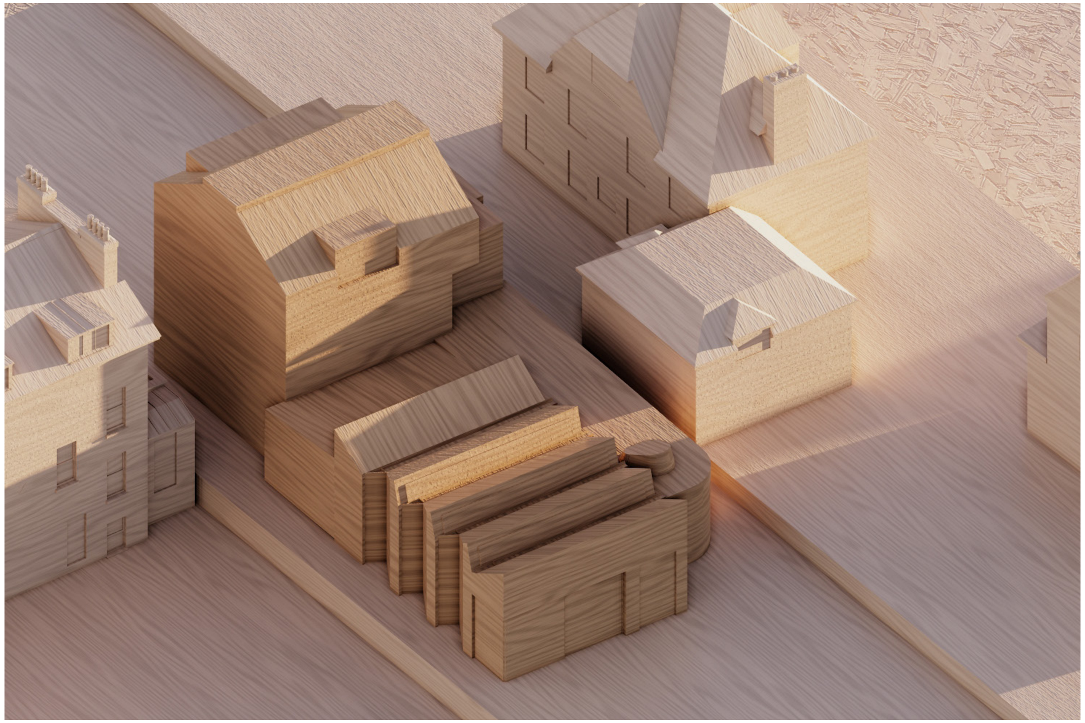
Life-cycle carbon analysis

12B Keats Grove
Hampstead NW3 2RN



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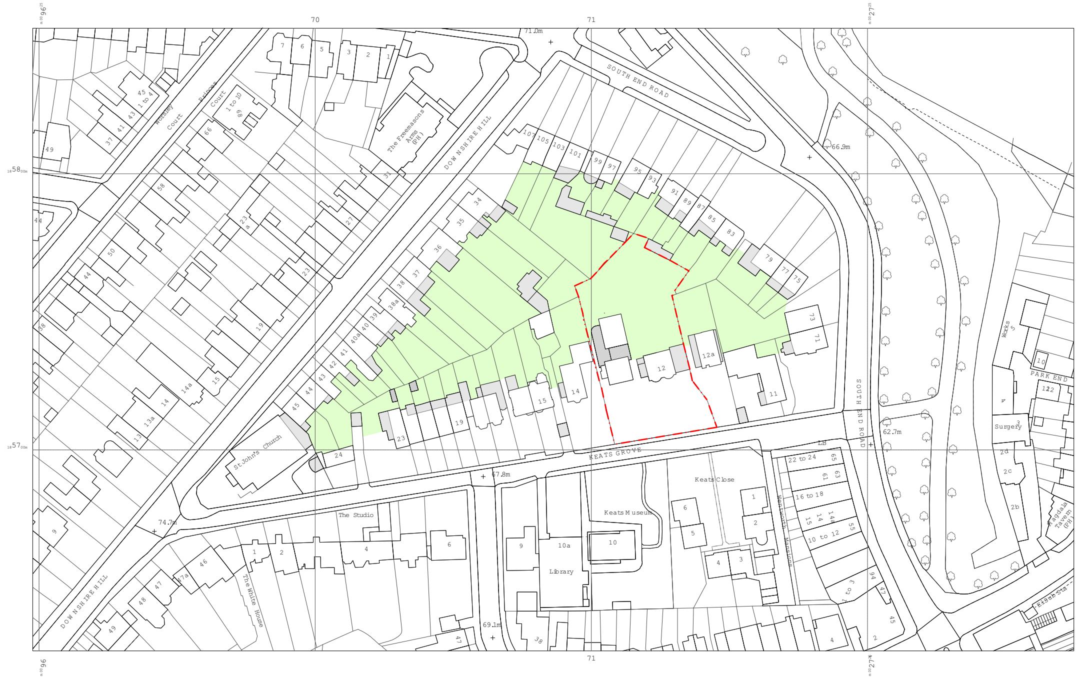
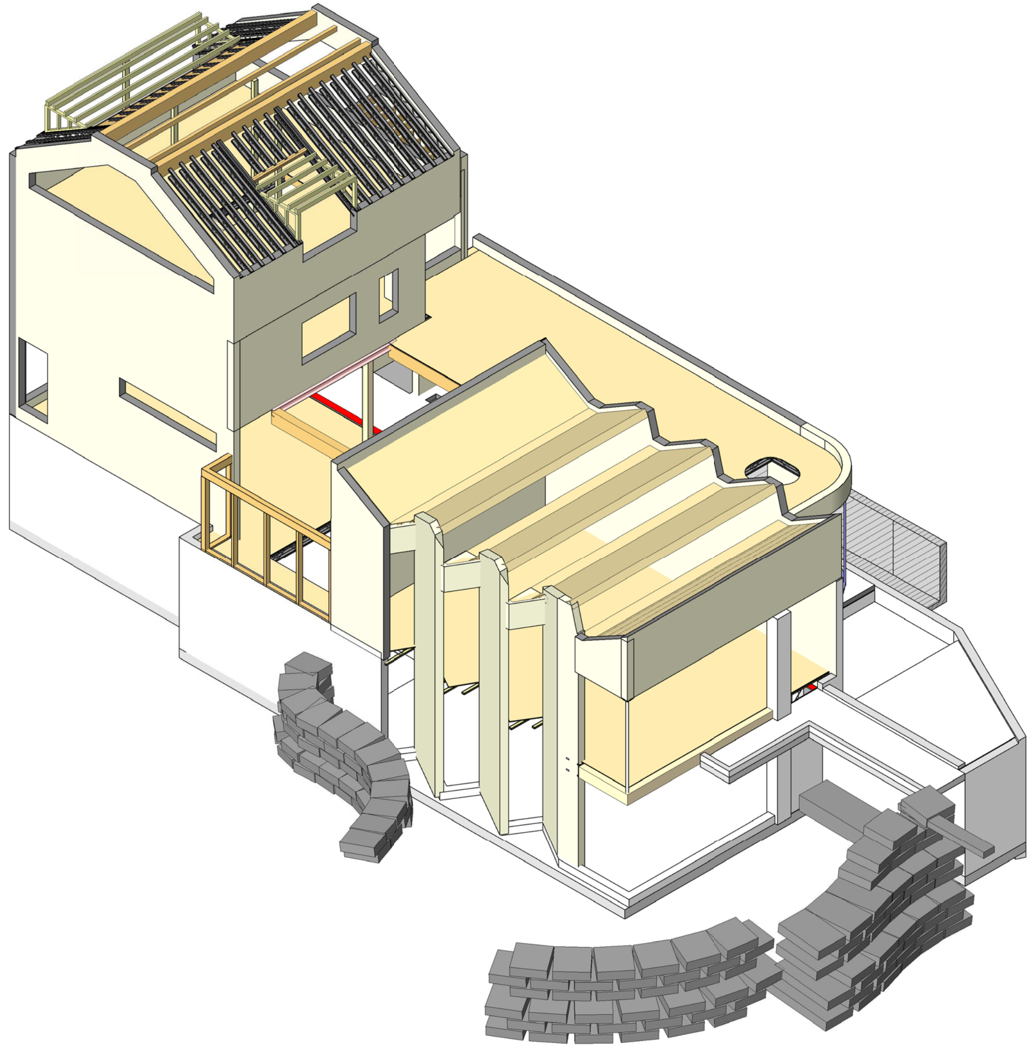
April 2022



