Ham Close Regeneration

Planning Application:

Whole Life Cycle Carbon Assessment

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Hill
Created for Living

rhp

LONDON BOROUGH OF RICHMOND UPON THAMES

Whole Life Cycle Carbon Assessment

Ham Close WLC

On behalf of Hill Residential

R05

Date: 27th April 2022

REVISION HISTORY

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R02	24/03/22	Amended	JM	WOB
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1. Executive Summary

This Whole Life Cycle Carbon Assessment (WLC) has been completed by Energist UK on behalf of Hill Residential ('the applicant'). It supports a full planning application for the redevelopment of Ham Close, Ham, Richmond Upon Thames, TW10 7PG. The proposed development comprises demolition of existing buildings on-site and phased mixed-use development comprising 452 residential homes (Class C3) up to six storeys; a Community/Leisure Facility (Class F2) of up to 3 storeys in height, a "Maker Labs" (sui generis) of up to 2 storeys together with basement car parking and site-wide landscaping.

This report sets out the carbon impact of the proposed and demonstrates the actions taken by the Design Team to reduce embodied carbon and explores future opportunities to reduce this further. At the Planning Stage, the report is based on the best available concept design information that the Design Team could provide. An 'As Built' WLC assessment will be completed at the Post Construction Stage based on actual project data.

This WLC Assessment has been completed in compliance with:

i) The London Plan (March 2022), Policy SI2 Minimising Greenhouse Gas Emissions.
ii) RICS Professional Statement. Whole Life Carbon Assessments for the Built Environment 2017.
iii) BS EN15978:2011- Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

The London Plan 2021, Policy SI2 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.

The Pre-planning workshops were carried out on the 22nd September and 11th November 2021 to determine the WLC principles applicable for the scheme. The high-level aspirations were discussed and potential improvements that could be implemented were reviewed.

The outcomes of the workshop are included within the Pre-Application tab of the GLA WLC Template which accompanies this report.

All proposed buildings within this mixed-use redevelopment have been modelled in line with the GLA Whole Life-Cycle Carbon Assessments guidance. The baseline model of the embodied carbon has been created using best available data and the estimated total carbon emissions are summarised here in Table 1. The most significant use type for the development by area is residential therefore the closest GLA benchmark is Residential, so this has been used for comparison.

	GLA Benchmark for Residential	**Kg CO_2e/m^2 GIA over 60 years**
Materials Embodied Carbon Module A1-A5	<850	647.86
In Use and End of life Module B-C (excluding B6&B7)	<350	161.7
A-C (excluding B6 & B7, including sequestration)	<1200	801.81

Table 1: Baseline carbon emissions

The design team has incorporated sustainable measures into the pre-planning concept design where feasible. The results in Table 1 shows that the WLC baseline emissions for A1-A5, B–C (excluding B6&B7) and A-C (excluding B6 & B7, including sequestration), are within the benchmarks for Residential set out in Table A2.1 of GLA WLCA guidance (March 2022). However, it should be noted that these benchmarks are for Residential whereas the model includes the embodied carbon for proposed non-domestic uses which has significantly higher B1-B5 emissions.

Guidance has been given to the Design Team in order to reduce the carbon emissions further as they enter Developed Design.

2. Introduction

2.1 Development Overview

This WLC Assessment has been prepared for the proposed development comprises demolition of existing buildings on-site and phased mixed-use development comprising 452 residential homes (Class C3) up to six storeys; a Community/Leisure Facility (Class F2) of up to 3 storeys in height, a “Maker Labs” (sui generis) of up to 2 storeys together with basement car parking and site-wide landscaping, as illustrated in Figure 2.1.

The report details the approach taken by the Applicant and Design Team to address the Whole Life Cycle Carbon principles and to incorporate these within the development design to reduce overall WLC carbon emissions.

