eight associates

Eight Associates
5th Floor
57a Great Suffolk Street
London
SE1 0BB

+44 (0) 20 7043 0418

www.eightassociates.co.uk
info@eightassociates.co.uk

Life Cycle Assessment
BREEAM RIBA Stage 2
51 Calthorpe Street

Document information

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Simon Firth
Link Laters

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Assessment information

Prepared by:
Khaled Abdou

Quality assured by:
Tianzong Li

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Executive Summary
BREEAM RIBA Stage 2
51 Calthorpe Street

Introduction	Eight Associates has been appointed to review the 51 Calthorpe Street development and undertake a life cycle assessment (LCA) exercise. This report will also demonstrate compliance with the BREEAM UK New Construction 2018 Mat 01 (‘Life Cycle Impacts’) and confirm the number of credits that may be awarded. For this scheme, a total of seven credits and three innovation credits are available under the BREEAM Mat 01 criteria.
Statement of compliance	The person undertaking this assessment can confirm that they are a 'competent person' as defined in the BREEAM manual. They have undertaken training in IMPACT–compliant LCA software (both One Click and eTool), and have carried out a minimum of 20 life cycle assessment and life cycle costing studies over a range of varied projects. They can confirm that they are not professionally connected to a single manufacturer.
Summary of results	This report presents the results obtained from the LCA over a study period of 60 years, in accordance with the BREEAM methodology for Mat 01. This report demonstrates that four credits may be awarded for Mat 01, as a result of undertaking the LCA during concept design stage. In addition to the BREEAM Mat 01 results, results for other elements that are not included within the Mat 01 Results Submission tool, i.e. estimated energy and water consumption during the operation of the building, are given in this report.

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BREEAM Requirements
BREEAM RIBA Stage 2
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BREEAM credits

The report will determine the number of BREEAM New Construction 2018 Materials credits the scheme can achieve. A total of seven credits and three innovation credits are available for this scheme under Mat 01. The BREEAM criteria is provided below.

BREEAM New Construction 2018 Mat 01 – Building Life Cycle Assessment

Mat 01 Environmental impacts from construction products – Building life cycle assessment (LCA)

The full credit criteria are as follows:

Up to six credits – Superstructure (all building types)

1. During the Concept Design, demonstrate the environmental performance of the building as follows:

a) Carry out a building LCA on of the superstructure design using either the BREEAM Simplified Building LCA tool or an IMPACT Compliant LCA tool according to the methodology.
b) Submit the Mat 01/02 Results Submission Tool to BRE at the end of Concept Design, and before planning permission is applied for (that includes external material or product specifications).

2. During Technical Design, demonstrate the environmental performance of the building as follows (office, industrial and retail buildings only):

a) As criterion 1.a.
b) Submit the Mat 01/02 Results Submission Tool to BRE at the end of Technical Design.

3 & 4. During Concept Design, identify opportunities for reducing environmental impacts as follows:

a) Carry out building LCA options appraisal of 2 to 4 significantly different superstructure design options (applicable to the Concept Design stage).
b) Use a building LCA tool that is recognised by BREEAM (as suitable for assessing superstructure during Concept Design) according to the methodology.
c) For each design option, fulfil the same functional requirements specified by the client and all statutory requirements (to ensure functional equivalency).
d) Integrate the LCA options appraisal activity within the wider design decision–making process. Record this in an options appraisal summary document.
e) Record the following in the Mat 01/02 Results Submission Tool: The differences between the design options; the design option selected by the client to be progressed beyond Concept Design; the reasons for selecting it and the reasons for not selecting the other design options.
f) Submit the Mat 01/02 Results Submission Tool to BRE at the end of Concept Design, and before planning permission is applied for (that includes external material or product specifications).

BREEAM Requirements
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BREEAM New Construction 2018 Mat 01 – Building Life Cycle Assessment

5. During Technical Design identify opportunities for reducing environmental impacts as follows:

a) Carry out building LCA options appraisal of 2 to 3 significantly different superstructure design options
b) Use a building LCA tool that is recognised by BREEAM (as suitable for assessing superstructure during Technical Design) according to the methodology.
c) As criteria 4.c to 4.e above. Where an options appraisal summary document was produced during Concept Design, update it to include the Technical Design options.
d) Submit the Mat 01/02 Results Submission Tool to BRE at the end of Technical Design. Where a project has not achieved criteria 3 and 4, criterion 5 may still be achieved.

One credit – Substructure and hard landscaping options appraisal during Concept Design (all building types)

6 & 7. During Concept Design identify opportunities for reducing environmental impacts as follows:

a) Carry out building LCA options appraisal of a combined total of at least six significantly different substructure or hard landscaping design options (at least two shall be substructure and at least two shall be hard landscaping).
b) Using a building LCA tool that is recognised by BREEAM (as suitable for assessing substructure and hard landscaping during Concept Design) according to the methodology.
c) As criteria 4.c to 4f.