Block plan, Keats Grove (51 architecture, 2022)

Heritage Statement

12B Keats Grove
Hampstead NW3 2RN



Proposed structural scheme (Price & Myers, 2022)

Introduction

1.1 About the LCA

Life-cycle carbon assessment (LCA) guages the environmental impacts of a project in terms of its embodied, operational and post-use impacts. This study is being carried out as part of a circular-economy approach to the project.

This study considers these impacts in terms of carbon dioxide equivalent (CO2e) emissions generated from the point of material extraction (the "cradle") to the point where the building is completed and occupied (the "gate"); and from the gate to the point at which the building is dismantled and its materials reused. This is a circular economy or "cradle-to-cradle" scope, covering LCA modules A1-D as defined by RICS.

The mass of the CO2e emissions generated is divided by the internal area of the building (as defined by RICS) to provide a rate of Global Warming Potential (GWP) per square metre, measured in kg CO2e/m^2.

Embodied impacts are the environmental impacts of the extraction of raw materials, their transport, transformation and manufacture into products, their transport to the site and the energy used to apply them in construction. Embodied impacts are distributed along the service life of the building or system, therefore the GWP of a product which generates little CO2e in production but lasts only a short time may have an equivalent GWP to one which generates more CO2e in manufacture but lasts for many years. As a generational home in a time of climate crisis, this project is designed with longevity in mind, combining durable materials with simple details for ease of maintenance.

Maintenance and repair generate CO2e emissions which are projected in the LCA as **recurring impacts**, taking their frequency into account.

The CO2e emissions generated from running the building are its **operational impacts**. These are reduced through passive design measures, ensuring that the building uses a minimum amount of energy to heat and power. In this case, the operational impacts are being separately assessed by the services engineers whose reports can be found in the Sustainability and Energy Statement attached to this application. As such, operational impacts are considered 'out of scope' for this LCA, however the data will be combined

Building Target	Equivalent letter banding
LETI **Design** 2020 Target	C
LETI **Design** 2030 Target	A
RIBA **Built** 2030 Target	B