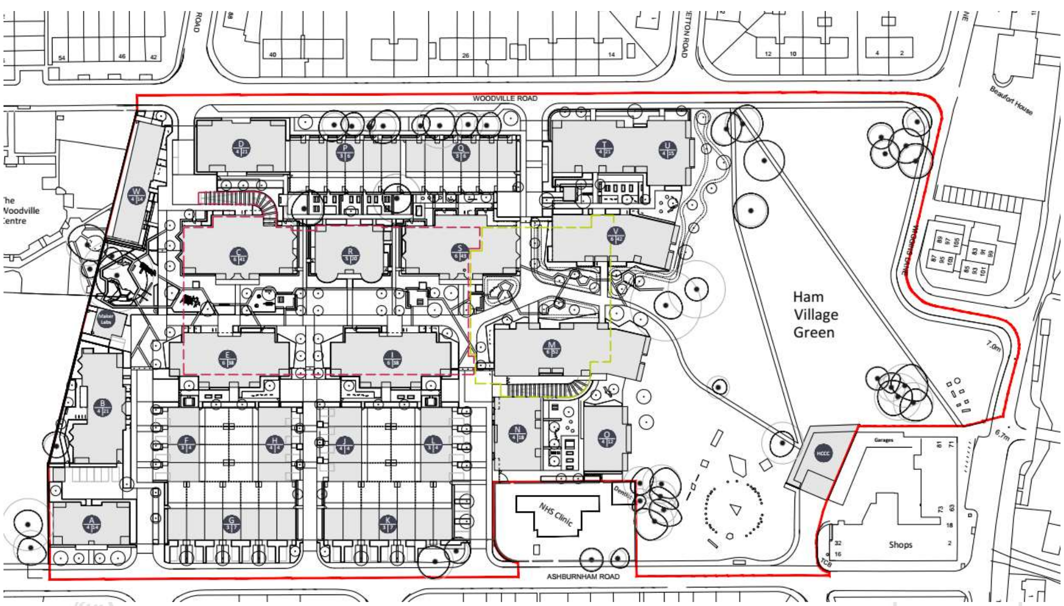

Figure 2.1 - Proposed Master Plan (Source BPTW Planning Issue Masterplan)

2.2 Policy Requirements

The GLA London Plan 2021 Policy SI2 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 proportions 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, manufacturer 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 referrable to the Mayor. Major non-referable development should calculate unregulated emissions and are encouraged to undertake whole life cycle carbon assessments.'

This policy sets out the requirement for WLC Carbon Assessments in referable schemes and recommends them for non-referable schemes. The guidance document for completing a WLC Assessment was first published in October 2020 and updated in March 2022. This includes requirements for assessment at the pre-application stage, planning application stage and post-construction stage.

Additional guidance documents are also referred to in the policy and these are to be used to inform WLC Assessments, these are:

i) RICS Professional Statement. Whole Life Carbon Assessments for the Built Environment 2017.
ii) BS EN15978:2011- Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.
iii) Operational carbon emissions for non-residential uses should be reported using CIBSE TM54.

2.3 Life Cycle Modules

The GLA guidance refers to the RICS Professional Statement and BS EN15978 which note that WLC assessments should be undertaken against the four stages of the typical building life cycle listed below.

- Module A1-A5- Product sourcing and construction stages
- Module B1-B7- Use stages
- Module C1-C4- End of life stages
- Module D- Benefits and loads beyond the system boundary

These are split down into their constituent parts in Table 2 below

Product sourcing and construction stages	A1- Raw material extraction and supply
	A2- Transport to manufacturing plant
	A3- Manufacturing and fabrication
	A4- Transport to project site
	A5- Construction and installation process
Use stages	B1- Use
	B2- Maintenance
	B3- Repair
	B4- Replacement
	B5- Refurbishment
End of life	C1- Deconstruction demolition
	C2- Transport to disposal facility
	C3- Waste processing for reuse, recovery or recycling
	C4- Disposal
Benefits and loads beyond the system boundary	Reuse, recovery, recycling potential

Table 2: Life cycle Modules

2.4 Methods

This WLC Assessment has been carried out using the RICS nationally recognised assessment methodology. The report demonstrates the actions taken to reduce WLC carbon emissions and recommendations. The assessment covers the development's carbon emissions across all life cycle modules over its lifetime. This accounts for:

- Operational carbon emissions (regulated and unregulated).
- Embodied carbon emissions.
- Any future potential carbon emissions benefits post end of life including benefits from reuse and recycling of building structures and materials.

As the most significant use type for the development by area is residential the GLA benchmark for Residential has been used for comparison.

2.4.1 Operational

The calculated operational carbon emissions from energy and water consumption are calculated separately using the Standard Assessment Procedure (SAP 10) methodology for residential buildings and TM54 methodology for commercial buildings. SAP10 emission factors are considered to represent current grid emissions, and these have been used in line with GLA requirements.

Energist UK has undertaken sample SAP calculations for representative dwellings. These encompass the different dwelling types for the proposed development and are a fair expectation of the likely unit mix of the proposals.

2.4.2 Embodied Carbon

Energist UK has used One-Click life cycle software to model each proposed building based on estimated bills of quantities provided by the design team. One-Click is an approved software tool recognised by the GLA and is a dedicated Life Cycle Assessment (LCA) tool containing generic and average life cycle indicators representative of the typical UK supply chain. The tool allows the embodied impacts for all the specified materials to be modelled using One Click's dedicated database which is integrated into the software.

All building elements have been included in the study in line with Table 6 of the RICS Professional Statement 2017. At this initial planning stage, exact data and specific material suppliers are not known in most instances therefore the WLC Assessment is based on project estimates and default figures within the One-Click template library to give as accurate a baseline as possible. As a result, high-level observations are given for reductions in embodied emissions.

