Whole Life Cycle Analysis and Building Circularity

Watts Close

London Borough of Haringey, N15 5DW

Project: 001058-PL
Version: v3
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Content

1. Executive Summary

Introduction

This document contains a Whole Life-Cycle Assessment and Building Circularity report accompanying the planning application for the proposed residential redevelopment of Watts Close, N15 5DW. The development consists of 18 new residential council units—12 flats and 6 houses—including communal gardens, play space, shared bicycle storage, and private gardens.

The statement takes into consideration the following Greater London Authority (GLA) London Plan policies published in March 2021:

- Policy SI2 - Minimising greenhouse gas emissions.
- Policy SI7 - Reducing waste and supporting the Circular Economy.

Whole Life-Cycle Assessment Strategy

To understand the impact of a building's carbon emissions, it is necessary to assess the operational and embodied carbon emissions as well as the interrelationship between them throughout the entire life span of the building. The whole life-cycle assessment of the new development was carried out using OneClickLCA software.

To reduce the whole life-cycle carbon emissions, the development has been designed to achieve beyond the net zero carbon requirement for the regulated operational emissions from a notional building compliant with Building Regs Part L. (See Energy Statement).
This is achieved by using air-source heat pumps and renewable energy from PV systems.

In order to reduce the embodied carbon emissions, the materials and components have been considered as well as the components' planned life expectancy, taking into account maintenance and replacement to reduce waste. For emissions related to product sourcing, product maintenance, repair, and replacement, manufacturers' estimations have been used as well as Environmental Product Declarations (EPDs), where possible.

The following strategy, shown in Figure 1, has been implemented.
The WLC assessments will be carried out at each stage of the project to identify materials and components with high carbon emissions and to find alternatives to reduce carbon emissions.

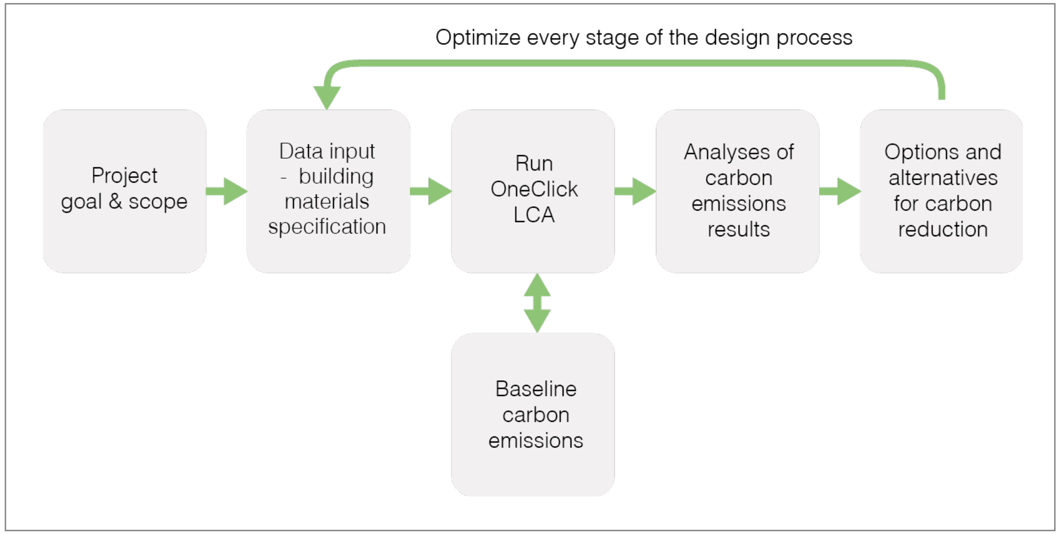

Figure 1. Suggested strategy to reduce embodied carbon emission

The proposed development has considered Circular Economy in its design, which can be found in the Building Circularity section of this report. A Draft Circular Economy Statement is also included, which describes how the Circular Economy principles are approached by the project team and how these principles will be carried out in the next stages of the building design.

Conclusion

This Statement defines a strategy to primarily reduce operational carbon emissions by implementing low-carbon heating systems and by the use of renewable energy sources. This strategy covers all regulated electricity use and part of the unregulated electricity use. By accounting for the decarbonisation of the UK's electricity grid, the total carbon emissions are reduced by 10%.

Whole life-cycle scope	Whole life carbon emissions kg CO_2e
Assessment 1 (SAP10) kgCO_2e	1183342 kgCO_2e
Assessment 2 (decarbonisation) kgCO_2e	1064405 kgCO_2e

Table 1. Summary of the whole life-cycle assessment emissions of the proposed development.

In order to reduce the embodied carbon of the development, the building's materials and components need to be considered. By carrying out the WLCA, materials with the biggest quantities can be identified and other options can be explored. The precast concrete elements and the external wall construction of the building contribute majorly to the embodied carbon emissions. Transportation and maintenance of these materials also contribute significantly. By taking into consideration the EPD's of the materials, the transportation distances, and maintenance/requirements, informed design decisions can be made.

The embodied carbon emissions can be further reduced through Circular Economy thinking. According to the circular economy principles, and the aspirations, the main strategic approach of the building design is reusability and recoverability. Meetings and workshops need to be arranged with the project team to ensure an integrated and effective approach. Key aspiration to reduce embodied carbon emissions are to reuse materials and components for the construction, use standardised detailing and materials that can be reused at the building's end-of-life, and manage waste. It is important to track the improvements for every stage through monitoring and the Circular Economy principles will be monitored throughout the design and construction process.

2. Introduction

This Whole Life-Cycle Assessment (WLCA) report was produced by Sustain Quality and accompanies a full planning application to the London Borough of Haringey for the proposed residential redevelopment of Watts Close, N15 5DW. The WLCA has been produced in line with the following policies:

- BS EN15978 Sustainability of construction works
- RICS Professional Statement UK – Whole Life Carbon Assessment for The Built Environment
- Greater London Authority (GLA), The London Plan
    - Policy SI 2: Minimising greenhouse gas
    - Policy SI 7: Reducing Waste and supporting the Circular Economy

Proposed development

The proposed development is located on Watts Close, N15 5DW, west of the Seven Sisters Underground and Rail Station. The proposal includes 18 new residential council units: 4 one-bedroom flats, 8 two-bedroom flats, 4 three-bedroom houses, and 2 four-bedroom houses. The buildings will be two and three storeys high with a total GIA of 1615m^2. The proposal includes communal gardens, play space, shared bicycle storage, and private gardens. The new landscaping will include green communal areas and new trees.

The Haringey Council strives to acquire affordable, high-quality, sustainable homes. The target is to achieve net-zero where possible.

Currently, 11 bungalows on the site are used as temporary accommodation, 9 parking bays, and an unused community hall. Watts Close is a cul-de-sac leading off Seaford Road. It will be integrated into the proposed communal gardens and will only have two parking bays to accommodate wheelchair users.

Assessment scope

A WLCA aims to get an understanding of the environmental impact of the development over its entire lifespan; it is used to inform the designers and the GLA on the benchmark whole life-cycle carbon performance for the proposed development. This WLCA was completed at the RIBA Stage 3. The purpose of a WLCA at an early stage is to set a baseline to compare the results of later assessments with and to monitor the carbon progress. The results will also be benchmarked and compared to similarly built projects to determine the Watts Close performance.