Carbon target letter band alignment, LETI, 2021

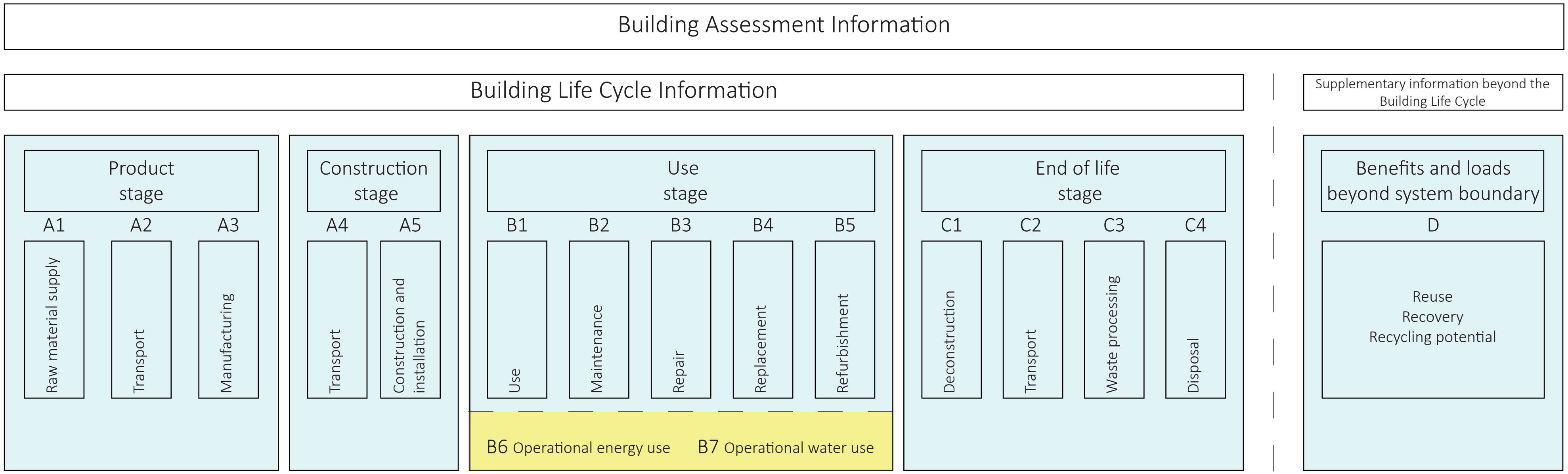
Introduction

1.1 About the LCA (cont.d)

The Whole Life Carbon Assessment will combine this LCA with the assessment of modules B6-7 as carried out by the services engineers.

Scope and responsibility for the assessment is as follows.

- Architectural impacts: 51 architecture
- Structural impacts: Price & Myers
- Operational water and energy: eb7 and Seneca



Life-cycle assessment modules

Introduction

1.2 Method statement

The LCA process for the project started with comparison of a baseline model using the project scope and scale against a benchmark residential project created by the makers of the LCA software, eTool. The baseline project is intended to show the kinds of impacts a project of this scale could have, with no modifications for low-carbon design, while the benchmark acts as a sense-checker, identifying any gaps in the scope of the assessment. The baseline model was found to have a GWP of 760.9 kg CO2e/m^2 compared with the benchmark project's 953.6 kg CO2e/m^2, a saving of 20% before specific materials had been factored in. This is due to the materially efficient structural scheme which maximises the potential of timber framing.

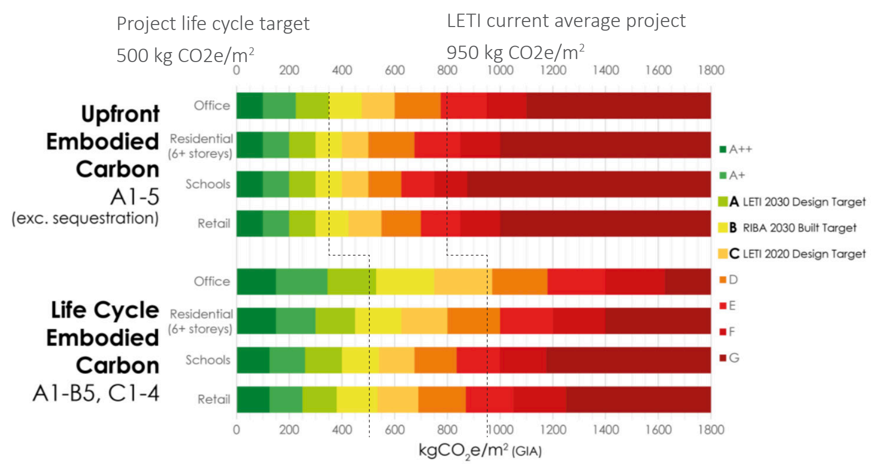
The baseline impacts were calculated by using the architectural CAD model of the design to create a materials take-off schedule which tracked the quantities of specific materials needed to construct the building. These quantities were entered into the LCA software, eToolLCD, and mapped to stand-in materials and components in the software library (for example, mineral wool insulation was used as a stand-in for wood fibre) with associated rates of GWP. This allowed the project team to quickly see what the embodied impacts of the building design might be, without the application of low-carbon materials and techniques. This information was used alongside data from LETI and the RIBA 2030 challenge to set a for the project's rate of GWP.

An aspirational carbon target of **500 kg CO2e/m^2** was set, with the aim of allocating about 50% of the impacts to the architecture and 50% to the structure. This target represents a 34% improvement on the baseline scheme and a 48% improvement from the benchmark project. It is also 20% less than the RIBA 2030 domestic/residential Climate Challenge which is set at 625 kg CO2e/m^2 or less GWP for projects completed in 2030 (see LETI Embodied Carbon Target Alignment chart, right).

The team then worked for several months to achieve reductions in the rate of GWP, using the London Plan Energy Hierarchy as a starting point. The improved model is currently being populated as build-up details become fixed. When complete, it will be internally checked and then submitted to the software providers for certification.

Price & Myers used IStructE's SCORS rating system for internal benchmarking of the structural impacts. The fixed structural strategy submitted for planning permission acheived a SCORS rating of C for upfront (Modules A1-A5) embodied impacts at a rate of 248.1 kg CO2e/m^2.

Once the architectural portion of the Improved scenario model has been certified, it will be combined with the consultant data, including the structural impact data, and sent to eTool for final certification. When this is complete, the final Whole Life Carbon report will be generated, covering modules A1-D.