2.5 Key Assumptions

The materials information and quantity has been provided by the Design team, in the form of materials schedules and email information. The general base build is ready-mix reinforced piled foundations, concrete slabs and frame; flat concrete slab and insulated inverted roof. External walls are external leaf brickwork with insulated metal stud. Internal walls are insulated metal stud with plasterboard.

Building services comprise of centralised air source heat pumps serving all dwellings.

Table 3 below sets out the key assumptions used within the study to determine the Whole Life Cycle Carbon baseline.

Environmental Indicator	Embodied Carbon CO_{2eq}
Study Period	60 years in line with GLA Guidance
Functional Units	Kg CO_{2eq} per m^2 GIA in line with GLA Guidance
Assessment Scope	All materials used within the proposed development's red line boundary in line with RICS PS
Material Specification	All materials information included within the study is taken from materials schedules and email information from The Design Team. Recycled content in materials has been included in line with RICS PS Table 6. For example, cement replacement has been used for piling, substructure

	and superstructure. Steel reinforcement bar recycled content of 97% and 20% for steel sections has been used.
Default Values	Where product-specific data is not available, default values from the One-Click database were used unless specified.
Material Lifespans and Transport Distances	One-Click default material lifespans and transport distances are in line with RICS PS Table 7 and have been used unless specifically stated.
Operational Energy and Water Modelling	The estimated annual energy consumption has been taken from the Planning Stage sample SAP and TM54 modelling and multiplied for a 60-year building life.
Construction site	One-Click default construction site impacts were used which are in line with RICS PS methodology.

Table 3: Key Assumptions

2.6 Limitations

Whole Life Cycle Carbon Assessments can be difficult to accurately apply and are only as good as the information available. This assessment has been completed in line with current industry best practice standards (RICS PS 2017 and BS EN 15978) however the following limitations should be noted:

- This study has been made using the estimates provided at this stage of the project.
- The One-Click database includes standard assumptions for waste factors, life expectancy, recycled content and transport distances for each material type. These might not be reflective of the as-built data for this project. The Circular Economy Statement end of life scenarios have been used where possible.
- There is a degree of imprecision at this early stage, therefore the major impacts should be focused on for improvement.
- The embodied carbon of building services is still a new area within the industry and available data is limited. Approximations have therefore been used to represent the proposed systems using existing datasets within the software.

3. Results and Analysis

3.1 Baseline Results

The design information has been fed into the One-Click software and exported to the GLA WLCA spreadsheet. Results are shown in Table 4 and Table 5 below.

Life Cycle Module	Description	Kg CO_{2eq} over 60 years
A1-A5	Construction materials Transport Construction site	27,636,914
B1-B5	Use Maintenance Repair Replace Refurbishment	4,589,660
B6-B7	Operational energy and water	15,751,323
C1-C4	Re-use, recycling or disposal	2,308,402

*Table 4: WLC Assessment Results (*Total Kg CO_{2eq} over 60 years)

Life Cycle Module	Description	Kg CO_{2eq}/m^2 GIA
A1-A5	Construction materials Transport Construction site	647.86
B1-B5	Use Maintenance Repair Replace Refurbishment	107.59
B6-B7	Operational energy and water	369.24
C1-C4	Re-use, recycling or disposal	54.11

*Table 5: WLC Assessment Results (*Kg CO_{2eq}/m^2 GIA)

The WLC Assessment baseline results demonstrate that for each block the highest contributors to overall emissions are the A1-A5 modules as expected.

3.2 Comparison with the GLA Benchmark

The WLC Assessment baseline has been compared to the GLA benchmarks for Apartments/Hotels building types below.

	GLA Residential Benchmark CO_2e/m^2 GIA over 60 years
Materials Embodied Carbon Module A1-A5	<850
In Use and End of life Module B-C (exc B6&B7)	<350
A-C (excluding B6 & B7, including sequestration)	<1200

Table 6: WLC Assessment Results

It can be seen by comparing Table 5 and Table 6 that the development's carbon emissions are in line with the GLA benchmarks for modules A1-A5 and B-C.

All efforts have been made to reduce the embodied carbon during conception design. However, additional measure(s) have been identified for further reduction during the Technical Design.

In line with the GLA Guidance, Energist has appraised options for reducing WLC carbon emissions in the next section. The recommendations for further embodied carbon reduction can be implemented during the Technical Design and Construction Stage to achieve the design performance and avoid any performance gap between the Planning Stage WLC and the Post Construction Stage WLC.

4. Options Appraisal

4.1 Proposed Design

The highest contributors to the WLC carbon emissions are broken down by life-cycle stages in figure 4.1 below.

