Patch Elm Lane, Embodied Carbon

Veya Homes

Embodied Carbon Assessment

AES Sustainability Consultants Ltd

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Rev.0	Cece Koczias	30.06.2023	Draft issue for comment
Rev1	Cece Koczias	18.07.2023	Final report issued
Rev 2			
Rev 3			

The predictions of embodied and operational impacts (including costs) conducted in OneClick LCA software at concept design, by their very nature, cannot be exact. AES have used OneClick LCA software which has been built and tested to enable informed decisions when comparing design options. Generic cost and environmental impact coefficients may not necessarily correspond to those of individual brands of the same product or service due to differences within industries in the way these products and services are delivered. Therefore, AES cannot make assurances regarding the accuracy of these reports for the above reasons.

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1. Executive Summary

1.1. AES Sustainability Consultants Ltd. have been appointed to undertake an Embodied Carbon Assessment for Veya Homes, Patch Elm Lane, Rangeworthy. The study refers to two detached (Plot 1 and 4) and two semi-detached (Plot 2 and 3) domestic homes of 124m^2 excluding the surrounding areas i.e., garden and parking. The project's design includes a timber façade with profiled steel sheet roof cladding and engineered hardwood flooring.

1.2. The purpose of the analysis is to model the environmental impact of various material options for the building and identify the carbon emission hotspots in the entire construction. Another objective of the report is to unveil opportunities for the reduction of environmental impacts.

1.3. This report has been written to summarise the process and results of the analysis of two detached and two semi-detached houses and analyse the chosen materials for the type of construction.

1.4. A comparative case study has also been conducted to see what the main differences are between Veya Homes' Plot 1-4 when compared to a traditional build. The traditional build study refers to a domestic building of **124m^2**. The design includes bay windows and a roofed porch with brick and block masonry walls. Veya Homes' Patch Elm Lane Plots 1-4 are a timber frame, timber façade domestic building of 124m^2 with profiled steel sheet roofing.

1.5. There is a significant increase in the availability of accurate data on the carbon cost of materials and systems. Typically, Environmental Product Declarations (EPDs) are used. These are now widely available for different products by the manufacturer and cover a wide range of data including embodied carbon.

1.6. By using IESVE and OneClick LCA software, the Embodied Carbon Assessment has found that based on the provided specification, residual embodied carbon of the proposed materials for the detached and semi-detached house types. The total for Plot 1 is 40,015 kgCO_2, Plots 2 and 3 as a combined figure is 64,957 kgCO_2, and Plot 4 is 37,613 kgCO_2. It was found that the highest embodied carbon by classifications were the finishes to floors, steel within the structural frame and external wall constructions.

1.7. Methodology: Modelling was completed using One Click LCA. Assessment method follows BS 15978:2011 Sustainability of Construction Works – Assessment Environmental Performance of Buildings.

1.8. Figure 1 shows the summary of results of all the dwelling types. The results show the embodied carbon for each of the plots (plot 2 and 3 are combined) for life cycle stages A1-A3, A4 and A5.

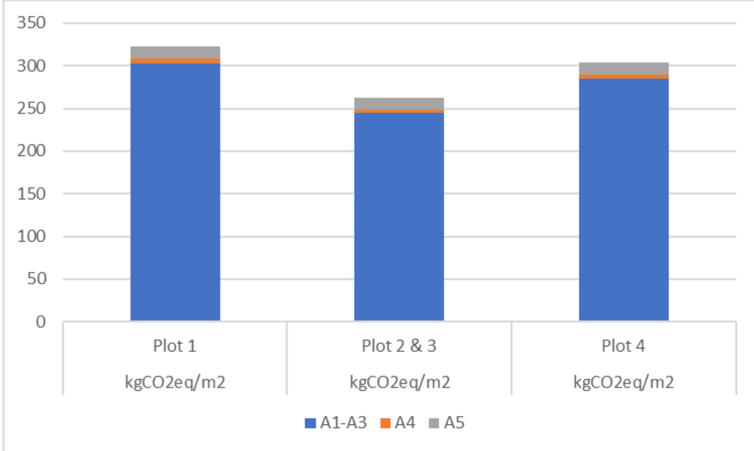

Figure 1. Embodied Carbon (kgCO2/m2)

1.9. The following figure shows that results of the comparison exercise, showing the Veya home to have a lower embodied carbon than a traditional build.

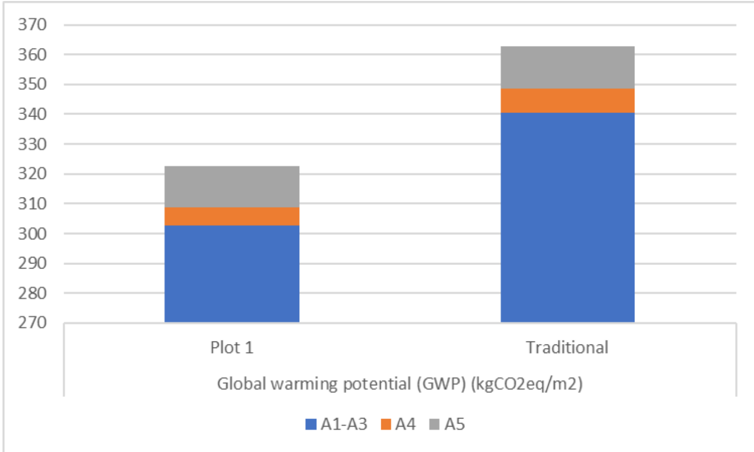

Figure 2. Comparison between Veya Homes Plot 1 and Traditional house

2. Introduction

2.1. AES Sustainability Consultants Ltd. Has been appointed to undertake an Embodied Carbon Assessment for Veya Homes, Patch Elm Lane, Rangeworthy. The study refers to two detached and two semi-detached domestic homes of 124m^2 excluding the surrounding areas i.e., garden and parking. The project's design includes a timber façade with profiled steel sheet roof cladding and engineered hardwood flooring.

2.2. All four plots were modelled considering their A1-A5 emissions (cradle to practical completion stages).

2.3. The purpose of the analysis is to model and understand the environmental impacts of various material options that arise from the material extraction and production, construction, and operation of the four plots, and to understand and analyse the total embodied carbon emissions of each house type. Additionally, the analysis will compare the results of Plot 1 with a typical traditional house build to better understand the key differences. This analysis will allow the design team to understand how the design decisions made influence the buildings' embodied carbon emissions in comparison with a typical traditional house build type. This study has not accounted for the building services, or the external hard landscaping materials used in the construction for either house types.