Embodied Carbon Target Alignment, LETI, 2021

Introduction

1.3 Data quality note

The LCA is currently assessing the improved design. The minimisation of the amount of concrete needed was a priority for the design team from the early stages and as such, the structural data is currently slightly more detailed than the architectural data. The improved model is a live document and the extracts reproduced in this report are for illustrative purposes only.

Appended structural LCA data generated by Price & Myers shows impacts with and without taking the cement replacement into account - this is because it will not be known what the availability of GGBS is until the project is on site, therefore the actual rate of cement replacement could be anywhere between 25% and 70%.

Gaps and assumptions in the architectural impacts are being monitored internally using the LCA software. Data quality will be rigorously assessed by eTool prior to the final report being issued.

The target setting demonstrated in this report refers to LETI guidance including the Climate Emergency Design Guide, Embodied Carbon Primer and Carbon Target Alignment. The project team consider these resources to be the most relevant to the project as the data relates specifically to London and has been created with rapid transformation of energy usage norms in mind.

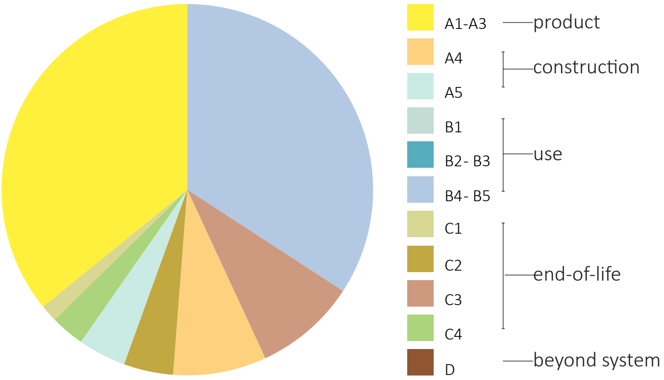
These publications refer to the archetypes of building making up the majority of new construction, namely small scale residential (terraced or semidetached houses); medium and large scale residential: (four floors and above); commercial offices and schools.

Detatched single dwellings form a small proportion of new development and therefore have not yet been reflected directly in the guidance, therefore when mentioning LETI targets, this document is referring to the **small scale residential** archetype as the closest relevant category. This target setting is made more rigorous since the project does not benefit from the economies of scale and form which can reduce life-cycle carbon in terraced and semi-detatched housing.

Analysis in progress

2.1 Benchmarking

Architectural and structural impacts are combined- both derive from the eTool OECD residential benchmark.



GWP_{ARCH} = XXX.X kg CO2e/m^2

GWP_{STRU}= XXX.X kg CO2e/m^2

Σ GWP = 953.6 kg CO2e/m^2

Project name: eTool OECD benchmark **Project sector:** Residential **Assessment date:** 01/03/2022 **Assessment by:** eTool **Location of data:** eTool library	**Upfront embodied carbon only** A1-A5 exc. sequestration ($kgCO_2e/m^2$)	**Total life cycle embodied carbon** A1-A5, B1-5, C1-4 ($kgCO_2e/m^2$)
A++	100	150
A+	225	345
A	350	530
B	475 B 472.5	750
C	600	970 C 953.6
D	775	1180
E	current average project (LETI)	1400
F	1100	1625
G		
Non-listed typology:		

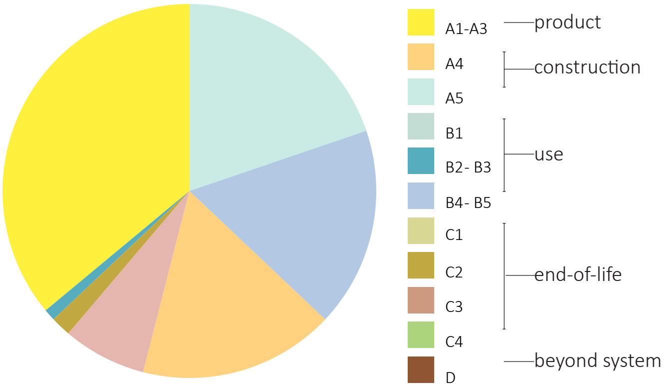
The **benchmark scenario** describes impacts of a generic domestic building as defined by eTool, their methodology is summarised at the following webpage: https://etoolglobal.com/eblog/engineering/etool-international-residential-benchmark-methodology-summary/ . It achieves a LETI letter rating of **C** for its life cycle embodied carbon.

N.B. The 2021 LETI carbon target alignment publication defines the LETI position on the letter ratings as follows: "*for buildings that are currently in the design stage, average design achieves an E, good design achieves a C (LETI 2020 target) and LETI 2030 design target achieves an A. The RIBA 2030 Climate Challenge built performance is equivalent of a B rating (note that this assumes practical completion in 2030, so designed earlier).*"