The functional unit for this WLCA is $kgCO_2e/m^2$ GIA and the operational design life of residential projects is 60 years. The cradle-to-grave system boundary of this WLCA covers all life-cycle stages of the building (A-C), which includes the product stage, construction stage, use stage, and end-of-life stage.

The table below describes the system boundaries according to EN15978 and RICS PS guidance.

Life-cycle stages	Boundaries
Product stage (A1-A3)	A1 Raw material extraction; A2 Transport; A3 Manufacturing
Construction stage (A4-A5)	A4 Transport; A5 Construction & Installation
Use stage (B1-B7)	B1 Use; B2 Maintenance; B3 Repair; B4 Replacement; B5 Refurbishment; B6 Operation energy; B7 Operational water
End-of-life stage (C1-C4)	C1 Demolition/Deconstruction; C2 Transport; C3 Waste processing; C4 Disposal
Benefits and loads beyond the system boundary (D)	D1 Reuse; D2 Recovery; D3 Recycling potential

Table 2. System boundaries according to EN15978

This WLCA needs to consider all building components and works related to the project, including any external works within the site's boundary.
This WLCA has used the scope of inclusions and exclusions detailed within the RICS guidance. To comply with Policy SI7, the WLCA needs to include all stages (A-D). Stage D is beyond the project's life cycle and will be reported separately.

3. Whole-Life Carbon Analysis

In this section of the report, we will analyse the carbon emission results based on the data provided. The Watts Close design team is committed to achieving the London Plan: Policy SI 2 'Minimising greenhouse gas emissions by preparing this whole-life carbon analysis. The requirement is to assess two scenarios, in which the second scenario accounts for future decarbonisation of the UK's electrical grid. The results are also required to provide an overview of the carbon emissions per life-cycle stage of the building and per building element. Finally, comparisons with benchmarks will provide a general idea of the building's performance.

Data sources

In accordance with the GLA and RICS Whole Life Cycle (WLC) guidance, the assessment for whole-life carbon emissions was carried out using OneClick LCA. The OneClick LCA software is based on the RICS guidance and corresponds closely to the GLA Excel spreadsheet. OneClick LCA includes a Future Energy Scenarios (FES) database to provide current and future emissions data.

In order to carry out the assessment, data were mainly derived from three sources, depending on the availability of data at the current stage of design:

- SAP (Standard Assessment Procedure) 10 calculations
- Architectural drawings and specification
- OneClick LCA material/component database

The results are based on the available data at a point in time. As the project progresses, more specifications and more detailed data will become available. This data will then be included in the assessment to give a more accurate representation of the embodied carbon emissions for the development. In the following design stages, optimisation of the design will be explored and applied.

The SAP10 calculations are used to predict operational energy consumption.

The materials used in the model are represented by using Environmental Product Declarations (EPDs) where possible. EPDs are produced by manufacturers and identify the carbon emissions of a product. The LCA tool has a limited database of materials, and whenever a specified material is not included in the database, a similar material in terms of material composition is selected.

Transport distances are provided by OneClick LCA and were estimated based on typical average transport distances and the project location. The water consumption is based on Building Regulations Part G 'Enhanced Consumption' of 105 l/pp/d and multiplied by the intended full occupancy of the development. The end-of-life stage © and the benefits and loads beyond the system boundaries (D) are based on OneClick LCA's default scenarios.

The table below lists the building elements that were included in this WLCA, in line with RICS PS.

	Building part	Building element	Included
0	Facilitating works	0.1 Temporary/Enabling works/Preliminaries	No
		0.2 Specialist groundworks	No
1	Substructure	1.1 Substructure	Yes
2	Superstructure	2.1 Frame	Yes
		2.2 Upper floors incl. balconies	Yes
		2.3 Roof	Yes
		2.4 Stairs and ramps	Yes
	Superstructure	2.5 External walls	Yes
		2.6 Windows and external doors	Yes
		2.7 Internal walls and partitions	Yes
		2.8 Internal doors	Yes
3	Finishes	3.1 Wall finishes	Yes
		3.2 Floor finishes	Yes
		3.3 Ceiling finishes	Yes
4	Fittings, furnishings, and equipment	Building related & non-building related	No
5	Building services/MEP	5.1-5.14 Building related services	Yes
		Non-building related services	No
6	Prefabricated Buildings and Building Units	6.1 Prefabricated Buildings and Building Units	N/A
7	Work to the existing building	7.1 Minor demolition and alteration works	N/A
8	External works	8.1 Site preparation works	No
		8.2 Roads, paths, paving, and surfacing	Yes
		8.3 Soft landscaping, Planting and Irrigation Systems	No
		8.4 Fencing, Railings, and Walls	Yes
		8.5 External fixtures	No
		8.6 External drainage	No
		8.7 External Services	No
		8.8 Minor Building Works and Ancillary Buildings	No

Table 3. Building parts and elements included in WLCA

Results

The table below shows a comparison between the baseline emissions based on the current status of the electricity grid and the future baseline emissions, taking into account the decarbonisation of the UK's electricity grid. The results are based on the Steady Progression 2050 scenario (FES 2020).

	Operational carbon emissions (B6) ($kgCO_2e$)	Embodied carbon emissions (A1-A5; B1-B5; C1-C4) ($kgCO_2e$)	Total ($kgCO_2e$)	Total $kgCO_2e/m^2$GIA
Assessment 1	259056 $kgCO_2e$	1415751 kgCO2e	1674807 kgCO2e	1037 $kgCO_2e/m^2$
Assessment 2 (with decarbonisation)	232099 $kgCO_2e$	832306 kgCO2e	1064405 kgCO2e	659 $kgCO_2e/m^2$

Table 4. Estimated WLCA baseline emissions from OneClick LCA results

Assessment 1 has been chosen as the baseline for the development. The regulated electricity use and part of the unregulated electricity use will be supplied by solar PV panels. Only the remaining electricity use will be supplied from the electricity grid and will be subject to decarbonization.

The London Plan WLCA guidance has established benchmarks for carbon emissions according to building type. The table below shows the carbon emission benchmark for apartments and the carbon emissions of the new development. The benchmarks help to understand the overall carbon performance of the new development.

	Modules (A1-A5)	Modules (B-C) (excluding B6 and B7)
WLC Benchmark CO_2 emissions ($kgCO_2e/m^2$ GIA)	750 to 850 $kgCO_2e/m^2$ GIA	300 to 400 $kgCO_2e/m^2$ GIA
Aspirational WLC Benchmark CO_2 emissions ($kgCO_2e/m^2$ GIA)	450 to 500 $kgCO_2e/m^2$ GIA	180 to 240 $kgCO_2e/m^2$ GIA
CO_2 emissions new development ($kgCO_2e/m^2$ GIA)	**640 kg CO_2e/m^2 GIA**	**180 kg CO_2e/m^2 GIA**

Table 5. Comparison with WLCA benchmarks for apartments

The table below gives an understanding of the distribution of the carbon emissions across the lifespan of the building and according to building element group, in line with RICS PS.