2.4. The analysis is based on the review of a default model, applied to more than one construction.

2.5. The life cycle greenhouse gas emissions (kgCO_2eq.) are reported for each element based on a 60-year building life.

2.6. Methodology: Modelling was completed using in One Click LCA. Assessment method follows BS 15978:2011 Sustainability of Construction Works – Assessment Environmental Performance of Buildings.

Development Description

2.7. The proposals consist of two detached and two semi-detached domestic dwellings. The ground and first floor elevations are built with external and internal timber stud walls, with floor joists and roof trusses forming the superstructure completing the structural frame transferring vertical and horizontal loads to the foundation. Additionally, all plots include double glazed timber framed windows, oak veneer internal and timber external doors. Plots 2 and 3 also have two roof lights each.

Figure 3. Patch Elm Lane, Rangeworthy (courtesy of Veya Homes)

3. Embodied Carbon Assessment

3.1. The embodied carbon assessment of a building is a methodology that is used to quantify the total carbon emissions associated with the construction materials used, in this case a domestic house. Considering the carbon emissions released during extraction, manufacturing, transportation and installation of building materials, this assessment provides valuable insights into the environmental impact of a house's construction process. The assessment involves a life cycle assessment associated with each stage of a building's life.

3.2. Increasingly it is being demonstrated that as operational energy demand of buildings is being reduced through the energy efficiency provisions of the Building Regulations, in-use energy demand is accounting for a decreasing proportion to the overall Whole Life Cycle (WLC) energy and CO_2 emissions[1]. As such, the necessity for consideration of the embodied carbon of construction is becoming more apparent to continue to reduce the climate impacts of the built environment.

3.3. The calculation and reduction of whole-life CO_2e emissions has the potential to;

- Ensure that a significant source of emissions from the built environment are accounted for which is necessary in achieving a net zero-carbon development.
- Achieve resource efficiency and cost savings by encouraging the re-use of existing materials instead of new materials and the retrofit and retention of existing structures and fabric over new construction.
- Identify the carbon benefits of using recycled material and the benefits of designing for future reuse and recycling to reduce waste and support the circular economy.
- Encourage a 'fabric first' approach to building design thereby minimising mechanical plant and services in favour of natural ventilation.
- Identify the impact of maintenance, repair and replacement over a building's life cycle which improves life-time resource efficiency and reduces life-cycle costs, contributing to the future proofing of asset value.
- Encourage durable construction and flexible design, both of which contribute to greater longevity, reduced obsolescence of buildings and avoiding carbon emissions associated with demolition and new construction.

Modelling Methodology

3.4. The calculation methodology follows the RICS Professional Statement for undertaking detailed carbon assessments. The RICS Whole Life Carbon Assessment for the Build Environment (2017) follows the European standard EN 15978.

3.5. The calculations were performed using the OneClick LCA calculation tool, which can assess life cycle impacts. The assessment methods conform with BS 15978:2011 Sustainability of Construction Works – Assessment of Environmental Performance of Buildings and cover the full life cycle stages.

- A1-A3 Construction Materials
- A4 Transport
- A5 Construction Site Impacts

3.6. Building life cycle stages are the different periods of a building's lifetime, see Figure 4. For instance: raw material harvesting, manufacturing of products, use phase of the building, end of life. In the European markets, the building life cycle stages are defined by EN 15978 and EN 15804 standards, which can be included in LCAs.

[1] Sansom, M. and Pope, R., 2012. A comparative embodied carbon assessment of commercial buildings. The Structural Engineer,.

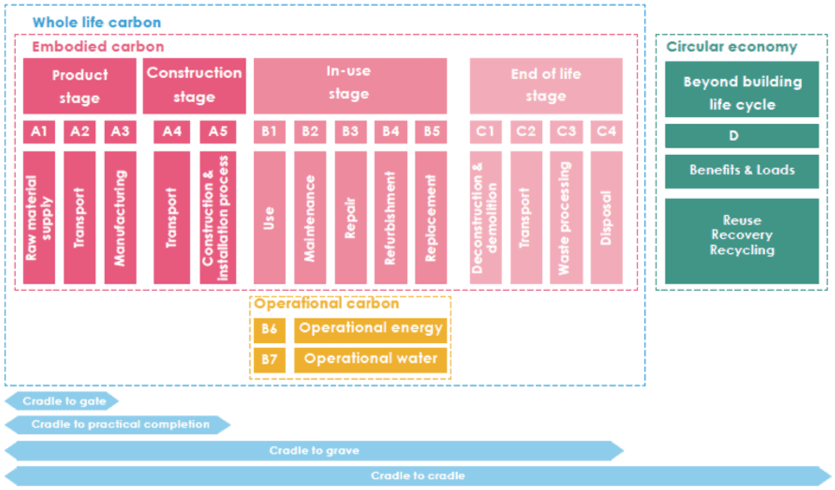

Figure 4. Life-cycle stages according to the EN standard

3.7. The following life-cycle modules are not assessed within OneClick LCA - B1, B2, B3 and B7, and the following are not in scope of this assessment – B1 to B5, C1 to C4, D.

3.8. The end-of-life impacts of each material have been included automatically by the database settings, mapping each individual material to the most likely end-of-life scenario: re-use, recycling, or disposal. Scenarios do not include end-of-life benefits and loads.

3.9. The material scope is according to the RICS Whole Life Carbon Assessment for the Built Environment.

3.10. OneClick LCA comprises a large database of generic and average materials for construction materials life cycle emissions and building use phase, water, and energy consumption, based on the UK market according to EN 15804 standard, including impact categories. The most suitable option for each material (where available) was chosen from the database in OneClick. The material LCA data has been chosen to be representative of the typical UK supply chain according to EN 15804 standard.

3.11. The buildings service life was estimated to be 60 years, this is fixed within OneClick LCAs tool settings.

3.12. It is recommended that material quantities from the following sources are to be used, in the following order of preference and subject to availability at the different project stages:

1. Materials delivery records,
2. BIM model,
3. Bill of quantities (BoQ) or cost plan,
4. Estimations from consultants' drawings.