Analysis in progress

2.2 Baseline

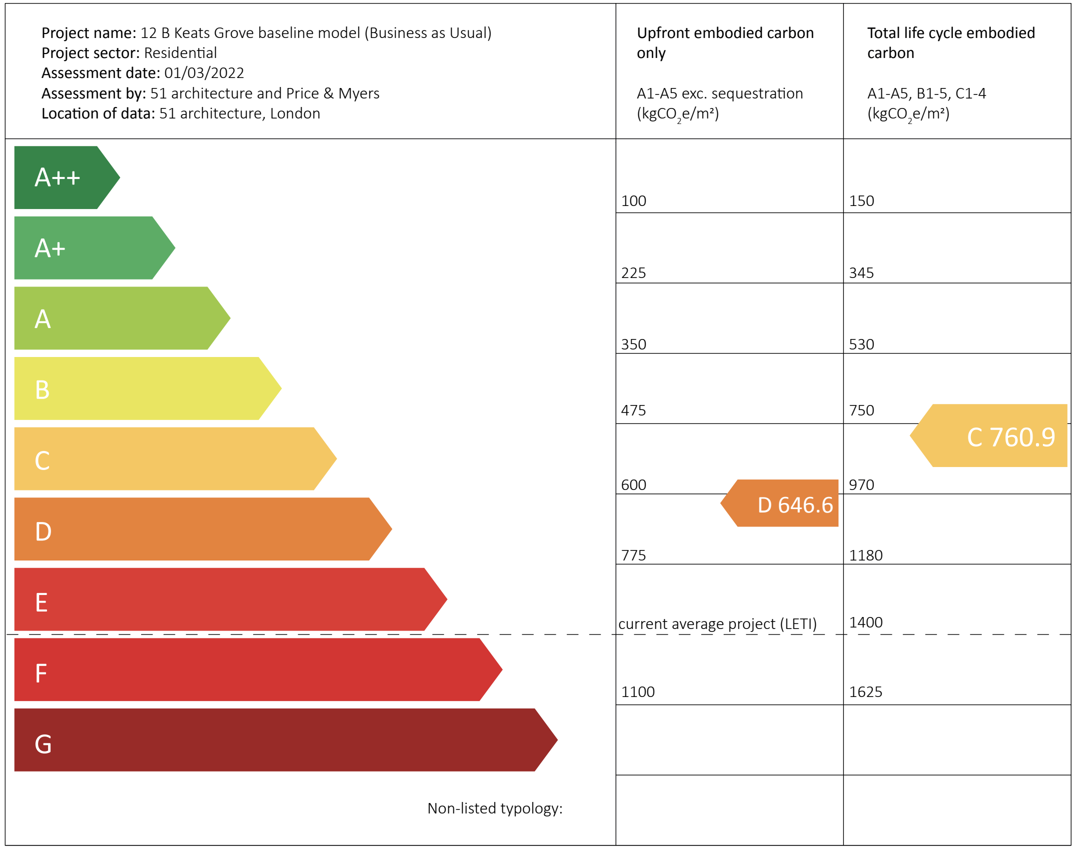
Architectural impacts assessed by 51 architecture using design material takeoffs and structural impacts assessed by structural engineers, Price & Myers.



GWP_{ARCH} = 446.3 kg $CO2e/m^2$

GWP_{STRU} = 314.6 kg $CO2e/m^2$

Σ GWP = 760.9 kg $CO2e/m^2$



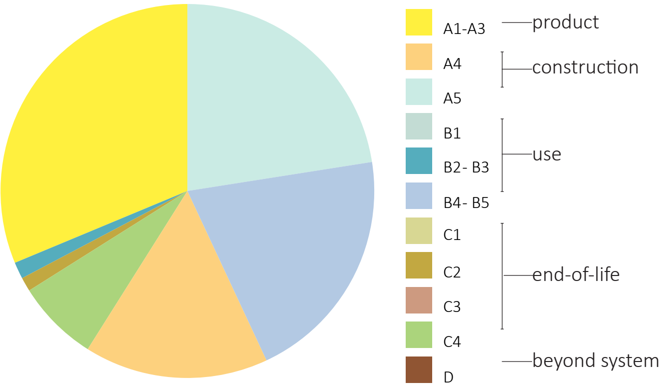
The **baseline scenario** reflects the specific characteristics and design of the project, but uses generic materials and build-ups in place of the low-impact ones specified. It is a single dwelling, in Hampstead, London with a gross internal area (GIA) as defined by RICS of 618.8 m². The structure is mainly of cross-laminated timber (CLT), with concrete retaining structure in the lower ground floor.

The building has an heat loss form factor (HLFF) of no more than 2.66 and the major portion of its embodied impacts derive from the product stage, with about 59% of the total embodied impacts resulting from the architecture and 41% from the structure. It acheives a LETI letter rating of **C** at 760.9 kg $CO2e/m^2$, the reliability of this rating is supported by the benchmark which was rated in the same band. LETI describe C rating as "good design".

