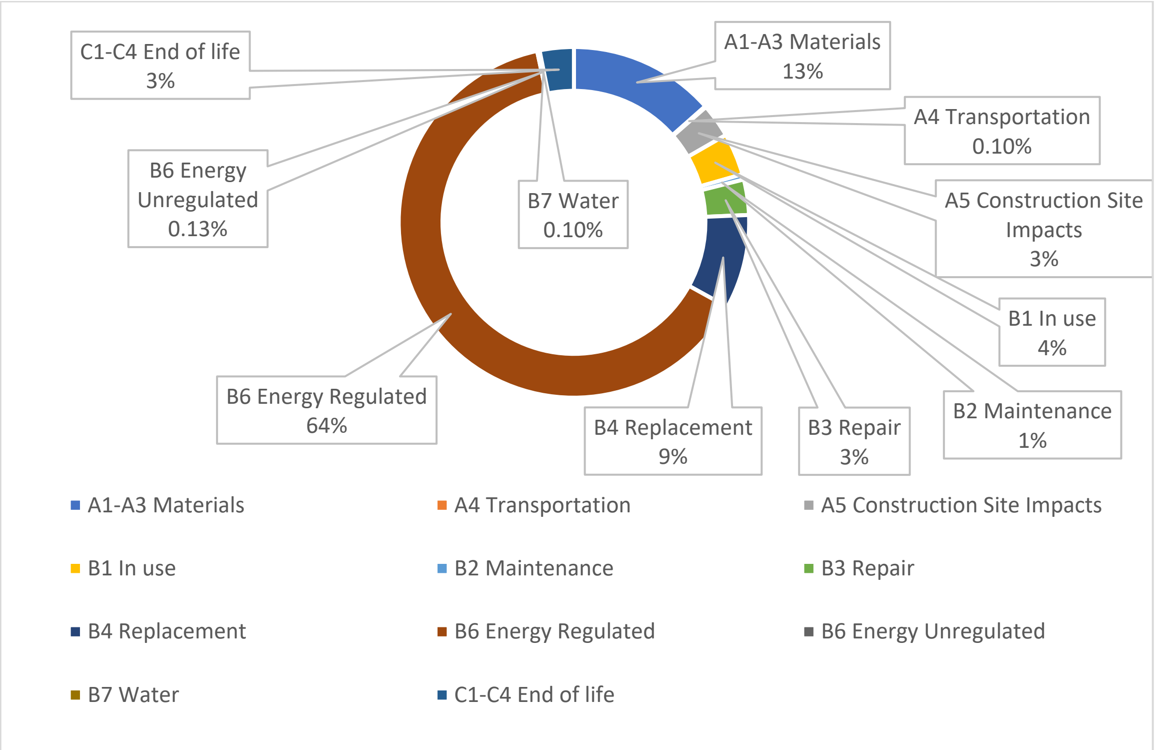

Figure 6: Total kgCO_2e - Life-cycle stages – Option 2

Analysis of Results

5.27 The energy performance of Option 2 is significantly worse than those demonstrated in Option 1. This is because significantly more materials would be required to achieve the same energy performance. As insulation improves and is made thicker (to improve the U-value), moisture vapour builds up inside a wall and the temperature condition are altered and the vapour can turn to water. This is known as 'interstitial condensation' and is a risk to the build up.

5.28 The site operations (Module A5) are also higher in Option 2. This is because of the additional temporary piling and temporary steel supports required for the refurbishment option.

5.29 A set of WLCCE benchmarks have been developed by the GLA in which applicants are required to compare against their own results as part of the assessment and which the GLA will refer to in its review of these assessments. An 'aspirational' set of benchmarks have also been devised for applicants that wish to go further. Both sets of benchmarks are included in this assessment are being reported on.

5.30 It must be noted that no benchmark has been set by the GLA for operational and energy use (life cycle stages B6-B7) due to insufficient data at present. The results for these have therefore been omitted from the totals in the tables above.

5.31 Figure 4 below outlines the expected kg CO^2/m_2 emissions that the two proposed options are expected to emit over a 60-year period, compared to the GLA benchmarks