3.13. Superstructure and substructure elements have been identified from design drawings and the effective communication with Veya Homes' professionals. Quantities for each applicable element have been entered within a +/- 10% precision.

3.14. The OneClick LCA tool is BRE certified and ensures each EPD included in their database is independently verified. The embodied carbon was calculated based on estimations and material specifications provided by the design team of Veya Homes. Where specific brands were identified, but their exact EPDs were not available in the software, the closest match has been chosen.

3.15. The metric used for quantifying the embodied carbon is kilogrammes of CO2 equivalent (kg CO2eq). This has been normalised in kg CO2 per m2 floor area.

Analysis Material Scope

3.16. The RICS Professional Statement outlines the building elements that should be included in a whole life carbon assessment. The building elements considered for the assessment are included in Table 1. Only the external areas and building services have been excluded from the assessment.

Table 1. Material scope

Category		Subcategory		Subcategory	Included
Substructure	1	Substructure	1	Standard foundations	Yes
			3	Lowest floor construction	Yes
Superstructure	2	Upper Floors	5	Timber frames	Yes
			1	Floors	Yes
	3	Roofs	1	Roof structure	Yes
			2	Roof covering	Yes
			4	Rooflights, skylights and openings	Yes
	4	Stairs and ramps	1	Stair / Ramp structures (Units 2 and 3 only)	Yes
	5	External walls	1	External enclosing walls above ground floor level	Yes
	6	Windows, ext. doors	1	External Windows	Yes
			2	External doors	Yes
	7	Internal Walls – Education buildings only	1	Walls and partitions	Yes

Performance Against the Benchmark

3.17. There are two aspects to benchmarking, comparing a project against itself over time 'dynamic', and comparing a project against other similar projects 'static'. 'Dynamic benchmarking' is where a whole life carbon assessment for the project is carried out at an early design stage thus providing a baseline to compare the results of later assessment iterations, to monitor the carbon progress project. 'Static benchmarking' is the collection and analysis of whole life carbon results from the 'as built' stage.

3.18. Carbon target setting happens once a credible benchmarking is in place, and thus the relevant targets can be set for the performance of built assets. Clear and quantifiable targets will thus allow the pursuit of emission reductions.

3.19. For the analysis of Veya Homes, it is proposed that the IMPACT compliant tool OneClick LCA is utilised to calculate the embodied carbon emissions and conduct the life cycle assessments.

3.20. IMPACT is a specification and database for software developers to incorporate into their tools to enable consistent LCA. It allows for the creation of benchmarks that are standardised.

Project Data Sources and Assumptions

Material Quantities (A1-A3)

3.21. Material information, including materials have been produced by Veya Homes.

3.22. Fabric elements have been entered as per the information provided by Veya Homes.

3.23. Data for all materials in the analysis has been collated from the OneClick database, including manufacturer specific data (where available), as well as generic data which represents the industry average for the selected material.

Building Material Transport Distances (A4)

3.24. Transport distances were estimated based on default transport distances based on material type provided by the calculation tool.

3.25. The OneClick LCA default values for distances travelled to site for the construction materials were used for each material item. More specific values will be used when the assessment is re-run once the design of the development has progressed further.

Construction site impacts (A5)

3.26. For the assessment of A5 Site operations emissions, the One Click Software default values have been used.

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4. Materials Descriptions

Facades/Enclosures

4.1. Façade and Frame: All four plots are timber façade and frame built. The timber studs to the external wall structure carry the loads imposed, before transmitting to the foundations. The construction consists of supporting steel posts, OSB panels, Therma Fleece Ultrawool insulation, as well as timber battens.

4.2. Windows and Doors: All four plots have been installed with the same internal and external doors and windows. The external doors are made of timber, including the double-glazed windows. The internal doors are oak veneer type. Plot 2 and 3, the semi-detached developments have four roof lights on the shared roof, two for each plot.

4.3. Roof: All four plots are constructed with timber roof trusses and joists, covered with VM Zinc Plus and Zinc Sheets. The supporting structure is a plywood deck covered by a bituminous vapour barrier. The thermal insulation layer is located immediately above the ceiling joists.

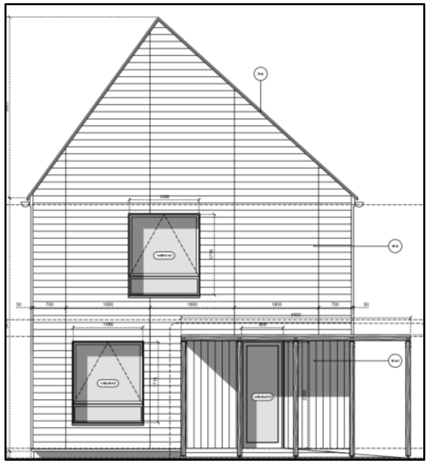

Figure 5. South Elevation of Plot 1 and 4 (courtesy of Mitchell Eley Gould)

Figure 6. South Elevation of Plot 2 and 3 (courtesy of Mitchell Eley Gould)

5. Results

5.1. The life cycle assessment for the embodied carbon case study was calculated using OneClick LCA software.

5.2. Table 3 presents the assessments results according to the different house types and the proposed design for Global Warming Potential (GWP), kgCO2eq according to OneClick LCA and the proposed design based on information provided by Veya Homes.