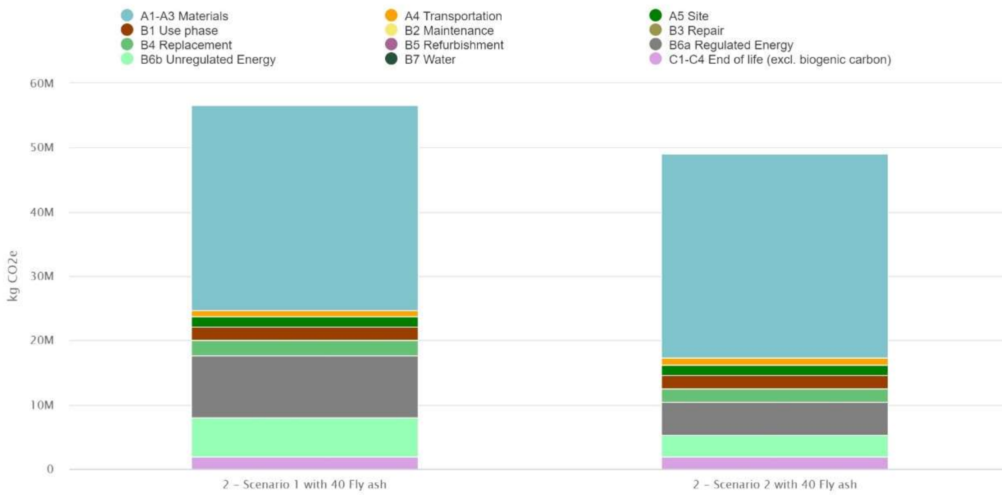

Figure 4.1 Global warming, kg CO2e - Life-cycle stages

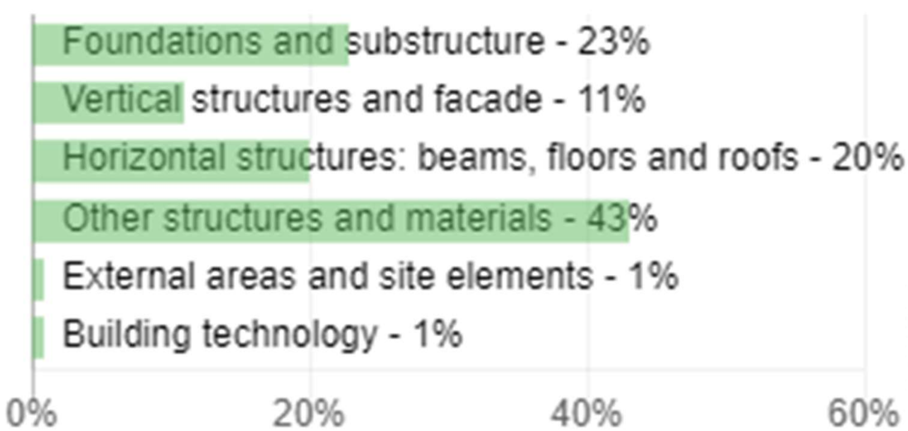

Figure 4.2- Embodied carbon by structure - A1-A3

The top 4 materials with the highest lifetime emissions contributors to modules A1-A5 are:

- Ready-mix concrete
- Brick
- Ferrous Metals | Steel | Reinforcement and Metal suds
- Building services equipment including working fluid

The results show that the worst offending materials for embodied emissions are the concrete and steel used for substructure and superstructure elements. These should be the elements with the highest focus for improvements as they will generate the largest reductions.

The assessment has shown that these materials are the highest contributors to the overall WLC carbon emissions of the proposed development. Priority should be given to reducing the emissions of these products and options have been appraised in the following sections to do this along with other high-level recommendations.

4.2 Cement Replacement

The RICS PS Table 6 baseline figure for cement replacement is 20%. To reduce the environmental impact of concrete, Ready-mix concrete with 40% cement replacement was used for all foundation, slabs and frame elements. Further cement replacements are possible (up to 75% for substructure), alternatively, hollow-core pre-cast concrete slabs can be considered.

4.3 Window Frames

The base model includes aluminium frames to all residential and retail openings. Aluminium is a very carbon-intensive material. Significant savings can be achieved by replacing aluminium windows with composite frame/hybrid aluminium, PVC or timber frame. The calculated savings are for embodied energy only, further savings are likely due to the increased thermal performance of timber.

PVC window frames can be considered as these are significantly better than aluminium but could be improved further by using timber-framed windows which have significantly lower embodied carbon. However, the benefits of these reduces over the building lifetime due to higher maintenance and replacement costs but there is an overall lifetime emissions reduction.