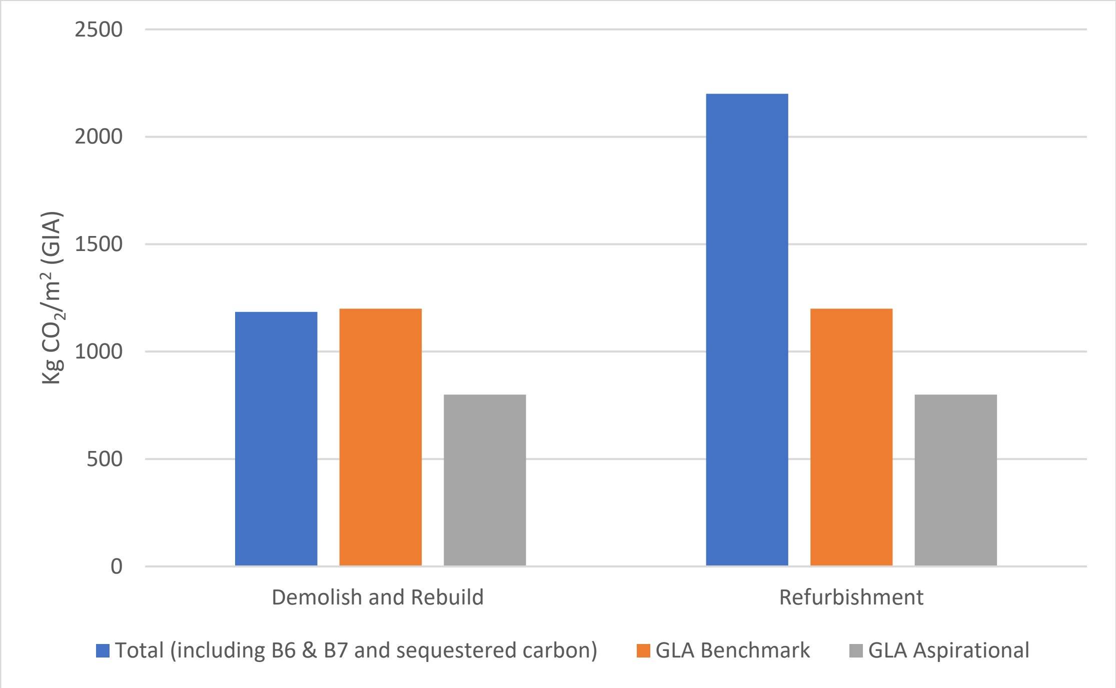

Figure 4: Total kg CO_2/m^2 for options proposed compared to GLA Benchmarks

Result Overview

5.32 The above results demonstrate that Option 1 (demolition and rebuild) will have fewer emissions over the 60-year life cycle of the building, compared to Option 2 (refurbishment).

5.33 Though Option 2 has lower emissions in Module A1-A5 and B-C compared to Option 1, the Operational Energy emissions are significantly higher for Option 2 than Option 1. **The resulting difference in emissions between Option 1 and Option 2 is 1,015 kgCO_2 over the life cycle of the building.**

5.34 Option 1 is the preferred option when considering the embodied carbon of the proposed development.

6. MEASURES IMPLEMENTED AND OPPORTUNIES

Measures Implemented

6.1 The proposed development has modelled potential measures throughout the design stage to further sustainability and reduce whole life carbon.

6.2 Specifying a high recycled content for steel is a good driver for products where the aim is to encourage and establish a market for recycled materials that are otherwise limited. Steel with 90% recycled content has been proposed for all floor constructions. **This has allowed for 102 $kgCO_2/m^2$ saving in A1-A3 emissions.**

6.3 Use of pre-fabricated balconies compared to concrete balconies have allowed for a reduction in embodied carbon of **2 $kgCO_2/m^2$ in A1-A3 emissions.**

Reduce material use

6.4 The **future demolition and deconstruction** of the development could be considered at the design stage. Consideration to be given to ways to facilitate dismantling, where possible.

6.5 Non-load bearing internal walls contribute material to the building that could otherwise be avoided. By **reducing the volume of non-load bearing walls** where possible, associated embodied carbon is also reduced.

6.6 The façade is under constant wear from the environment which can lead to frequent repairs and maintenance. By using **durable materials** for exposed elements, this not only reduces the cost and frequency of refurbishment but also reduces the use of material replacement and its associated carbon footprint.

6.7 Using pre-cast concrete floor slabs as opposed to hollow-core floor slabs could result in **carbon emissions savings of 46 $kgCO_2/m^2$.** The use of pre-cast concrete would also support the circular economy principles for the site.

6.8 Similarly, **an extensive maintenance and repair schedule** could also be produced during the design life of the development to ensure that specific materials and pieces of equipment are able to remain in situ during their expected lifespan. This will minimise the need to replace and refurbish and reduce emissions under life cycle stages C1-C4.

Recycled materials

6.9 **Innovative cement mixes** are now increasingly available, using a mixture that is 40% ground granulated furnace slag (GGBS) can save up to **106 $kgCO_2/m^2$** in carbon emissions. This cement mixture could be investigated further for use at the appropriate stage, and if suitable could be used for building elements such as foundations. If implemented, this could facilitate the reduction of life cycle stages A1-A3 (materials) quite significantly.

6.10 Areas of hardstanding could make use of **any excess recycled crushed concrete/gravel** to remove the associated carbon emissions from the assessment. These materials could similarly be recycled at the end-of-life scenario.

6.11 At end-of-life, **concrete can be completely recycled**. After demolition, concrete can be processed and used as recycled aggregate in fresh concrete. If the site is intended for new construction the demolished concrete can be crushed on-site and used onsite as hard core, fill, or in landscaping.

Sustainable procurement

6.12 The transportation of materials from the manufacturing facility to the building site adds to the carbon of the development. Buying from **local sources or utilising off-site manufacturing processes** could help reduce the emissions produced during transportation. There is a balance to be struck between material transport and processes deployed in their manufacture. As such, details on this cannot be known until the detailed design phase. This review would impact life cycle A4 - emissions from transportation to site.

6.13 **Sustainable/natural insulation materials** have lower embodied carbon and often increase biogenic carbon storage, which reduces the overall emissions of the development.

7. CONCLUSION

7.1 This Whole Life Cycle Carbon Emissions (WLCCE) Assessment for the proposed development at Sheldon House within the London Borough of Richmond Upon Thames has been prepared by Hodkinson Consultancy, a specialist energy and environmental consultancy for planning and development, appointed by Richmond Housing Partnership.

7.2 The purpose of this WLCCE assessment is to demonstrate that the proposed development has undertaken an initial assessment based on the information available to date which will need to be updated as the project progresses.

7.3 The above results demonstrate that, in terms of total carbon emissions over the 60-year life cycle of the building, Option 1 has lower carbon emissions as opposed to Option 2.

7.4 Though the emissions for modules A1-A5 and B-C are higher for Option 1, the considerable difference in operational energy emissions indicate that Option 1 is the preferred option in terms of embodied carbon.

7.5 A series of high-level opportunities to further reduce carbon emissions post planning have also been made. These measures will be looked at in detail in the next stage of the design development process and included, where possible.