Table 2. A1-A3 Construction Materials

Construction Materials:		Global warming potential (GWP) ($kgCO_2eq$)		
		Plot 1	Plot 2 & 3	Plot 4
A1-A3	Substructure	10240	10164	8004
	Frame	12910	21352	12910
	Upper Floors	381	762	381
	Roof	3412	7311	3412
	Stairs and Ramp	300	600	300
	External Walls	5452	10903	5452
	Windows and External Doors	1461	2922	1461
	Internal Walls and Partitions	927	1853	927
	Internal Doors	146	292	146
	Finishes	2288	4575	2288
Total		37516	60735	35280

Table 3. A4 Building Material Transportation to Site

Building Material Transportation to Site		Global warming potential (GWP) ($kgCO_2eq$)		
		Plot 1	Plot 2 & 3	Plot 4
A4	Substructure	685.56	594	517.08
	Frame	8.12	12	8.12
	Upper Floors	1.36	2.73	1.36
	Roof	6	12	6
	Stairs and Ramp	0.08	0.17	0.08
	External Walls	41.21	82.42	41.21
	Windows and External Doors	0.69	1.39	0.69
	Internal Walls and Partitions	26.04	52.08	26.04
	Internal Doors	0.11	1.46	0.11
	Finishes	8.29	16.50	8.29
Total		777	775	609

Table 4. A5 Building Site Operations

Building site Operations		Global warming potential (GWP) ($kgCO_2eq$)		
		Plot 1	Plot 2 & 3	Plot 4
A5	Other or overall site construction	1725	3450	1725
Total		1725	3450	1725

Table 5. A1-A3, A4, A5 Total Emissions

Total Emissions	Global warming potential (GWP) ($kgCO_2eq$)		
	Plot 1	Plot 2 & 3	Plot 4
A1-A3	37516	60735	35280
A4	777	775	609
A5	1725	3450	1725
Total	40018	64959	37614

5.3. The results show that based on the life cycle stages, stage A1-A3 Materials - raw material supply, transportation and the manufacturing of materials constitutes the highest GWP contribution with a total of 37,516 $kgCO_2e$ for Plot 1, 60,735 $kgCO_2e$ for Plots 2 & 3, and 35,280 $kgCO_2e$ for Plot 4. This is followed by stage A5 building site operational emissions totalling 1,725 $kgCO_2e$ for Plots 1 & 4, and 3,450 $kgCO_2e$ for Plots 2 & 3. Finally, A4 building material transportation to site emissions with 776 $kgCO_2e$ for Plot 1, 773 $kgCO_2e$ for Plot 2 & 3, and 608 $kgCO_2e$ for Plot 4.

5.4. The following graphs show the breakdown of emissions across the life cycle stages and classifications for Plot 1.

5.5. The graph in Figure 7 shows the information regarding embodied carbon (i.e., operational carbon is not included) by life cycle stages. Considering the scope of the report, B4-B5, C2 and C3 have been excluded from the figures.

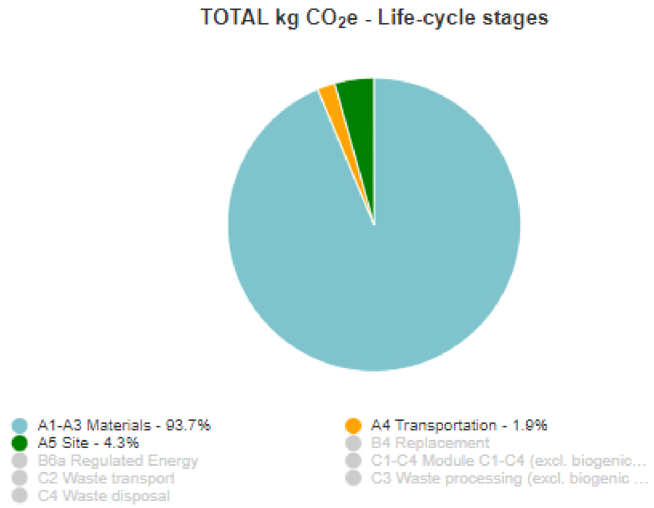

Figure 7. Total kg CO2e – Life Cycle Stages – Plot 1

5.6. Results show that the product stage (A1-A3) shows the largest contribution with greater than 90%.

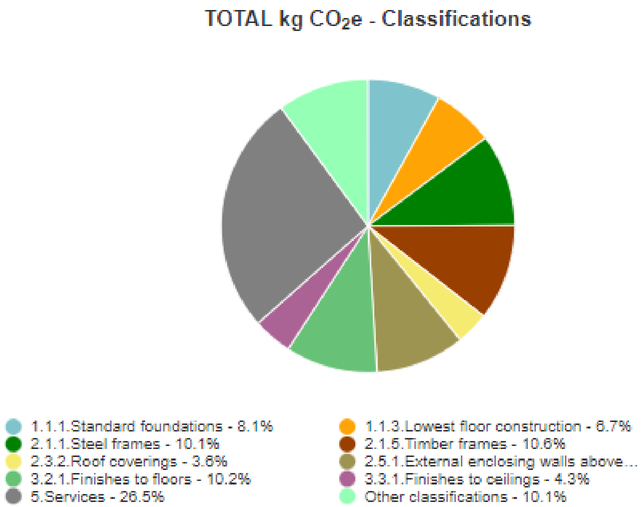

Figure 8. Total kg CO2e by Classifications – Plot 1

5.7. Exhibiting the findings from the total kgCO_2e by Classifications, figures show the largest contributing materials are the timber structural elements, floor finishes, and the regulated operational energy use associated with annual electricity use of Plot 1 which is 2789.87 kwh/annum. The related emissions of the annual electricity consumption of Plot 1 are calculated based on the Government's Standard Assessment Procedure (SAP) for Energy rating of Dwellings Version 10.0. The Global Warming Potential category values match SAP 10.0.

5.8. Other classifications include items such as the construction site impacts calculated based on a OneClick average value as explained in 7.7.

5.9. The preliminary design of the building has presented the design team with recognising the main materials related to emissions that contribute to the highest GWP. The main A1-A3 elements include the materials associated with the structural frame including the timber and steel components, the floor finishes, and the external enclosing walls above ground floor level and the foundation.

5.10. In the figure below, the mass kg by classifications figures is broken down for each element of the building. Quantities for each applicable element have been entered within a +/- 10% precision.

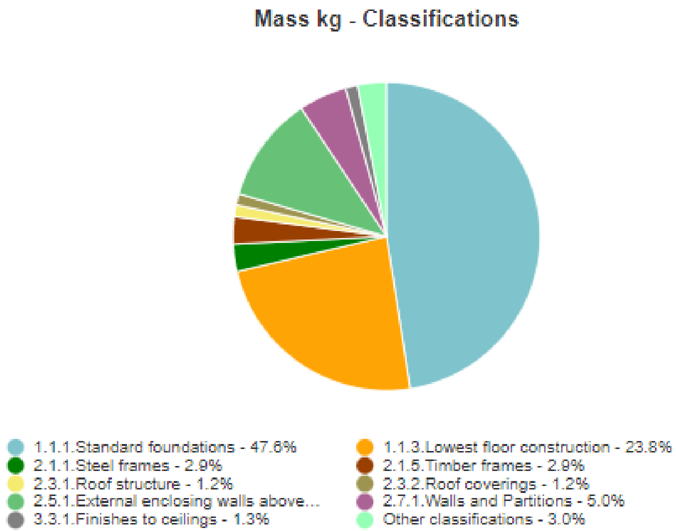

Figure 9. Mass kg Classifications of Plot 1

5.1. For further improvements, we propose the choice of high recycled content concrete used for the construction of the foundation. Recycled concrete reduces the reliance on virgin materials, thus reducing its negative environmental impact associated with the extraction and transportation of the materials.