	A1-A3 Product Stage	A4 Transport to site	A5 Site operati.	B1 Use Phase	B3 Repair	B4 Replace ment	B6 Operational Energy use	B7 Operational Water use	C1-C4 End-of-Life stage	Module D (Not included in totals)	TOTAL kgCO_2e
1 Substructure	90867	21876	2428		0				2802	-27992	**117598**
2.1-2.4 Superstructure	148364	45468	4821		0	26320			7439	-58203	**231968**
2.5-2.6 Superstructure	214957	35441	17222		0	23780			4661	-9154	**294329**
2.7-2.8 Superstructure	18875	20335	5006		0	10717			117828	-49697	**56676**
3 Finishes	17262	1860	2530		0				5085	-17794	**101609**
4 Fittings, furnishings & equipment					0						
5 Services (MEP)	501721	463	322		0	15573	259056	91980	281	-21251	**869397**
6 Prefabricated buildings and building units					0						
7 Work to the existing building					0						
8 External works	1137	1991			0				102	-1376	**3230**
Unclassified/other					0						
TOTAL kgCO2e	**501721**	**127435**	**32331**		**0**	**151263**	**259056**	**91980**	**138196**	**-185468**	**1674807**
TOTAL kgCO2e GIA	**615**	**79**	**20**		**0**	**94**	**160**	**57**	**85**	**-115**	**1037**

Table 6. Assessment 1 estimated WLCA emissions for each life-cycle module per building element

The figures below show a further breakdown of the carbon emissions according to the life-cycle stage, classification of materials, and resource type.

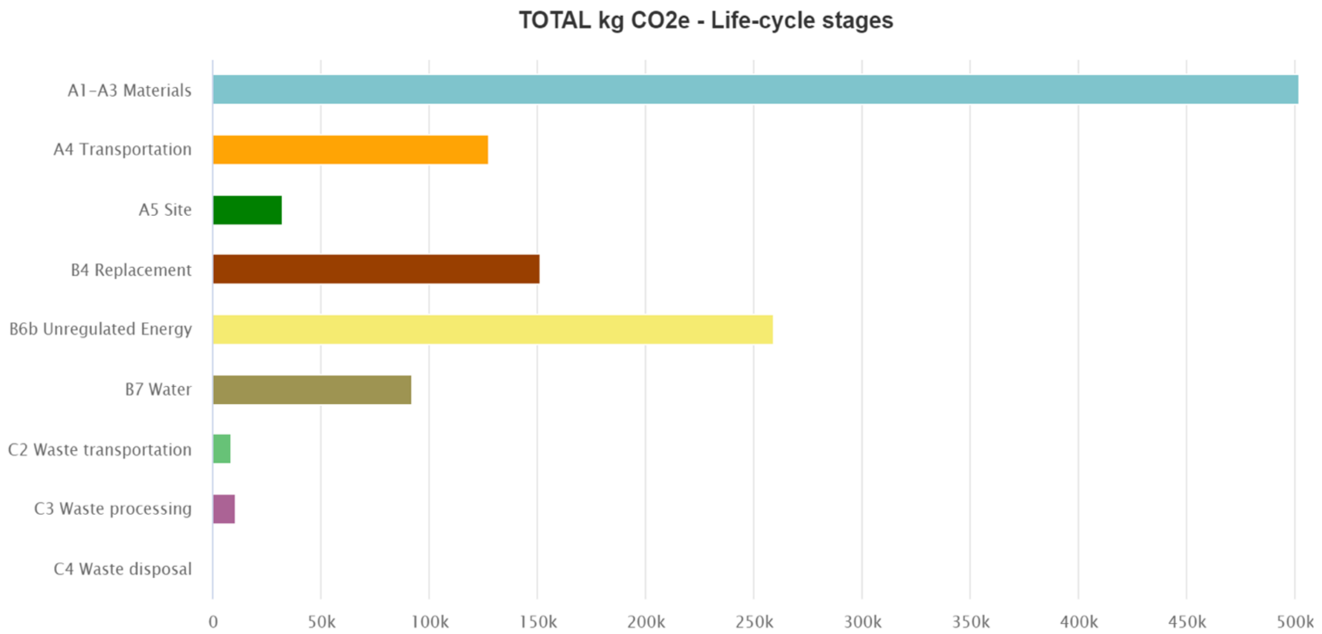

Figure 2. Breakdown of total LCA carbon emissions per life-cycle stage

The largest quantity of carbon emissions takes place in the product stage (A1-A3). This includes the material extraction, transport, and manufacturing of the products. The second-largest quantity is due to the building's unregulated energy use, which accounts for the services and utilities' 29.7% share of total emissions in Figures 3 and 4 respectively.