4.4 Working Fluid Type

Working fluid within the air source heat pumps has been modelled using R407C and R513A refrigerant for residential and R410A for commercial units, during this high-level assessment. This has a high Global Warming Potential (GWP) as shown in the below refrigerant summary table. The working fluid used is under review and is likely to change to a Class A refrigerant with a GWP nearer to 600 once different systems have been reviewed.

Refrigerant	GWP $KgCO_2eq/Kg$	Advantages	Disadvantages
R410a	2125	Established and common. Good performance.	High GWP
R407c	1825	Established and common. Good performance	High GWP
R22	1810	Established and common. Good performance	High GWP
R134a	1430	Established and common. Good performance.	High GWP
R32	700	0.7kg of R32 in a 3kw split system with an equivalent performance to 1kg of R410a. Lower cost than R410a.	Slightly flammable. Polyolester oil is not miscible with R32 so new oil is required.
R-513A	572	Relatively lower GWP Good performance.	Polyol ester (POE) oil is the recommended

		No stratospheric ozone impact. Non-toxic and non-flammable (ASHRAE A1 Class).	lubricant for the protection of motor windings with R-513A.
R-1234yf	1	Significantly lower GWP	Slightly less efficient. Higher cost. Less availability. Significant additional expertise to install and then maintain.
R-744 (CO_2)	1	Significantly lower GWP	Less efficient Significant additional expertise to install and then maintain. Significantly more expensive.
R-1234ze	1	Significantly lower GWP. Coefficient or performance (COP) ratio better than traditional refrigerants. Non-flammable	Cooling capacities 25% lower than R134a
R-717 (Ammonia)	0	No GWP.	Slightly less efficient. Toxic in high concentrations Flammable. High cost.

Table 7 - Refrigerant Summary

5. Further Observations

The below observations have been made based on the overall WLC principles and potential improvements that could be considered as the development enters the Technical Design Stages.

- Revision of the early stage estimated material quantity/Bill of quantity and consider reduction of slab thickness and or steel reinforcement as applicable.

- Consider the specification of hollow core concrete slab (with 50% cement replacement) for upper floors.

- Steel Reinforcement (rebar) - The typical steel rebar in the UK has 97% recycled content and the RICS PS requires 97% recycled content for base specification. Therefore, further reductions in steel rebar are difficult as there are not many different steel manufacturers with products in the UK market.

- Structural steel sections - Steel has inherently high embodied CO2. the RICS PS requires 20% recycled content for base specification, but reductions can be made by procuring structural steel with 90% recycled content or structural steel from arc furnace production suppliers which can have 1/3 the embodied carbon. Sourcing suppliers who have signed up to SteelZero will also ensure embodied energy is reduced as they have committed to net zero steel by 2050.

- Pre-demolition audit: A pre-demolition audit will be completed on the existing site. The results of this will be reviewed to determine any elements of the building that can be re-used or repurposed.

- Produce a maintenance and Repair Schedule for the proposed buildings to fulfil and enhance the life expectancy of the building materials. This will reduce the need to replace and refurbish the building elements and reduce C1-C4 emissions.

- Reduce finishing materials. Leaving exposed concrete in core and stairwells will reduce the embodied carbon from fit-out items. Where finishes are required, ensure these have a high life expectancy: for example, vinyl flooring has double the life expectancy of carpet so will have significantly lower lifetime replacement carbon costs.

- Produce a Sustainable Procurement Plan detailing procedures for local procurement. At the Post Construction Stage actual transport distances will be used so emissions will be reduced the closer these have been procured from site.

- Review any further opportunities for lightweight construction as the design develops and ensure an optimised structural design is in place. The largest contributors are steel and concrete so any reductions that can be made to reinforcement percentage and pile size will have a significant impact.

- Maximise timber use. Timber has a negative carbon figure due to the sequestration of carbon from its growth. Consider using timber stud walls where possible or using timber frame in low rise areas.

- Review the building service equipment including working fluid based on detail design as opposed to BSRIA Rule of thumb.

- The SAP data used during this stage are based on representative samples of each block. Therefore, the energy consumption is estimated. The calculated energy data for each residential dwelling will only be available at RIBA stage 4 Technical design.

In addition to the options appraised in Section 4 and the further observations above, the 16 WLC principles appraised at the Pre-Application Stage (Appendix A) should continue to be reviewed at Technical Design Stage to find any further savings that can be made.

6. Conclusions

Energist UK have completed a Whole Life Cycle Carbon (WLC) Assessment on Energist UK on behalf of Hill Residential for the proposed redevelopment of Ham Close, Ham, Richmond Upon Thames, TW10 7PG. This is in support of the planning application for the proposed development. The purpose of the assessment is to demonstrate that the proposed development is in line with GLA benchmarks and that options have been appraised and implemented to provide a more sustainable design.