6. Embodied Carbon Comparison

Modelling Methodology

6.1. The calculation methodology for the comparison of Veya Homes and a typical traditional house type followed the RICS Professional Statement for undertaking detailed carbon assessments. The RICS Whole Life Carbon Assessment for the Build Environment (2017) follows the European standard EN 15978.

6.2. The tool used for the comparative assessment is the OneClick LCA tool, which is BRE certified and ensures each EPD included in their database is independently verified. The embodied carbon was calculated based on estimations and material specifications provided by the design team of Veya Homes. Where specific brands were specified, but their exact EPDs were not available in the software, the closest match has been chosen.

6.3. The metric used for quantifying the embodied carbon is kilogrammes of CO_2 equivalent (kg CO_2eq). This has been normalised in kg CO_2 per m^2 floor area. For example, the floor area used for the analysis of Plot 1 is 124 m^2. The same area has been used to model a typical traditional house type with the use of the Carbon Designer 3D tool which is a tool within the OneClick LCA software. The reference building has been built with the consideration of the RICS Whole Life Carbon Assessment' guidelines, and have used the same quantities as in Veya Homes, translated into a typical traditional house type construction for comparability.

6.4. All building elements included in the Veya Homes assessment have also been included in the traditional build for comparison.

Baseline Specification

6.5. The embodied carbon was calculated using a baseline specification consisting of materials that are currently commonly applied but tend to be carbon intensive.

6.6. The construction of the typical traditional house type consists of a concrete strip foundation and precast concrete slab for the ground floor, with a standard 75mm screed, reinforcement, and EPS insulation. The upper floor construction consists of screed, concrete and reinforcement.

6.7. The roof is made of prefabricated roof trusses and battens with clay roof tiles, damp proof membrane, rockwool insulation and plywood decking.

6.8. The external walls are a double skinned blockwork cavity wall, with clay brick outer leaf, mortar, a vapour control layer, insulation, a concrete block inner leaf, mortar, timber battens and plasterboard.

6.9. The windows are double glazed uPVC, while the doors, both internal and external are wooden. The internal partitions are a standard timber partition with two layers of plasterboard and a 100mm timber stud. The internal finishes have all the same values but use slightly different construction materials. As an example, the paint in the typical traditional house type is a high quality and durable water-borne emulsion pant with no recycled content. In case of Veya Homes, the paint used is Lick, a certified B-Corp brand. All Lick paint is water-based and low VOC (contains less volatile organic compounds), however as there is no available EPD datapoint on the OneClick software, a close match has been chosen.

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7. Comparison Results

7.1. The embodied carbon of the typical traditional house type shows an initial result of 44,970 $kgCO_2$ equivalent. See in the table below how it compares to Plots 1, 2-3 and 4.

Table 6. A1-A3, A4, A5 Total Emissions

	Global warming potential (GWP) ($kgCO_2eq$)			
	Plot 1	Plot 2 & 3	Plot 4	Traditional
A1-A3	37516	60735	35280	42233
A4	777	775	609	1012
A5	1725	3450	1725	1725
Total	**40018**	**64959**	**37614**	**44970**

7.2. The following figure shows that the largest contributor in both cases are the A1-A3 product stage emissions.

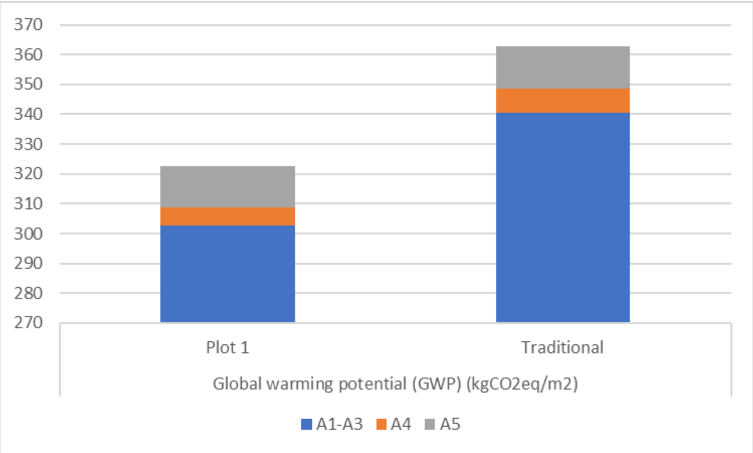

Figure 10. Comparison Veya Homes Plot 1 and Traditional total embodied carbon

7.3. Table 7 shows the breakdown of the embodied carbon by product stage (A1-A3) of Plot 1 and the Typical Traditional House Type, which shows the largest embodied carbon contribution for the traditional house to be the external walls and for the Veya home the frame.