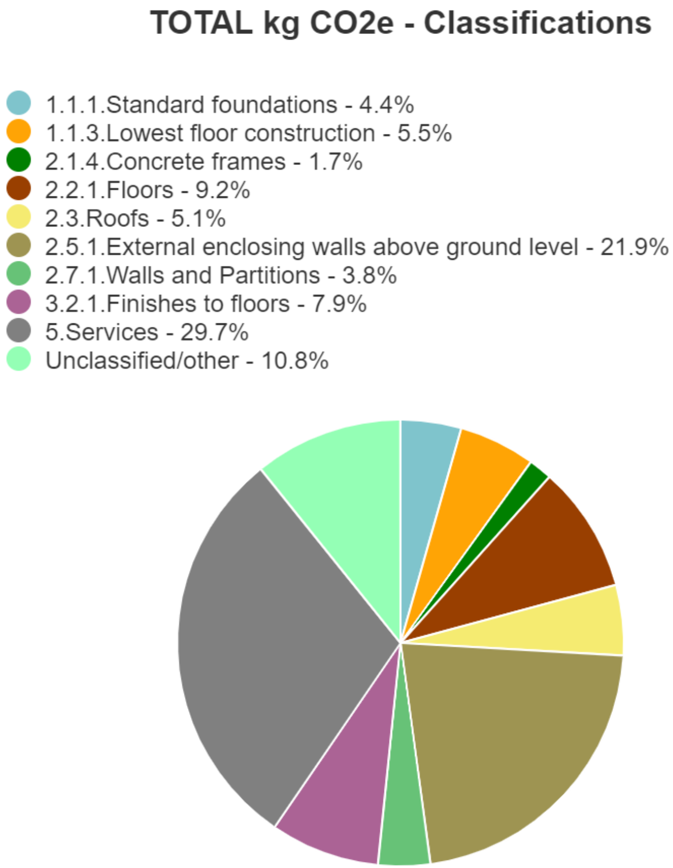

Figure 3. Total carbon emissions according to material classification

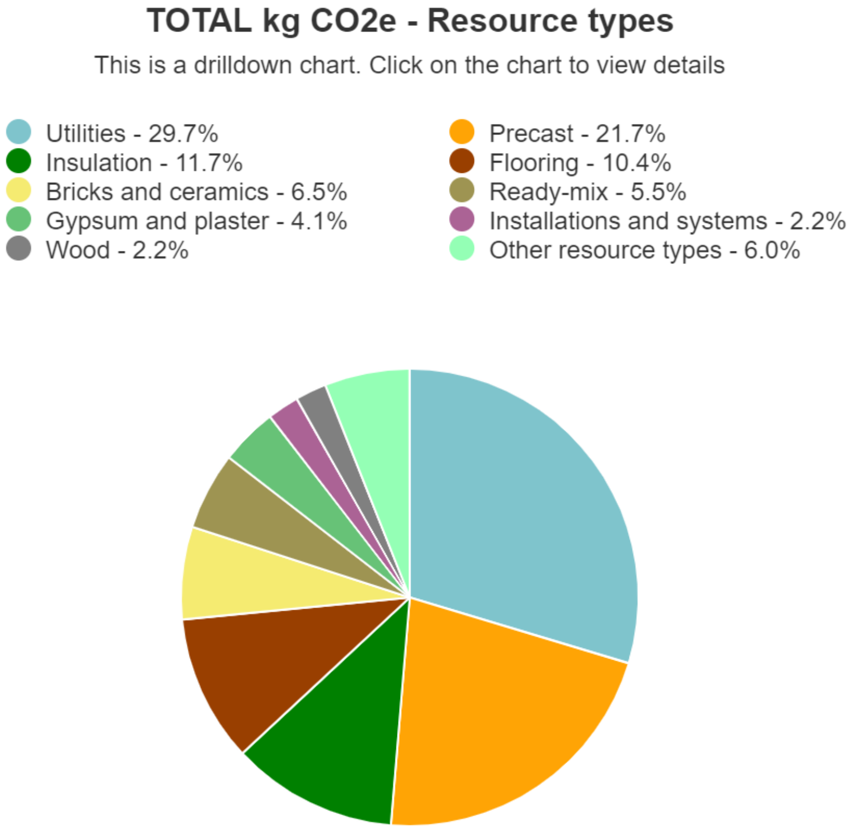

Figure 4. Total carbon emissions according to resource type

A considerable amount of carbon emissions is due to the transportation and replacement of building materials in the use stage. Figure 3 shows that external enclosing walls and floors are responsible for large quantities of carbon emission. Figure 4 shows that 21.7% of the emissions are due to precast elements. Insulation accounts for 11.7% and flooring for 10.4%. These are focus areas for reducing carbon emissions. To reduce carbon emissions related to the building's use of materials, especially in the product stage, the environmental impact of each material (which can be found in its respective EPD) needs to be considered.

4. Building Circularity

The goal of a Circular Economy is to retain the value of materials and resources indefinitely, creating no waste. This is in contrast to our current linear system, where materials are mined, manufactured, used, and thrown away. Circular Economy principles would reduce the quantity of new materials imported into the UK, reduce the amount of waste, reduce transportation of materials as well as greenhouse gas emissions, and save costs. To achieve this, there needs to be a transformation in the way buildings are designed, built, operated, and deconstructed.

To achieve London Plan 2021: Policy SI7 'Reducing waste and supporting the Circular Economy, the GLA has set out a policy framework that supports the delivery of a circular built environment. It is required to submit a Circular Economy Statement as part of the planning application. The Circular Economy Statement is underpinned by three core Circular Economy principles:

- Conserving resources, increasing resource efficiency, and sourcing sustainably
- Designing to eliminate waste (and for ease of maintenance)
- Managing waste sustainably and at the highest value

OneClick LCA's Building Circularity tool has been used as a base for the Circular Economy Statement. It offers a mass-based assessment of building materials to calculate the amount of reused and recycled materials. The software uses end-of-life processes and includes the benefits of designing for adaptability and disassembly.

Results

The following results were derived from the calculation using OneClick LCA's Building Circularity tool. Figure 5 shows the building materials that will be used in the new development by weight, according to their classification. Figure 6 shows the amount of reused and recycled materials to be used in the construction of the development and the possible end-of-life scenarios for these materials.

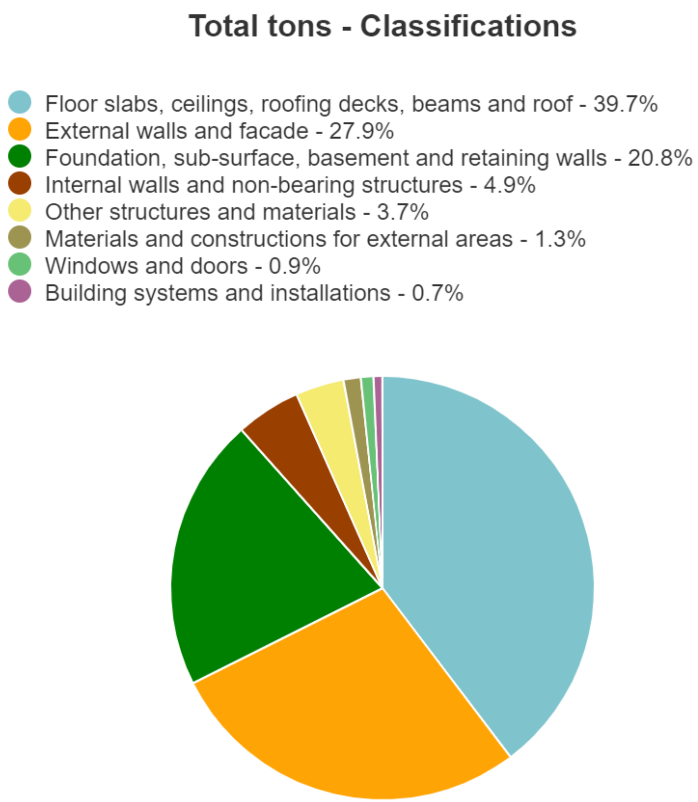

Figure 5. Building materials per weight

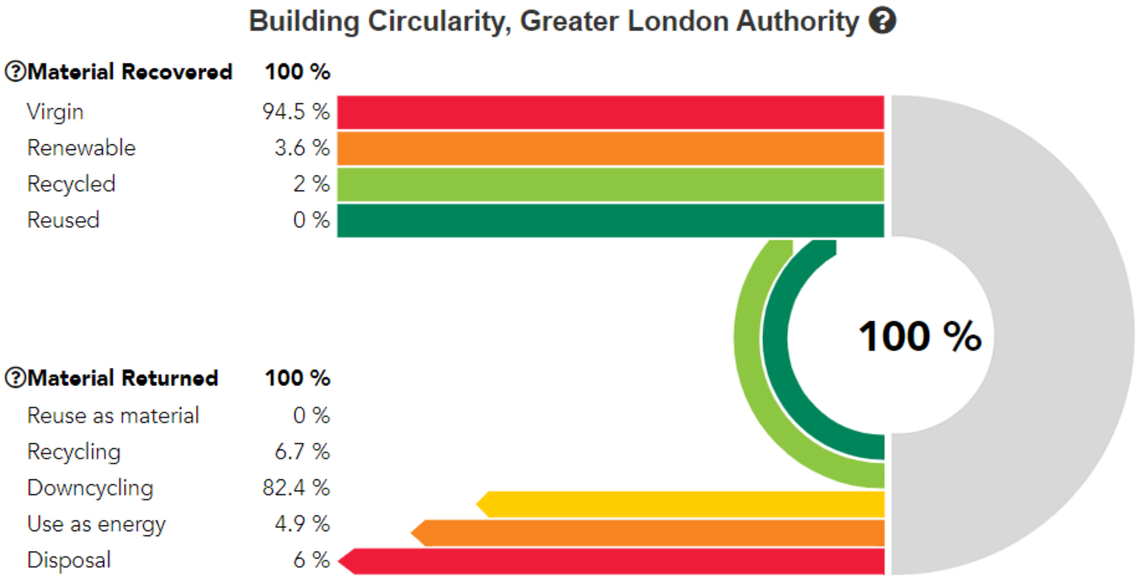

Figure 6. Building circularity of the new development

Ranked by weight, the largest quantity of materials used in the new development are concrete floor slabs, external wall elements and foundation. According to the OneClick LCA end of life scenarios, 94.5% of the used materials are from virgin materials. Of the returned materials, 6% is disposed of and 94% is recycled, downcycled or used as energy. None of the materials are reused as a whole.