This WLC Assessment has been prepared in line with the GLA's London Plan Policy SI2 and using the methodology detailed in GLA Whole Life Cycle Carbon Assessment Guidance (March 2022), the RICS Professional Statement 2017 and BS EN15978:2011. The carbon emissions for the A1-A5 and B-C life cycle stages have been compared to the GLA benchmarks as shown below and are within the typical benchmark levels. This indicates that the proposed development incorporates the most feasible sustainable design options.

	GLA Benchmark for Residential	Block E CO_2e/m^2 GIA over 60 years
Materials Embodied Carbon Module A1-A5	<850	647.86
In Use and End of life Module B-C (exc B6&B7)	<350	161.70
A-C (excluding B6 & B7, including sequestration)	<1200	801.81

Table 10: Comparison to GLA Benchmark

Energist UK has taken the following steps to reduce the overall CO_2eq for the proposed development:

- Use of EPD Certified ready mixed concrete with 40% cement replacement for concrete foundations, frames and slabs.
- Use of EPD Certified steel Reinforcement with 97% recycled material.
- Use of EPD Certified structural steel with a minimum of 90% recycled material.

- Use of EPD Certified Aluminium windows and doors with 60% recyclable aluminium.

Appendix A

Whole Life Cycle Carbon (WLC)- Pre-Application Stage Report Submission Note

Energist UK has been appointed by Hill Residential to complete the pre-application WLC Assessment requirements for the mixed-use development at Ham Close, Ham, Richmond Upon Thames, TW10 7PG. The proposed development comprises demolition of existing buildings on-site and phased mixed-use development comprising 452 residential homes (Class C3) up to six storeys; a Community/Leisure Facility (Class F2) of up to 3 storeys in height, a "Maker Labs" (sui generis) of up to 2 storeys together with basement car parking and site-wide landscaping.

This submission note has been completed in tandem with the Greater London Authority WLC template to accompany the pre-application submission for the development. The Design Team have reviewed the WLC principles in the table below and considered how these can be applied on the development to influence the development's design. Reasons for not considering certain principles have also been provided.

Principle	Description	Planning Team Comments
Reuse and retrofit of existing built structures	Before embarking on the design of a new structure or building, the retrofit or reuse of any existing built structures, in part or as a whole, should be a priority consideration as this is typically the lowest carbon option. Significant retention and reuse of structures also reduces construction costs and can contribute to a smoother planning process.	The site is an existing RHP owned estate, with 6 small parcels of land owned by the council. The site has 14 existing residential blocks, plus some ancillary uses including garages. The site does not contain designated heritage assets or locally listed heritage assets. The flats at Ham Close are of poor construction, with poor insulation by today's standards. Many have condensation/damp issues. In addition, there are no private gardens, terraces or lifts, leaving a number of flats inaccessible to people with disabilities. RHP and Richmond Council are therefore working with the local community

		to develop plans to improve Ham Close. The existing structures are not fit for the intended purpose. The proposed new site layout and occupancy density and amenities are significantly different to the existing site. Therefore, no parts of the existing superstructure or substructure will be retained. The Council supports the regeneration of Ham Close including demolition of the existing buildings and new build reprovision of all residential and non-residential buildings, plus the provision of additional new residential accommodation.
Use recycled or repurposed materials	Using recycled or repurposed materials, as opposed to newly sourced raw materials, typically reduces the carbon emissions from constructing a new building and reduces waste. This process would start by reviewing the materials already on site for their potential for inclusion into the proposed scheme. Many of the currently available standard products already include a degree of recycled content. Applicants should obtain this information from the supply chain, preferably in the form of an EPD.	A pre-demolition audit will be completed to understand the quantities of existing materials on site that can be reused on-site or recycled off-site. There is likely to be a significant quantity of concrete that can be crushed and re-used as pile matt and fill material. Hill Residential will review the potential for using recycled materials on-site for example the use of secondary aggregates such as fly ash or GGBS cement substitutes. Steel procurement will also be reviewed with a view to maximising recycled content.
Material selection	This is the most important issue affecting the WLC 'cost' of a new building. Appropriate low carbon material choices are key to carbon reduction. Ensuring that there is synchronicity between materials selected and planned life expectancy of the building reduces waste and the need for replacement, thus reducing in-use costs. EPDs should be referenced.	Low carbon materials will be procured wherever possible with a focus on selecting materials with Environmental Product Declarations (EPDs). The current proposal is for a reinforced concrete frame and traditional construction. It is likely that the concrete and steel will have the highest embodied carbon therefore options will be reviewed in the WLC Assessment to reduce the