Table 7. A1-A3 Product Stage emissions comparison

		Global warming potential (GWP) ($kgCO_2eq$)	
Construction Materials:		Plot 1	Traditional
A1-A3	Substructure	10240	11514
	Frame	12910	1295
	Upper Floors	381	3889
	Roof	3412	4649
	Stairs and Ramp	300	300
	External Walls	5452	15331
	Windows and External Doors	1461	3273
	Internal Walls and Partitions	927	395
	Internal Doors	146	146
	Finishes	2288	1443
Total		**37516**	**42233**

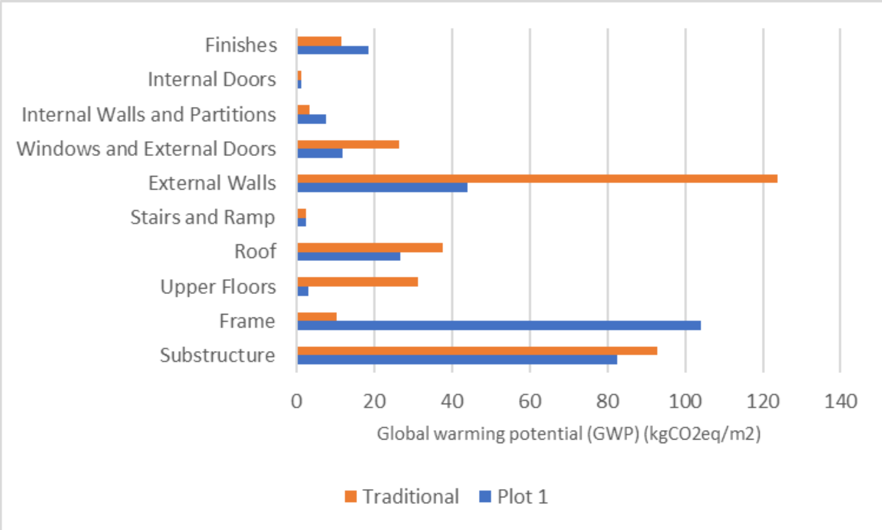

Figure 11. Comparison between Veya Homes Plot 1 and Traditional house A1-A3

7.4. The following table shows the A4 building material transportation to site emissions for both Veya Homes and the Typical Traditional House Type. Where specified for Veya homes, the transportation distances have been modified accordingly (i.e., timber structural elements, and the materials of the staircase). In case of the Typical Traditional House Type the transportation, values have not been modified and thus the OneClick standard values have been applied.

7.5. In case of the finishes, Veya homes has a higher GWP due to the Therma Fleece Ultrawool insulation within the ceiling when compared to the standard, chipboard, batten, and plasterboard buildup of the traditional house type. Even though the Therma Fleece Ultrawool has a higher GWP, its properties would show a benefit in operational emissions when compared to the traditional home.

Table 8. A4 Building material transportation to site emissions comparison

		Global warming potential (GWP) ($kgCO_2eq$)	
Building Material Transportation to Site		Plot 1	Traditional
A4	Substructure	685.56	558.80
	Frame	8.12	56.05
	Upper Floors	1.36	190.52
	Roof	6	33.23
	Stairs and Ramp	0.08	1.81
	External Walls	41.21	141.27
	Windows and External Doors	0.69	6.76
	Internal Walls and Partitions	26.04	7.59
	Internal Doors	0.11	0.73
	Finishes	8.29	14.97
Total		777	1012

7.6. In terms of the A5 Building Site Operations values, these have been generated based on the m² gross internal floor area of the two different house types. Since the two different house types have been calculated with the same gross internal floor area, the results have represented the same values.

7.7. The quantitative data used to model the construction site processes in this study is obtained from research of the OneClick LCA software conducted on construction site operations in temperate and tropical (southern) climatic regions. (The calculated electricity and fuels use are respectively: 23.58 kWh; 1.12 l diesel and 0.05l petrol all per 1m2 GFA. The used upstream database in the calculation of the impacts is Ecoinvent 3.6 and includes machine operation, spent hydraulic and machine oils, and diesel used in construction machinery.)

7.8. The processes modelled are limited to the demolition of the building only. Any mass transfer outside the construction site is not included in the calculations.

8. Summary of Conclusions

8.1. By using IESVE and OneClick LCA software, the Embodied Carbon Assessment has found that by using the provided specification, residual embodied carbon of the proposed materials for Veya Homes is as follows: Plot 1 is 40,018 $kgCO_2$, Plots 2 and 3 are 64,959 $kgCO_2$ as a combined figure, and Plot 4 is 37,614 $kgCO_2$. It was found that the highest embodied carbon by classifications were the finishes to floors, steel in frame and external wall constructions.

8.2. Following the embodied carbon analysis for the four plots, it was found that the most carbon intensive stage is the Product Stage (Module A1-A3) with a total of 37,516 $kgCO_2eq$ for Plot 1, 60,735 $kgCO_2eq$ for Plots 2 & 3 combined, and 35,280 for Plot 4.

8.3. Following the guidance of RICS Whole Life Carbon assessment and Veya Homes' requirements for a specific scope of interest, this study has only accounted for the A1-A3 Product Stage, A4 Transportation to Site Stage and A5 Site Operations stages. Emissions were calculated in biogenic carbon ($kgCO_2$ equivalent). The assessment has been completed with the aim of understanding the initial environmental impact of the building within the 'Product' and 'Construction' lifecycle modules.

8.4. The results of the embodied carbon assessment of the different dwelling types helped identify the most contributing materials.

8.5. Embodied carbon assessments are still a relatively new discipline. The parameters to which the assessments are calculated are quite fluid and these background changes have a measurable impact and influence on the results. Nevertheless, as time goes on it is expected that these will normalise and the quality and extent of material data available through OneClick LCA will only increase.