Analysis in progress

2. 3 Improved model

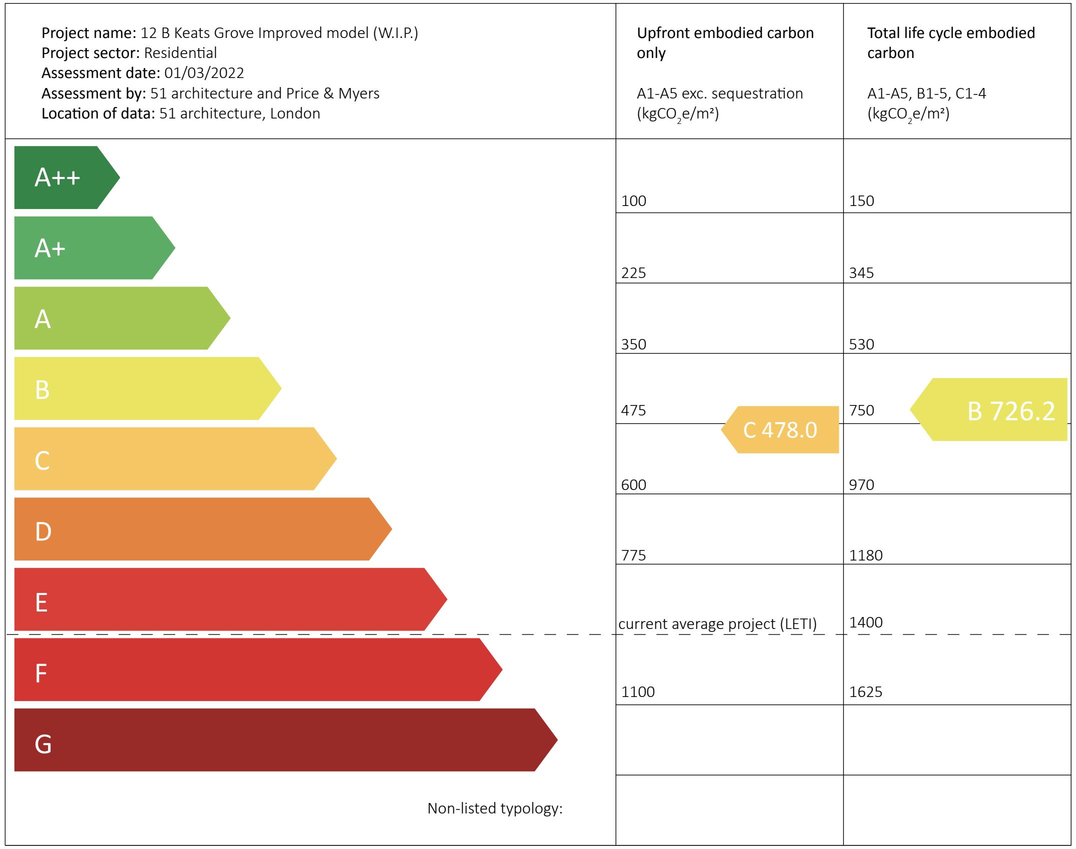
In progress. Architectural impacts assessed by 51 architecture using design material takeoffs and structural impacts assessed by structural engineers, Price & Myers.



$GWP_{ARCH} = 478.1 kg\ CO2e/m^2$

$GWP_{STRU} = 248.1\ kg\ CO2e/m^2$

$\Sigma\ GWP = 726.2\ kg\ CO2e/m^2$



The **improved scenario** reflects the specific characteristics and design of the project while beginning to integrate the specific materials which will be used to construct it. It also reflects a revised design including further material efficiencies, particularly in the structure. The materials specified have been chosen for their low embodied impacts, durability, reuse potential and the availability of environmental product declarations (EPDs). The GIA is 618.8 m² and the structure is mainly of timber casettes formed from 200 mm studwork sheathed in plywood, with concrete retaining structure in the lower ground floor, certified up to 70% cement replacement.

The building has an HLFF of no more than 2.66 and the major portion of its embodied impacts derive from the product stage, with about 66% of the total embodied impacts resulting from the architecture and 34% from the structure. It acheives a LETI letter rating of **B** at 726.2 kg $CO2e/m^2$, which betters LETI's definінition of "good design".

Analysis in progress

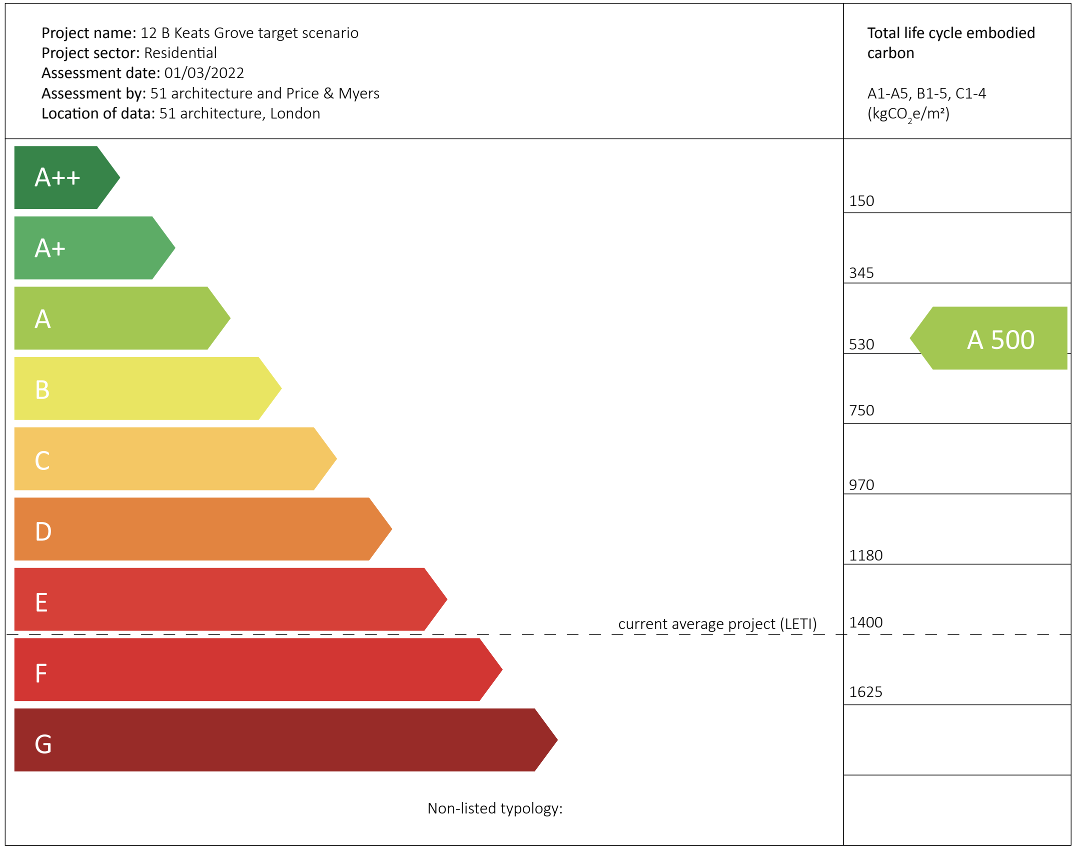
2.4 Target

Aspirational carbon target. This will be acheived by modelling the low-impact natural materials specified using their Environmental Product Declarations, rather than relying on substitutes in the model.