Draft Circular Economy Statement

Executive Summary

This document accompanies the Whole Life-Cycle Assessment report for a new development located on Watts Close, N15 5DW. The development consists of 18 new residential units—12 flats and 6 houses—including communal gardens, play space, shared bicycle storage, and private gardens. The project team consists of the client, which is Haringey council, Newground Architects for the design, and SustainQuality Ltd. to ensure the sustainability of the new development.

This Draft Circular Economy Statement demonstrates the aspiration for the proposed development to consider the Circular Economy principles so as to minimise embodied carbon and operate within a Circular Economy, maximising the value extracted from materials and prioritising their reuse and recycling. The statement takes into account the key points of the London Plan: Policy SI7 'Reducing waste and supporting the Circular Economy'.

The design of the new development has taken the Circular Economy principles into consideration by carrying out a WLCA. The principles will be further considered through the following key commitments:

1. Meetings need to be organised with the design team to discuss Circular Economy aspirations. Workshops will be held to further develop and investigate Circular Economy objectives.
2. A pre-demolition assessment of the current site needs to be carried out to clarify the opportunities for reusing existing components and materials.
3. Investigations should be carried out as early as possible to establish the possibility of reusing materials and components from other projects.
4. A waste management plan needs to be considered for both the construction and operation stage.
5. Circular Economy principles will be monitored throughout the design and construction process. Data collection plans are needed for this.

Introduction

This Draft Circular Economy Statement has been prepared to demonstrate that the proposed development has considered the Circular Economy principles to minimise embodied carbon and operate within a Circular Economy, maximising the value extracted from materials and prioritising their reuse and recycling. The statement takes into consideration the following policies and regulations:

- Greater London Authority (GLA) - Draft New London Plan: Policy SI7 'Reducing waste and supporting the Circular Economy.

Method Statement

The Circular Economy principles and waste hierarchy need to be proactively considered throughout the entire construction process: specification, design, procurement, construction, and operation. There needs to be a collaboration with stakeholders to explore and develop solutions to implement these principles. As the project is at an early stage of design, there is no detailed bill of quantities for building materials, thus assumptions and general estimations have been made. The approach to the Circular Economy principles has been applied in the following ways:

- A Whole Life-Cycle Carbon Analysis (WLCA) report has been produced to improve the overall environmental impact. The initial results and early recommendations have been included in the WLCA Report. The WLCA takes into consideration the life cycle of each material or component in the building and covers the end-of-life stage as well as the potential for reuse and recycling.

Circular Economy Aspirations

The following section will review Circular Economy principles and aspirations that could potentially be implemented throughout the design.

Principle 1. Conserve resources and source sustainably

- To reduce the demand for building materials and the waste of the existing buildings on the site, components or materials could be reused in the new development. The existing buildings are residential, which might present opportunities to find suitable materials. A pre-demolition assessment of the current site could clarify the opportunities for reusing existing components and materials. Where there are no opportunities, good practice measures will be employed in the demolition to ensure maximum recovery of materials through recycling.
- The new development is planned to be constructed on a brownfield site. An optimisation of the land's use needs to be ensured through the construction of more housing and through improving the landscaping with more green areas and new trees.
- Investigations need to be carried out as early as possible to establish the possibility of reusing materials and components from other projects (including major assemblies such as structural steel frame, components, materials, etc.)

Principle 2. Design to eliminate waste (and for ease of maintenance)

- Consideration could be given to the reusability and recoverability of the building materials. When choosing materials and assembly methods, the ability to disassemble and reuse materials should be maximised. Standardised building components and detailing may be applied to ensure the components' reusability.
- To ensure longevity, simple maintenance strategies for the lifespan of the building could be planned at the design stage.

Principle 3. Manage waste sustainably and at the highest value

- During the construction stage, waste materials could be recycled onsite. Keeping the waste onsite will reduce carbon emissions associated with the proposed development through less transportation of waste and materials as well as through the reuse and recycling of materials.
- The construction site could incorporate accessible space and signage to store waste separately as well as encourage recycling, reuse, or collection.
- Waste during building operations could be managed by incorporating sufficient internal waste storage containers to promote the separation of recyclable materials at the residential units.

Circular Economy Goals and Strategic Approach

The goals and strategic approach to the circular economy is outline below. The targets need to be set to report against at the detailed stage of the design and to determine the required information. According to the aspirations mentioned in the previous section, the main strategic approach of the building design is for reusability and recoverability. Meetings and workshops need to be arranged with the project team to ensure an integrated and effective approach. Table 7. describes and justifies the strategic approach.

ASPECT	PHASE / BUILDING / AREA	STEERING APPROACH	EXPLANATION	TARGET	SUPPORTING ANALYSIS / STUDIES / SURVEYS / AUDITS
Circular Economy approach for the new development	The new buildings developed on the site will follow best practice principles in their design and construction with the aims of reducing material usage, minimising waste, and embedding longevity, flexibility, and adaptability			95% diversion from landfill at end of life	Whole Life-Cycle Assessment Sustainability strategy
Circular Economy approach for the existing site	Investigate whether construction materials or components can be reused			95% diversion from landfill	Pre-demolition audit
	Use additional rows where differentiation is appropriate				
Circular Economy approach for municipal waste during operation	A strategy needs developed to consider the flow of waste through the development, from residents to storage and collection, in a sustainable manner.			65% diversion from landfill 50:50 waste storage for general & recycled waste	Analysis of waste storage and collection requirements, waste streams calculations

Table 7. Strategic approach

5. Recommendations

Through the completion of the WLCA model and review of the design information, the following observations and recommendations have been made. The project team needs to review these recommendations to ensure the most appropriate strategy is taken on. In general, for the specification of materials for the development, it is encouraged that suppliers with established Environmental Product Declarations (EPDs) are specified during Stage 4. This should help reduce the environmental impacts of the scheme and allow for a greater understanding and refinement of the site's WLC emissions.

From the results of the WLCA, the highest carbon emissions are produced in the product stage—the raw material extraction, transport, and manufacturing of materials stage. To conserve resources, in line with the Circular Economy, an investigation needs to be carried out to establish opportunities for reusing existing components and materials. This could be from the buildings currently existing on the site or elsewhere.

Precast concrete elements, such as the floor slabs, roof decks, and concrete blocks, as well as the external wall construction, have a large mass and contribute a considerable share of the embodied carbon emissions. The designers can choose suitable low-carbon solutions. There are cement mixes available consisting of cementitious materials that have lower embodied carbon, such as GGBS. An alternative to using concrete could be to use timber floor elements. Some manufacturers produce solid floor constructions that are durable, stable, fire-resistant, and sound-insulated (Appendix B). Timber could also be considered for other building elements, such as stairs.

Local recycled or reclaimed bricks could be used. This will reduce the use of virgin materials and reduce the materials being sent to landfill. In addition, an alternative mortar mix could be considered. The mortar mix should be durable but allow for the bricks to be easily reclaimed at the end of the building's life. A soft lime mortar is a possibility.

Standardised detailing and standardised elements would take into consideration future disassembly of the building and reuse of the components and elements. This will minimise waste and maintain its environmental and economic value.

Lastly, consideration should be given to the use of locally sourced material suppliers and material products with a certified Environmental Product Declaration (EPD). This will significantly reduce carbon emissions due to the transport of materials to the site. It also makes the replacement of elements easier.

With regards to maintenance, replacement, and the technical service life of building components, durable elements could be chosen. To ensure longevity, simple maintenance strategies could be planned.