Appendix A – Plots 2 and 3

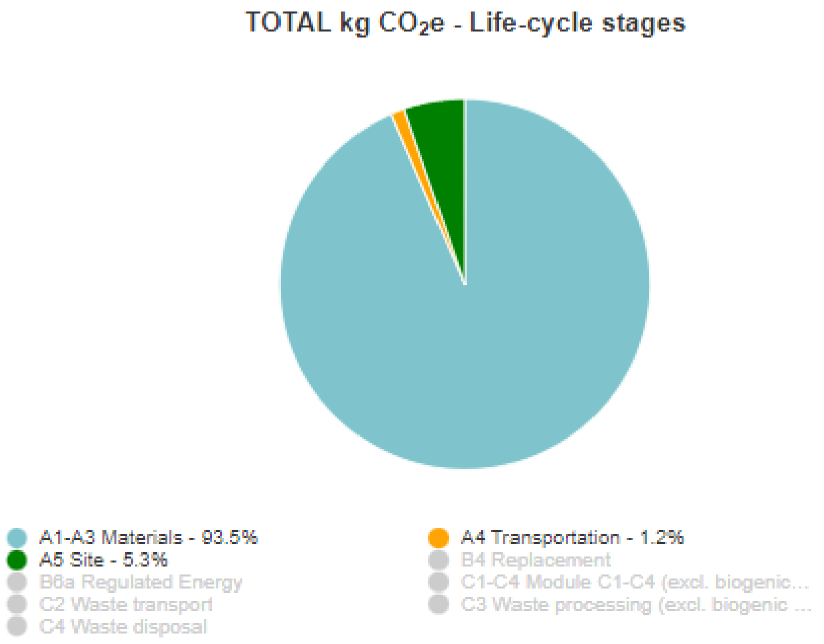

Figure 12. Total kg CO2e – Life Cycle Stages Plot 2 & 3

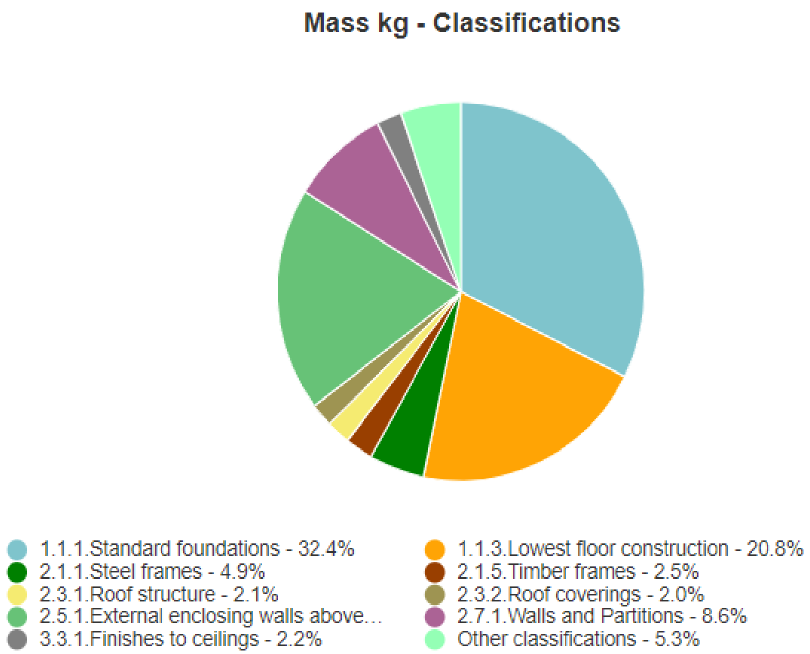

Figure 13. Mass kg Classifications of Plot 2 & 3

Table 7. Mass kg Classifications of Plot 2 & 3

Item	Value	Unit	%
1.1.1. Standard foundations	47 000	kg	32.43%
1.1.3. Lowest floor construction	30 000	kg	20.81%
2.1.1. Steel frames	7 100	kg	4.90%
2.1.5. Timber frames	3 500	kg	2.45%
2.3.1. Roof structure	3 000	kg	2.10%
2.3.2. Roof coverings	2 900	kg	2.00%
2.5.1. External enclosing walls above ground level	28 000	kg	19.18%
2.7.1. Walls and Partitions	12 000	kg	8.64%
3.3.1. Finishes to ceilings	3 200	kg	2.19%
Other classifications	7 600	kg	5.29%

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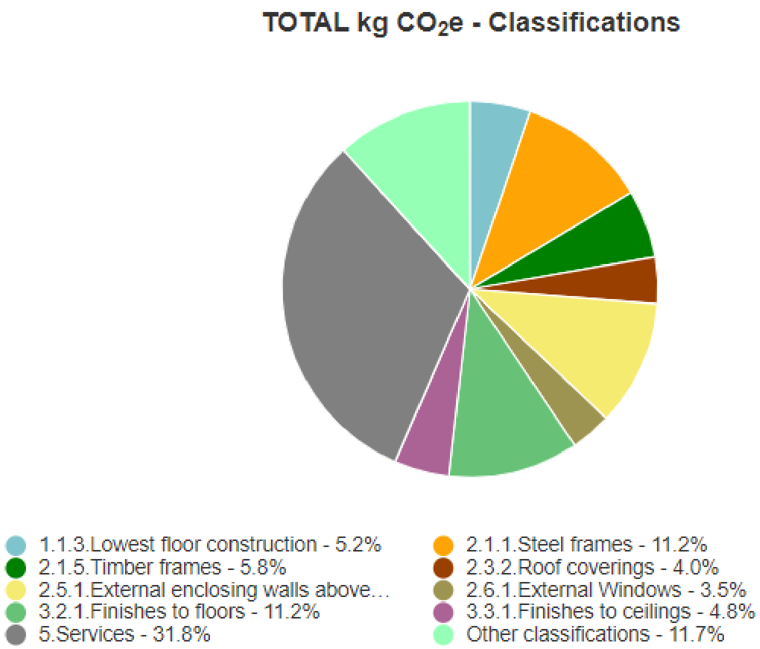

Figure 14. Total Kg CO2e by Classifications of Plot 2 & 3

Table 8. Total kg CO2e Classifications of Plot 2 & 3

Item	Value	Unit	%
1.1.3. Lowest floor construction	8 200	kg CO_2e	5.23%
2.1.1. Steel frames	17 000	kg CO_2e	11.17%
2.1.5. Timber frames	9 100	kg CO_2e	5.84%
2.3.2. Roof coverings	6 300	kg CO_2e	4.01%
2.5.1. External enclosing walls above ground level	17 000	kg CO_2e	10.82%
2.6.1. External Windows	5 500	kg CO_2e	3.54%
3.2.1. Finishes to floors	17 000	kg CO_2e	11.18%
3.3.1. Finishes to ceilings	7 400	kg CO_2e	4.75%
5. Services	50 000	kg CO_2e	31.76%
Other classifications	18 000	kg CO_2e	11.71%