GWP_{ARCH} = 251.9kg $CO2e/m^2$

GWP_{STRU}= 248.1 kg $CO2e/m^2$

Σ GWP = 500.0 kg $CO2e/m^2$



The **target scenario** reflects the latest LETI guidance on target setting: " Current best-practice performance is considered to be a C rating, while a B and above is considered a robust stretch target", while A and above represent LETI 2030 design. The target scenario is rated **A**.

While the amount of embodied carbon resulting from the structure remains the same as in the baseline model (due to the structural design being fixed earlier than the architectural design) the architectural portion has reduced 47% from 478.1 kg $CO2e/m^2$ to 251.9 kg $CO2e/m^2$, making the two portions roughly equal in impact.

This goal is deemed feasible as specific EPDs are fed into the LCA model and the low-impact materials specified replace generic stand-ins. For example, the wood fibre insulation product specified has a GWP roughly ⅙ that of the mineral wool stand-in used in the baseline scenario.

Data

3.1 Baseline architectural impacts

These are the impacts of the architectural elements of the baseline design, which combine with the baseline structural impacts to obtain the total baseline impacts.

Module	A1-A3	A4	A5	B1	B2-B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	D5	
Description	**Product stage**	**Transport**	**Construction**	**General use**	**Maintenance**	**Replacement**	**Deconstruction**	**Waste transit**	**Waste processing**	**Disposal**	**Operational energy exports**	**Closed loop recycling**	**Open loop recycling**	**Materials energy recovery**	**Direct reuse**	**Total**
GWP (kg CO2e)	99,535.390	47,934.010	59,204.250	0.000	2,587.030	47,197.190	0.000	5,052.580	0.000	19,852.740	0.000	-1,394.120	0.000	-2,083.020	0.000	277,886.040
GWP/GIA (kg CO2e/m2)	162.110	78.068	96.424	0.000	4.213	76.868	0.000	8.229	0.000	32.333	0.000	-2.271	0.000	-3.393	0.000	452.583

Architectural component	GWP (kg CO2e)	GWP/GIA (kg CO2e/m2)
Demolition	5,821.760	9.482
Excavation	56,938.740	92.734
Concrete slab	34,088.160	55.518
Concrete retaining wall	6,415.810	10.449
Internal buttress wall	2,678.320	4.362
Upper floors	24,816.970	40.419
External timber stud wall	22,081.540	35.963
External wall brick outer-leaf	30,301.090	49.350
Internal timber stud wall	9,350.260	15.228
Windows	37,169.590	60.537
Green roof	15,630.990	25.458
Sawtooth roof	12,425.110	20.236
Tiled roof	10,780.770	17.558
Total	277,886.040	452.583

Data

3.2 Structural engineers' reporting

Estimated Total Embodied Carbon			**188,975**	**$kgCO_2e$**
Carbon Sequestration - not included in total above*			***-80,082***	$kgCO_2e$
Estimated Embodied Carbon by GIA			**308**	**$kgCO_2e/m^2$**
Carbon Sequestration by GIA - not included in total above*			***-130***	$kgCO_2e/m^2$
The value lies in an estimated range between	**212**	and	**398**	$kgCO_2e/m^2$

NOTES:
ECF = Embodied Carbon Factor
Carbon = Carbon dioxide equivalent emissions for that module in $kgCO_2e$
Seq = Sequestered Carbon in $kgCO_2e$

Module				A: Product								B: Use		C: End of Life				D: Beyond	
				A1-A3 Product Manufacture				A4 Transport		A5w Site Wastage		B1 Use		C2 Transport of Waste		C3 & C4 Waste Disposal		D Outside the System Boundary	
Material	**Element Description**	**Quantity**	**Units**	ECF A1-A3	Carbon A1 -A3	Seq ECF A1-A3	Seq A1-A3	ECF A4	Carbon A4	ECF A5w	Carbon A5w	ECF B1	Carbon B1	ECF C2	Carbon C2	ECF C3-C4	Carbon C3-C4	ECF D	Carbon D
Timber (Softwood, C16)	Upper Floors & Balconies	4281.3404	kg	0.263	1,126	-1.55	-6,636	0.03195	137	0.05925	254								
Steel (Hot-Rolled)	Upper Floors & Balconies	2619.9645	kg	1.55	4,061			0.03195	84	0.01616	42								
Concrete (C30/37, Av. Mix)	Vertical Structure	193092.84	kg	0.12127	23,417			0.00533	1,028	0.00731	1,411								
Timber (Softwood, C16)	Vertical Structure	38973.849	kg	0.263	10,250	-1.55	-60,409	0.03195	1,245	0.05925	2,309								
Timber (Glulam, GL28c)	Upper Floors & Balconies	206.56555	kg	0.512	106	-1.64	-339	0.16056	33	0.00829	2								
Concrete (C30/37, Av. Mix)	Upper Floors & Balconies	44051.655	kg	0.12127	5,342			0.00533	235	0.00731	322								
Timber (OSB Smartply, Propr)	Upper Floors & Balconies	4199.486	kg	0.355	1,491	-1.379	-5,791	0.03195	134	0.08848	372								
Timber (Softwood, C16)	Secondary Elements	334.64957	kg	0.263	88	-1.55	-519	0.03195	11	0.05925	20								
Concrete (C30/37, Av. Mix)	Ground Floor Slab	257684.82	kg	0.12127	31,250			0.00533	1,372	0.00731	1,883								
Timber (Ply, Birch)	Vertical Structure	630.14097	kg	0.681	429	-1.61	-1,015	0.1827	115	0.11578	73								
Steel (Hot-Rolled)	Vertical Structure	30.278907	kg	1.55	47			0.03195	1	0.01616	0								
Timber (Glulam, GL28c)	Vertical Structure	367.17124	kg	0.512	188	-1.64	-602	0.16056	59	0.00829	3								
Steel (Reinforcement)	Upper Floors & Balconies	89.731415	kg	1.99	179			0.03195	3	0.10738	10								
Steel (Reinforcement)	Vertical Structure	8437.247	kg	1.99	16,790			0.03195	270	0.10738	906								
Steel (Reinforcement)	Secondary Elements		kg	1.99				0.03195		0.10738									
Steel (Reinforcement)	Ground Floor Slab	11733.947	kg	1.99	23,351			0.03195	375	0.10738	1,260								
Steel (Cold-Rolled Galvanised)	Upper Floors & Balconies	631.5	kg	2.76	1,743			0.03195	20	0.31225	197								
Timber (Softwood, C16)	Upper Floors & Balconies	2504.8124	kg	0.263	659	-1.55	-3,882	0.03195	80	0.05925	148								
Steel (Cold-Rolled Galvanised)	Upper Floors & Balconies	1,531	kg	2.76	4,225			0.03195	49	0.31225	478								
Timber (Softwood, C16)	Upper Floors & Balconies	78	kg	0.263	21	-1.55	-121	0.03195	2	0.05925	5								
Timber (OSB Smartply, Propr)	Upper Floors & Balconies	557	kg	0.355	198	-1.379	-768	0.03195	18	0.08848	49								
					124,960		**-80,082**		**5,270**		**9,745**								
								Carbon A5a (Construction:)			**49,000**								