6. Conclusion

This Whole Life-Cycle Analysis (WLCA) report was produced by Sustain Quality in accordance with the GLA and RICS Whole Life Cycle (WLC) guidance using an approved software for the proposed residential redevelopment at Watts Close, N15 5DW.

This Statement defines a strategy to reduce embodied carbon emissions by implementing a carbon strategy with an estimated total CO_2 emission of **1.674.807 KgCO2** and **1037 KgCO2/m2GIA** for modules (A-C) and with **1,064,405 KgCO2** and **659KgCO2/m2GIA** for modules (A-C) with decarbonisation. The decarbonisation of the UK's electricity grid results in a carbon emission reduction of 10% across the lifespan of the building.

The overall life-cycle performance of the new development is well below the benchmarks. This is due to the low-carbon heating system and renewable electricity sources. To further reduce carbon emissions across the building's life cycle, the embodied carbon of the building materials needs to be reduced. Consideration of the EPDs of each material and component is needed to reduce the carbon emissions.

To apply the Circular Economy principles, meetings need to be held with the project team. The overarching strategic approach is reusability and recoverability of the building materials. According to the OneClick LCA end of life scenarios, only **3.8%** of the building materials are recovered from reuse, recycle and **94.5%** of the used materials are from virgin materials. Of the returned materials at the end of the building life, **6%** is disposed of and **94%** is recycled, downcycled or used as energy.

Key aspirations are to use fewer virgin materials by assessing the possibility of reusing the materials of the existing structures on the site or reusing materials from elsewhere, by incorporating standardised details and components into the design to ensure easy and complete disassembly of the building and to manage waste. Circular Economy principles need to be monitored throughout the design and construction process.

This approach reflects the quality, performance, and attributes of the Watts Close proposed development, demonstrating the client and design team's commitment to the development's low embodied carbon emissions.

Appendix A - Limitations

The recommendations contained in this Report represent Sustain Quality professional opinions, based upon the information listed in the Report, exercising the duty of care required of an experienced Environmental Consultant. Sustain Quality do not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions.

Sustain Quality obtained, reviewed, and evaluated information in preparing this Report from the Client and others. Sustain Quality conclusions, opinions and recommendations has been determined using this information. Sustain Quality do not warrant the accuracy of the information provided to it and will not be responsible for any opinions which Sustain Quality has expressed, or conclusions which it has reached in reliance upon information which is subsequently proven to be inaccurate.

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Appendix B - GLA spreadsheet

Project details	
Project name	Watts Close
Planning application reference number (if applicable)	
Use Type	C3 a
Brief description of the project	The proposal includes 18 new council homes, 4 one-bedroom flats, 8 two-bedroom flats, 4 three-bedroom houses and 2 four-bedroom houses. The homes will be two and three storeys high.
GIA (m^2)	1615
Authors (organisation or individuals)	SustainQuality ltd.
Date of assessment	08/09/2021
Nationally recognised assessment method used	BS EN 15978, with additional guidance from RICS Professional Statement
Reference study period (if not 60 years)	[This cell should only be filled in if the reference study period, i.e. the assumed building life expectancy, exceeds or is less than 60 years. Applicants should state the reference study period in this cell. While the assessment should still be done to 60 years, applicants may, if they choose to, submit an additional assessment of the modules B, C and D for the actual reference study period by copying and pasting an additional 'GWP potential for all life-cycle modules' table, see below].
Software tool used	OneClick LCA
Source of carbon data for materials and products	EPD & OneClick LCA database
EPD database used	EPD's in accordance with BS EN 15804, ISO 14025, ISO 14040 and 14044

Estimated WLC emissions (Assessment 1)
N.B. This forms the WLC baseline for the development. The results from Assessment 1 below are automatically populated here.

	Module A1-A5	Module B1-B5	Module B6-B7	Module C1-C4	Module D
TOTAL kg CO_2e	1,034,313 kg CO2e	151,263 kg CO2e	351,036 kg CO2e	136,028 kg CO2e	-185,468 kg CO2e
TOTAL kg CO_2e/m^2 GIA	640.4412384	93.6613065	217.3594551	84.22798762	-114.8407988
Comparison with WLC benchmarks (see Appendix 2 of the guidance) if Assessment 1 was used to inform design decisions	The carbon emissions for assessment 1 are below the aspirational benchmarks for apartments. This is due to the low operational energy use of the buildings. The building make use of low carbon heating system and renewable energy sources.				

Estimated WLC emissions (Assessment 2)
N.B. The results from Assessment 2 below are automatically populated here.

	Module A1-A5	Module B1-B5	Module B6-B7	Module C1-C4	Module D
TOTAL kg CO_2e	542,847 kg CO2e	151,263 kg CO2e	232,099 kg CO2e	138,196 kg CO2e	-185,468 kg CO2e
TOTAL kg CO_2e/m^2 GIA	336.1283963	93.6613065	143.7142786	85.57021672	-114.8407988
Comparison with WLC benchmarks (see Appendix 2 of the guidance) if Assessment 2 was used to inform design decisions	[Explain the reasons for any divergences from WLC benchmarks, including against the WLC aspirational benchmarks. Please note that grid decarbonisation has not been accounted for in the benchmarks]				

Key site opportunities and constraints in reducing WLC emissions	Since there are existing structures on the building site, a site assessment to establish oppurtunities to reuse building materials and components could be carried out. Reusing materials will reduce the carbon emissions in the product stage of the building life cycle

	Action	WLC reduction (kg CO_2e/m^2 GIA)
Summary of key actions to reduce whole life-cycle carbon emissions that have informed this assessment, including the WLC reductions	Replacing pre-cast concrete floor and roof slabs with solid timber floors.	21
	Using reclaimed bricks for the externall wall contruction	37
	Use more locally sourced materials to reduce transport distances. When reducing transport distances in km by	68

	Further potential opportunities	WLC reduction potential (kg CO_2e/m^2 GIA)
Specify further opportunities to reduce the development's whole life-cycle carbon emissions. including the WLC reduction potential	Efficient fabrication with standardised details and components to make disassembly easier at the end of the bu	