	It is important to note that the overall life-time carbon footprint of a product can be as much down to its durability as to what it is made of. For example, bricks may have a high carbon cost in terms of their manufacture, however they have an exceptionally long and durable life expectancy. The selection of reused or recycled materials and products, plus products made from renewable sources, such as timber, will also help reduce the carbon footprint of a project.	embodied carbon of concrete to be specified. The design team is currently investigating low embodied carbon structural elements such as SIPS / CLT for the internal structure of the Community facilities. When selecting construction products Hill Residential will review options based on the life expectancy of the building to ensure replacement cost and associated emissions are reduced wherever possible.
Minimise operational energy use	A 'fabric first' approach should be prioritised to minimise the heating and cooling requirement of a building. Naturally ventilated buildings avoid the initial carbon and financial costs of a ventilation system installation, and the repeat carbon and financial costs of its regular replacement.	In line with New London Plan requirements, Hill Residential will achieve a 10% fabric first emissions reduction for residential and 15% reduction for non-residential areas. Hill Residential will review the potential for passive design measures. The proposed construction is a concrete frame therefore the building will have a high thermal mass, helping to reduce heating and cooling demand. The glazing areas will also be carefully considered to reduce solar gains.
Minimise operational water use	Carbon emissions from water use are largely due to the materials and systems used for its storage and distribution, the energy required to transfer it around the building, and the energy required to treat any wastewater. The choice of materials used and the durability of the systems, which help avoid leakage and resulting damage to building fabric, are therefore key aspects of reducing the carbon cost of water use. On-site water collection, recycling and treatment, and storage can have additional positive environmental impacts as well as reducing in-use costs.	Building services will be carefully designed to achieve the most efficient outcome and reduce embodied carbon. Water leak detection systems will be installed to commercial and residential areas to prevent potential damage to building fabric causing additional carbon costs from replacement. Hill Residential will review all opportunities for rainwater harvesting for irrigation purposes.
Disassembly and reuse	Designing for future disassembly ensures that products do not become future waste and that they maintain	The design team will endeavour to maximise the use of internal demountable partition walls.

	their environmental and economic value. A simple example is using lime rather than cement mortar; the former being removable at the end of a building's life, the latter not. This enables the building's components (e.g. bricks) to have a future economic value as they can be reused for their original purpose rather than becoming waste or recycled at a lower level (e.g. hardcore in foundations). Designing building systems (e.g. cladding or structure) for disassembly and dismantling has similar and even broader benefits. Ease of disassembly facilitates easy access for maintenance and replacement leading to reduced maintenance carbon emissions and reduced material waste during the 'in-use' and 'end of life' phases. This leads to the potential for material and product reuse which also reduces waste and contributes to the circular economy principle.	All non-domestic areas will be designed to accommodate changes of use and future tenant layout and fit-out. Hill Residential will review the potential to use lime mortar in some applications so that brickwork can be disassembled, and the bricks reused at end of life.
Building shape and form	Compact efficient shapes help minimise both operational and embodied carbon emissions from repair and replacement for a given floor area. This leads to a more efficient building overall, resulting in lower construction and in-use costs. A complex building shape with a large external surface area in relation to the floor area requires a larger envelope than a more compact building. This measure of efficiency can be referred to as the 'wall to floor ratio', or the 'heat loss form factor'. This requires a greater use of materials to create the envelope, and a potentially greater heating and/or cooling load to manage the internal environment.	The proposed buildings utilise compact efficient shapes and the architect is being challenged to reduce the wall to floor ratio as far as possible to increase efficiency.
Regenerative design	Removing CO_2 from the atmosphere through materials and systems absorbing it makes a direct contribution to carbon reduction.	The design team will endeavour to maximise areas of exposed concrete such as stair cores, lift shafts, commercial areas.

	Examples include unfinished concrete, some carpet products and maximising the amount of vegetation.	The development will also look to install green roofs wherever possible and maximise soft landscaping and tree planting.
Designing for durability and flexibility	Durability means that repair and replacement is reduced which in turn helps reduce life-time building costs. A building designed for flexibility can respond with minimum environmental impact to future changing requirements and a changing climate, thus avoiding obsolescence which also underwriters future building value. Buildings designed with this principle in mind will be less likely to be demolished at the 'end of life' as they lend themselves to future refurbishment. Examples include buildings being designed with 'soft spots' in floors to allow for future modification and design as well as non-structural internal partitions to allow layout change.	A full review of building durability measures will be made to determine the vulnerable areas of the building likely to be impacted by vehicle collision or high pedestrian traffic. Measures will be installed in the building to reduce impact and wear and tear thus reducing replacement cost over the building life cycle. A Functional Adaptability Plan will be produced to determine possible measures to improve the flexibility of the buildings. Demountable partitions will be maximised where applicable and soft spots will be investigated. The commercial areas will be left as Shell and Core to allow flexibility for future tenants. The fully fitted community facilities will be designed to allow for future adaptation to other uses such as commercial community offices.
Optimisation of the relationship between operational and embodied carbon	Optimising the relationship between operational and embodied emissions contributes directly to resource efficiency and overall cost reduction. For example, the use of insulation has a clear carbon benefit whereas its fabrication has a carbon cost. This means that it is important to look not only at the U-value of insulation, but also the carbon cost of the manufacture and installation of different product options. Avoiding fully glazed façades will reduce cooling demand and limits the need for high-carbon materials (glass units, metal frame, shading device etc) both at the construction stage, and the 'in use' stage through wholesale replacements.	Hill Residential will review both embodied and operational carbon costs in the WLC assessment. Careful consideration will be given to the building fabric to ensure that embodied carbon is minimised where possible and the impact on operational heating and cooling emissions are not unduly impacted. Fully glazed facades are not proposed and the construction will be predominantly concrete frame and brick, so unnecessary heating and cooling demands will be avoided.
Building life expectancy	Defining building life expectancy gives guidance to project teams as to the most efficient life expectancy choices for materials and products.	Hill Residential will review the life expectancy of the building and consider this for material procurement decisions. A building