Appendix B – Plot 4

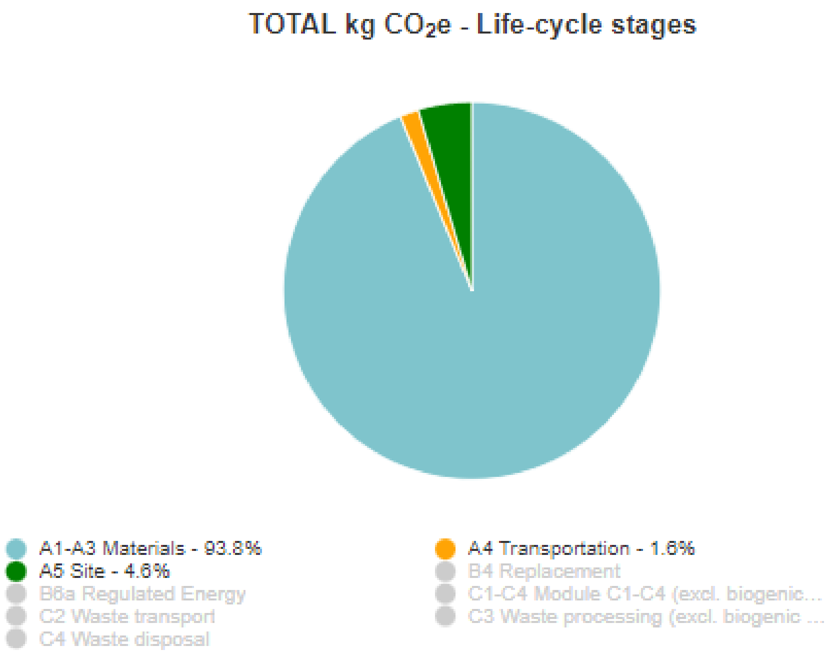

Figure 15. Total kg CO2e – Life Cycle Stages Plot 4

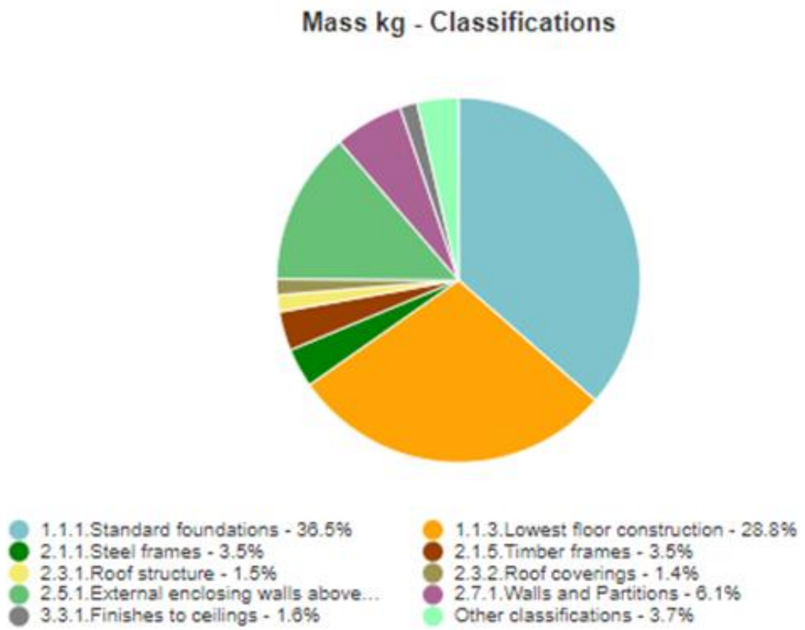

Figure 16. Mass kg Classifications of Plot 4

Table 9. Mass kg Classifications of Plot 4

Item	Value	Unit	%
1.1.1. Standard foundations	37 000	kg	36.44%
1.1.3. Lowest floor construction	29 000	kg	28.82%
2.1.1. Steel frames	3 500	kg	3.46%
2.1.5. Timber frames	3 500	kg	3.47%
2.3.1. Roof structure	1 500	kg	1.48%
2.3.2. Roof coverings	1 500	kg	1.46%
2.5.1. External enclosing walls above ground level	14 000	kg	13.55%
2.7.1. Walls and Partitions	6 200	kg	6.11%
3.3.1. Finishes to ceilings	1 600	kg	1.55%
Other classifications	3 700	kg	3.66%

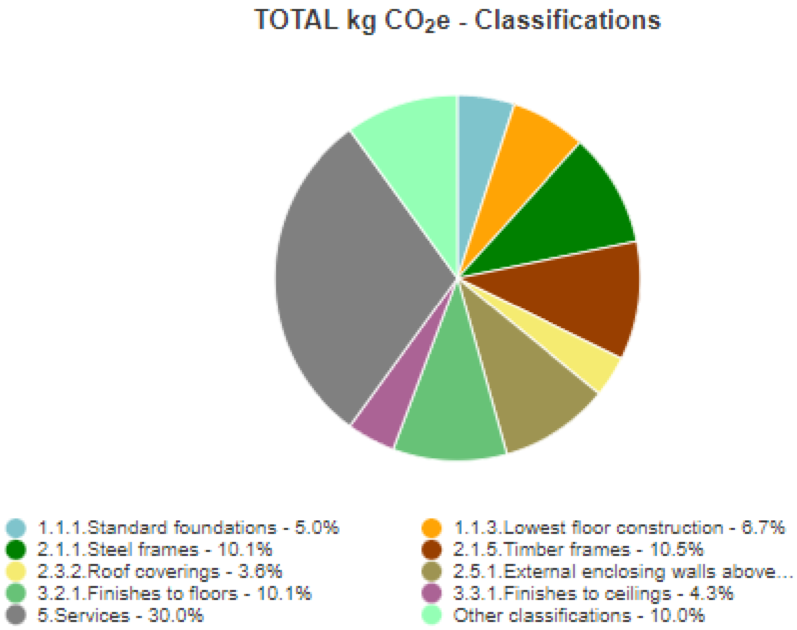

Figure 17. Total Kg CO2e by Classifications of Plot 4

Table 10. Total kg CO2e Classifications of Plot 2 & 3

Item	Value	Unit	%
1.1.1 Standard foundations	4 400	kg CO_2e	5.05%
1.1.3 Lowest floor construction	5 800	kg CO_2e	6.67%
2.1.1. Steel frames	8 700	kg CO_2e	10.06%
2.1.5. Timber frames	9 100	kg CO_2e	10.52%
2.3.2. Roof coverings	3 100	kg CO_2e	3.63%
2.5.1. External enclosing walls above ground level	8 500	kg CO_2e	9.74%
3.2.1. Finishes to floors	8 700	kg CO_2e	10.06%
3.3.1. Finishes to ceilings	3 700	kg CO_2e	4.28%
5. Services	26 000	kg CO_2e	30.02%
Other classifications	8 700	kg CO_2e	9.98%