ASSESSMENT 1 - current status of the electricity grid

GWP POTENTIAL FOR ALL LIFE-CYCLE MODULES[1] (kgCO2e)		Sequestered (or biogenic) carbon (negative value) (kgCO2e)	Product stage (kgCO2e)	Construction process stage (kgCO2e)		Use stage (kgCO2e)							End of Life (EoL) stage (kgCO2e)				TOTAL Modules A-C $kgCO_2e$	Benefits and loads beyond the system boundary (kgCO2e)
			Module A			Module B							Module C					Module D*
Building element category			[A1] to [A3]	[A4][2]	[A5]	[B1]	[B2]*	[B3]*	[B4]*	[B5]*	[B6]	[B7]	[C1]	[C2]	[C3]	[C4]		
0.1	Demolition: Toxic/Hazardous/Contaminated Material																0 kg CO2e	
0.2	Major Demolition Works																0 kg CO2e	
0.3	Temporary Support to Adjacent Structures																0 kg CO2e	
0.4	Specialist Ground Works																0 kg CO2e	
0.5	Temporary Diversion Works																0 kg CO2e	
1	**Substructure**	-379 kg CO2e	90,870 kg CO2e	21,876 kg CO2e	2,428 kg CO2e			0 kg CO2e						2,168 kg CO2e	623.6 kg CO2e	11 kg CO2e	117,598 kg CO2e	-27,992 kg CO2e
2.1	Superstructure: Frame	0 kg CO2e	15,120 kg CO2e	3,447 kg CO2e	1,406 kg CO2e			0 kg CO2e						158 kg CO2e	19 kg CO2e		20,149 kg CO2e	-1,325 kg CO2e
2.2	Superstructure: Upper Floors	-444 kg CO2e	60,557 kg CO2e	22,286 kg CO2e	888 kg CO2e			0 kg CO2e	19,404 kg CO2e					999 kg CO2e	4,889 kg CO2e		108,579 kg CO2e	-31,344 kg CO2e
2.3	Superstructure: Roof	0 kg CO2e	55,154 kg CO2e	18,025 kg CO2e	1,268 kg CO2e			0 kg CO2e	6,916 kg CO2e					781 kg CO2e	89 kg CO2e	26 kg CO2e	82,259 kg CO2e	-11,336 kg CO2e
2.4	Superstructure: Stairs and Ramps	0 kg CO2e	17,533 kg CO2e	1,710 kg CO2e	1,260 kg CO2e			0 kg CO2e						439 kg CO2e	40 kg CO2e		20,981 kg CO2e	-14,198 kg CO2e
2.5	Superstructure: External Walls	0 kg CO2e	201,977 kg CO2e	34,867 kg CO2e	17,136 kg CO2e			0 kg CO2e	10,800 kg CO2e					2,197 kg CO2e	187 kg CO2e	335 kg CO2e	267,498 kg CO2e	-7,334 kg CO2e
2.6	Superstructure: Windows and External Doors	-1,731 kg CO2e	12,980 kg CO2e	574 kg CO2e	86 kg CO2e			0 kg CO2e	12,980 kg CO2e					198 kg CO2e	1,744 kg CO2e	1 kg CO2e	26,832 kg CO2e	-1,821 kg CO2e
2.7	Superstructure: Internal Walls and Partitions	-107,092 kg CO2e	13,779 kg CO2e	18,576 kg CO2e	5,006 kg CO2e			0 kg CO2e	5,621 kg CO2e					752 kg CO2e	107,992.2 kg CO2e	10 kg CO2e	44,645 kg CO2e	-49,697 kg CO2e
2.8	Superstructure: Internal Doors	-8,994 kg CO2e	5,096 kg CO2e	1,759 kg CO2e	0 kg CO2e			0 kg CO2e	5,096 kg CO2e					21 kg CO2e	9,050 kg CO2e	3 kg CO2e	12,032 kg CO2e	0 kg CO2e
3	Finishes	0 kg CO2e	17,262 kg CO2e	1,860 kg CO2e	2,531 kg CO2e			0 kg CO2e	74,873 kg CO2e					400 kg CO2e	4,682 kg CO2e		101,609 kg CO2e	-17,795 kg CO2e
4	Fittings, furnishings & equipment																0 kg CO2e	
5	Services (MEP)	0 kg CO2e	501,721 kg CO2e	463 kg CO2e	322 kg CO2e			0 kg CO2e	15,573 kg CO2e		0 kg CO2e 259,056 kg CO2e	91,980 kg CO2e		186 kg CO2e	91 kg CO2e	5 kg CO2e	869,397 kg CO2e	-21,251 kg CO2e
6	Prefabricated Buildings and Building Units																0 kg CO2e	
7	Work to Existing Building																0 kg CO2e	
8	External works	0 kg CO2e	1,137 kg CO2e	1,991 kg CO2e	0 kg CO2e			0 kg CO2e						91 kg CO2e	11 kg CO2e		3,230 kg CO2e	-1,376 kg CO2e
TOTAL kg CO2e		**-118,640 kg CO2e**	**993,186 kg CO2e**	**127,435 kg CO2e**	**32,331 kg CO2e**	**0 kg CO2e**	**0 kg CO2e**	**0 kg CO2e**	**151,263 kg CO2e**	**0 kg CO2e**	**259,056 kg CO2e**	**91,980 kg CO2e**	**0 kg CO2e**	**8,390 kg CO2e**	**129,417 kg CO2e**	**389 kg CO2e**	**1,674,807 kg CO2e**	**-185,468 kg CO2e**
TOTAL - kg CO2e/m2 GIA		**-73 kg CO2e/m2 GIA**	**615 kg CO2e/m2 GIA**	**79 kg CO2e/m2 GIA**	**20 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**94 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**160 kg CO2e/m2 GIA**	**57 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**5 kg CO2e/m2 GIA**	**80 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**1,037 kg CO2e/m2 GIA**	**-115 kg CO2e/m2 GIA**

Notes:

* Report non-decarbonised values for both material and operational emissions using current status of the electricity grid.

[1] If you have entered a reference study period in cell C10 because the assumed building life expectancy is greater or less than 60 years, this table should be copied and pasted below using the actual assumed life expectancy. This should be done for both GWP reporting tables and should be clearly labelled.
[2] Use the 'European manufactured' transportation scenarios (see Table 7, page 19 of the RICS PS) to calculate transportation emissions of MEP equipment.