	This aids overall resource efficiency, including cost efficiency and helps future proof asset value.	life expectancy of at least 60 years will be used for WLC assessment purposes. All building materials will be procured in line with the Hill Residential Sustainable Procurement Plan. A Maintenance and Repair Schedule will be produced for the project to ensure that material life expectancy is maintained appropriately.
Local sourcing	Sourcing local materials reduces transport distances and therefore supply chain lengths and has associated local social and economic benefits e.g. employment opportunities. It also has benefits for occupiers as replacement materials are easier to source. Transport type is also highly relevant. A product transported by ship will have a significantly lower carbon cost per mile than one sent by HGV. A close understanding of the supply chain and its transport processes is therefore essential when selecting materials and products.	All materials will be procured in line with the Hill Residential Sustainable Procurement Plan which aims to source materials locally wherever possible. A sub-contractor tender matrix will also be used which gives additional weighting to local procurement. Additional onus will be placed on local and UK procurement due to current global and political uncertainties and the impact this has on acquiring materials.
Minimising waste	Waste represents an unnecessary and avoidable carbon cost. Buildings should be designed to minimise fabrication and construction waste, and to ease repair and replacement with minimum waste, which helps reduce initial and in-use costs. This can be achieved through the use of standard sizes of components and specification and by using modern methods of construction. Where waste is unavoidable, the designers should establish the suppliers' processes for disposal or preferably reuse of waste.	Hill Residential will complete a Site Waste Management Plan detailing procedures for waste minimisation on site. Current BREEAM targets are above Outstanding level minimum requirements at less than 6.5 tonnes per 100sqm GIFA. Hill Residential are also aiming to divert at least 90% of construction waste from landfill. Procuring windows that use steel stillages for transportation is proposed to reduce packaging waste and also potential breakage waste. Balconies are also proposed to be pre-fabricated off-site to reduce waste. Hill Residential will review any other feasible MMC such as pod construction for elements of the residential units.
Efficient fabrication	Efficient construction methods (e.g. modular systems, precision manufacturing and modern methods of construction) can contribute to better build quality, reduce	The Design Team will endeavour to specify the correct material sized for the building wherever possible to reduce the chance of off-cuts. Due consideration will be given to

	construction phase waste and reduce the need for repairs in the post completion and defects period (snagging). Such methods can also enable future disassembly and reuse with attendant future carbon benefits.	standard manufacturing sizes in the design. 2.5m ceiling heights are proposed and the material will be selected in line with this.
Lightweight construction	Lightweight construction uses less material which reduces the carbon footprint of the building as there is less material to source, fabricate and deliver to site. Foundations can then also be reduced with parallel savings. Lightweight construction can also be easier to design for future disassembly and reuse. The benefits of lighter construction should be seen in the context of other principles such as durability.	The building will be a concrete frame so lightweight construction will be difficult however SFS infill is proposed to residential areas which will reduce overall load. Lightweight construction is proposed for set-back top floors on 6 storeys blocks.
Circular economy	The circular economy principle focusses on a more efficient use of materials which in turn leads to financial efficiency. Optimising recycled content, reuse and retrofit of existing buildings, and designing new buildings for easy disassembly, reuse and retrofit, and recycling as equivalent components for future reuse is essential. The use of composite materials and products can make future recycling difficult. Where such products are proposed, the supplier should be asked for a method statement for future disposal and recycling.	A full Circular Economy Statement will be developed. Hill Residential will maximise the use of construction materials that are fully re-usable at the end of life. The re-use of building components will be investigated with manufacturers and techniques such as lime mortars will be reviewed for potential use subject to structural and cost sign off.