Data

3.2 Structural engineers' reporting (cont.d)

Adjusted to take 75% cement replacement into account- this is the maximum amount certified.

Estimated Total Embodied Carbon			**152,316**	**$kgCO_2e$**
Carbon Sequestration - not included in total above*			***-80,082***	$kgCO_2e$
Estimated Embodied Carbon by GIA			**248**	**$kgCO_2e/m^2$**
Carbon Sequestration by GIA - not included in total above*			***-130***	$kgCO_2e/m^2$
The value lies in an estimated range between	**190**	and	**289**	$kgCO_2e/m^2$

NOTES:
ECF = Embodied Carbon Factor
Carbon = Carbon dioxide equivalent emissions for that module in $kgCO_2e$
Seq = Sequestered Carbon in $kgCO_2e$

				Module															
				A: Product								**B: Use**		**C: End of Life**				**D: Beyond**	
				A1-A3 Product Manufacture				A4 Transport		A5w Site Wastage		B1 Use		C2 Transport of Waste		C3 & C4 Waste Disposal		D Outside the System Boundary	
Material	**Element Description**	**Quantity**	**Units**	ECF A1-A3	Carbon A1 -A3	Seq ECF A1-A3	Seq A1-A3	ECF A4	Carbon A4	ECF A5w	Carbon A5w	ECF B1	Carbon B1	ECF C2	Carbon C2	ECF C3-C4	Carbon C3-C4	ECF D	Carbon D
Timber (Softwood, C16)	Upper Floors & Balconies	4281.3404	kg	0.263	1,126	-1.55	-6,636	0.03195	137	0.05925	254								
Steel (Hot-Rolled)	Upper Floors & Balconies	2619.9645	kg	1.55	4,061			0.03195	84	0.01616	42								
Concrete As-Built 1 (C30/37,CIIIB)	Vertical Structure	193092.84	kg	0.05071	9,792			0.00533	1,029	0.00378	730								
Timber (Softwood, C16)	Vertical Structure	38973.849	kg	0.263	10,250	-1.55	-60,409	0.03195	1,245	0.05925	2,309								
Timber (Glulam, GL28c)	Upper Floors & Balconies	206.56555	kg	0.512	106	-1.64	-339	0.16056	33	0.00829	2								
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Timber (Softwood, C16)	Secondary Elements	334.64957	kg	0.263	88	-1.55	-519	0.03195	11	0.05925	20								
Concrete As-Built 1 (C30/37,CIIIB)	Ground Floor Slab	257684.82	kg	0.05071	13,068			0.00533	1,373	0.00378	974								
Timber (Ply, Birch)	Vertical Structure	630.14097	kg	0.681	429	-1.61	-1,015	0.1827	115	0.11578	73								
Steel (Hot-Rolled)	Vertical Structure	30.278907	kg	1.55	47			0.03195	1	0.01616	0								
Timber (Glulam, GL28c)	Vertical Structure	367.17124	kg	0.512	188	-1.64	-602	0.16056	59	0.00829	3								
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Steel (Reinforcement)	Secondary Elements		kg	1.99				0.03195		0.10738									
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Steel (Cold-Rolled Galvanised)	Upper Floors & Balconies	631.5	kg	2.76	1,743			0.03195	20	0.31225	197								
Timber (Softwood, C16)	Upper Floors & Balconies	2504.8124	kg	0.263	659	-1.55	-3,882	0.03195	80	0.05925	148								
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Timber (Softwood, C16)	Upper Floors & Balconies	78	kg	0.263	21	-1.55	-121	0.03195	2	0.05925	5								
Timber (OSB Smartply, Propr)	Upper Floors & Balconies	557	kg	0.355	198	-1.379	-768	0.03195	18	0.08848	49								
				90,044		**-80,082**		**5,273**		**7,999**									
								Carbon A5a (Construction:)			**49,000**								

Data

3.3 Service engineers' reporting

Please refer to the Service engineers' Sustainability & Energy statement for details of operational energy demand and on-site generation of energy from renewables.