(blue cell)	Mandatary cells for completion
(crossed cell)	N/A

ASSESSMENT 2 - expected decarbonisation of the electricity grid

GWP POTENTIAL FOR ALL LIFE-CYCLE MODULES[1] (kgCO2e)		Sequestered (or biogenic) carbon (negative value) (kgCO2e)	Product stage (kgCO2e)	Construction process stage (kgCO2e)		Use stage (kgCO2e)							End of Life (EoL) stage (kgCO2e)				TOTAL Modules A-C $kgCO_2e$	Benefits and loads beyond the system boundary (kgCO2e)
			Module A			Module B							Module C					Module D*
Building element category			[A1] to [A3]	[A4][2]	[A5]	[B1]	[B2]*	[B3]*	[B4]*	[B5]*	[B6]	[B7]	[C1]	[C2]	[C3]	[C4]		
0.1	Demolition: Toxic/Hazardous/Contaminated Material																0 kg CO2e	
0.2	Major Demolition Works																0 kg CO2e	
0.3	Temporary Support to Adjacent Structures																0 kg CO2e	
0.4	Specialist Ground Works																0 kg CO2e	
0.5	Temporary Diversion Works																0 kg CO2e	
1	Substructure	-379 kg CO2e	90,870 kg CO2e	21,876 kg CO2e	2,428 kg CO2e			0 kg CO2e						2,168 kg CO2e	624 kg CO2e	11 kg CO2e	117,598 kg CO2e	-27,992 kg CO2e
2.1	Superstructure: Frame	0 kg CO2e	15,120 kg CO2e	3,447 kg CO2e	1,406 kg CO2e			0 kg CO2e						158 kg CO2e	19 kg CO2e		20,149 kg CO2e	-1,325 kg CO2e
2.2	Superstructure: Upper Floors	-444 kg CO2e	60,557 kg CO2e	22,286 kg CO2e	888 kg CO2e			0 kg CO2e	19,404 kg CO2e	0 kg CO2e				999 kg CO2e	4,889 kg CO2e		108,579 kg CO2e	-31,344 kg CO2e
2.3	Superstructure: Roof	0 kg CO2e	55,154 kg CO2e	18,025 kg CO2e	1,268 kg CO2e			0 kg CO2e	6,916 kg CO2e	0 kg CO2e				781 kg CO2e	89 kg CO2e	26 kg CO2e	82,259 kg CO2e	-11,336 kg CO2e
2.4	Superstructure: Stairs and Ramps	0 kg CO2e	17,533 kg CO2e	1,710 kg CO2e	1,260 kg CO2e			0 kg CO2e						439 kg CO2e	40 kg CO2e		20,981 kg CO2e	-14,198 kg CO2e
2.5	Superstructure: External Walls	0 kg CO2e	201,977 kg CO2e	34,867 kg CO2e	17,136 kg CO2e			0 kg CO2e	10,800 kg CO2e	0 kg CO2e				2,197 kg CO2e	187 kg CO2e	335 kg CO2e	267,498 kg CO2e	-7,334 kg CO2e
2.6	Superstructure: Windows and External Doors	-1,731 kg CO2e	12,980 kg CO2e	574 kg CO2e	86 kg CO2e			0 kg CO2e	12,980 kg CO2e	0 kg CO2e				198 kg CO2e	1,744 kg CO2e	1 kg CO2e	26,832 kg CO2e	-1,821 kg CO2e
2.7	Superstructure: Internal Walls and Partitions	-107,092 kg CO2e	13,779 kg CO2e	18,576 kg CO2e	5,006 kg CO2e			0 kg CO2e	5,621 kg CO2e	0 kg CO2e				752 kg CO2e	107,992 kg CO2e	10 kg CO2e	44,645 kg CO2e	-49,697 kg CO2e
2.8	Superstructure: Internal Doors	-8,994 kg CO2e	5,096 kg CO2e	1,759 kg CO2e	0 kg CO2e			0 kg CO2e	5,096 kg CO2e	0 kg CO2e				21 kg CO2e	9,050 kg CO2e	3 kg CO2e	12,032 kg CO2e	0 kg CO2e
3	Finishes	0 kg CO2e	17,262 kg CO2e	1,860 kg CO2e	2,531 kg CO2e			0 kg CO2e	74,873 kg CO2e	0 kg CO2e				400 kg CO2e	4,682 kg CO2e		101,609 kg CO2e	-17,795 kg CO2e
4	Fittings, furnishings & equipment																0 kg CO2e	
5	Services (MEP)	0 kg CO2e	10,256 kg CO2e	463 kg CO2e	322 kg CO2e			0 kg CO2e	15,573 kg CO2e	0 kg CO2e	0 kg CO2e 140,119 kg CO2e	91,980 kg CO2e		186 kg CO2e	91 kg CO2e	5 kg CO2e	258,994 kg CO2e	-21,251 kg CO2e
6	Prefabricated Buildings and Building Units																0 kg CO2e	
7	Work to Existing Building																0 kg CO2e	
8	External works	0 kg CO2e	1,137 kg CO2e	1,991 kg CO2e	0 kg CO2e			0 kg CO2e						91 kg CO2e	11 kg CO2e		3,230 kg CO2e	-1,376 kg CO2e
TOTAL kg CO2e		**-118,640 kg CO2e**	**501,721 kg CO2e**	**127,435 kg CO2e**	**32,331 kg CO2e**	**0 kg CO2e**	**0 kg CO2e**	**0 kg CO2e**	**151,263 kg CO2e**	**0 kg CO2e**	**140,119 kg CO2e**	**91,980 kg CO2e**	**0 kg CO2e**	**8,390 kg CO2e**	**129,417 kg CO2e**	**389 kg CO2e**	**1,064,405 kg CO2e**	**-185,468 kg CO2e**
TOTAL - kg CO2e/m2 GIA		**-73 kg CO2e/m2 GIA**	**311 kg CO2e/m2 GIA**	**79 kg CO2e/m2 GIA**	**20 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**##############**	**94 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**87 kg CO2e/m2 GIA**	**57 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**5 kg CO2e/m2 GIA**	**80 kg CO2e/m2 GIA**	**0 kg CO2e/m2 GIA**	**659 kg CO2e/m2 GIA**	**-115 kg CO2e/m2 GIA**

Appendix C – Wood, An intelligent raw material

binderholz NATURE IN ARCHITECTURE

WOOD - AN INTELLIGENT RAW MATERIAL

Wood is a fascinating, versatile and intelligent material that plays an important role for us humans in many different ways. In addition to its important role as a provider of well-being, protection and wood as a natural raw material the young tree in the forest fulfils another valuable function: it extracts harmful CO_2 from the air, binds carbon C and releases oxygen O_2 into the atmosphere. Wood has a broad and fascinating range of uses. Whether as a simple wooden spoon, a musical instrument, object of art, furniture, heat and energy provider or as a hightech product for solid wood structures, we come into contact with this unique raw material every day. The characteristics of this intelligent material are reflected in its loadbearing capacity, durability, stability and fire resistance, to name but a few. Wood also has a positive influence on the well-being of humans and therefore on their health.

BENEFITS OF SOLID BINDERHOLZ CLT BBS CONSTRUCTION

uncomplicated I fast I dry

The solid BBS construction method combines all of the advantages of solid structures such as sound insulation, fire protection, solid construction, value retention, etc., with the ecological benefits of wood as a sustainable raw material.

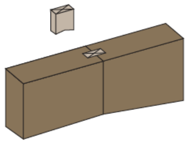
solid construction • dimensional stability • living space comfort
short construction times • visible quality • space gain
prefabrication • low thermal conductivity

(Binderholz CLT BBS - extracted from www.binderholz.com on 09 July 2021)

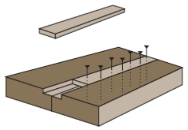
BINDERHOLZ CLT BBS

BBS is multilayered, completely solidly made of wood. Thanks to the gluing of longitudinal and transverse layers, the working behaviour of the wood is reduced to a negligible degree. Thus, meeting standards of a modern building material are assured. BBS is a solid prefabricated element made of wood that insulates heat and can simultaneously carry heavy loads. It has a building fire resistance and has a good sound absorbing effect. It can be constructed fast, dry and has a positive effect on the well-being of humans. BBS is made from 99,4 % timber and 0,6 % glue - that is BBS, a monolithic building material.
Combining the BBS 125 system format with the large-format panel BBS XL enables builders and designers to work even more flexibly with BBS cross-laminated timber and therefore making targeted use of each individual format.

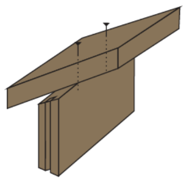
BINDERHOLZ CLT BBS I AT ONE SIGHT



BBS WALLS
BBS wall elements solidly and definitely fulfil all static, reinforcement, fire prevention, and building physics requirements. With BBS, low-energy, passive-energy and plus-energy buildings can be produced. BBS constructions fulfil all of the standard heat insulation values in accordance with the best available technology and provide a comfortable and balanced living climate thanks to vapour permeability and the ability to reduce peak room air humidity values.



BBS CEILINGS
Building the ceilings with BBS does not only have constructive advantages such as self-supporting and dry construction methods, slab effect, dimensionally stable components, adequate fire rating and sound-proofing, but also provides finished visible surfaces, as well as a fair dose of living comfort due to the positive effect the bulk of wood has on the air condition in the room.



BBS ROOF
BBS can be used for every kind of roof. Thus, rain impermeability and finished visible surfaces on the inside are quickly possible. BBS roof constructions securely and solidly fulfil all static, fire prevention and sound technical requirements. As BBS insulates with excellent heat storage properties, it not only contributes in winter to a comfortable warm room temperature but also to effective protection from the building overheating in the summer (summer heat protection).