BREEAM New Construction 2018 Mat 01 (Exemplary Credit criteria) – Building Life Cycle Assessment

One credit – Core building services options appraisal during Concept Design (all building types)

8 & 9. During Concept Design identify opportunities for reducing environmental impacts as follows:

a) Carry out building LCA options appraisal of at least 3 significantly different core building services design options.
b) Use a building LCA tool that is recognised by BREEAM (as suitable for assessing core building services during Concept Design) according to the methodology.
c) As criteria 4.c to 4f.

One credit – LCA and LCC alignment (all building types)

10 & 11. Achieve Elemental LCC plan and Component Level LCC options appraisal credits (Man 02 Life cycle cost and service life planning).

12. Include design options appraised for criteria 3 to 4 (and 6 to 7 and 8 to 9, if pursued) during Concept Design in the elemental LCC plan

13. Include the design options appraised for criterion 5 during Technical Design in the ‘Component level LCC option appraisal’ (in Man 02 Life cycle cost and service life planning).

14. Integrate the aligned LCA and LCC options appraisal activity within the wider design decision-making process. Record this in an options appraisal summary document including the relevant cost information from the ‘elemental LCC plan’ and ‘Component level LCC option appraisal’.

One credit – Third party verification (all building types)

15 & 16. A suitably qualified third party either carries out the building LCA work or verifies the building LCA work (if by others), and produces a report describing how they have checked the building LCA work accurately represent the designs under consideration during Concept Design and Technical Design with reference to the requirements of criteria 1 to 7 (and 8 to 14 if pursued).

17. For each LCA option, itemise in the report the checks made by the suitably qualified third party including, as a minimum, the quality requirements.

18. Include details of the suitably qualified third party's relevant skills and experience and a declaration of their third party independence from the project client and design team in the report.

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Methodology
BREEAM RIBA Stage 2
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Overview

The following pages provide the basis upon which the assessment has been undertaken, including which parts of the scope and lifecycle stages have been included or excluded.

Life Cycle Assessment

The LCA has been calculated using the 'eTool LCD' software, data from the Eight Associates' construction database and Real Estate Environmental Benchmark (REEB), for the operational energy of the building. The results are presented using the metrics of global warming potential, acidification, eutrophication, ozone depletion potential, formation of ozone of lower atmosphere and non-hazardous waste disposal.

Life Cycle Assessment (LCA) is a technique for assessing the potential environmental impacts of a product or service. LCAs involve cradle-to-grave analysis of production systems and provide comprehensive evaluations of all upstream and downstream energy inputs and a number of environmental emissions. A graphical illustration of each of the LCA stages is shown in Figure 1:

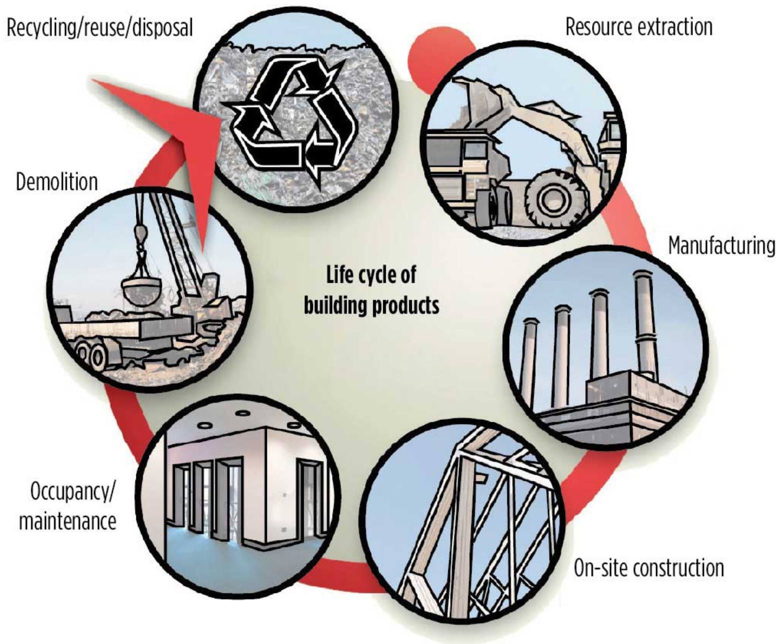

Figure 1: Graphical illustration of each of the stages included within an LCA

Existing buildings are responsible for a major share of energy use, greenhouse gas emissions and the environmental impacts of the construction sector. Renovating buildings improves operational energy performance, but it also increases the environmental impacts due to the materials and building services that are added to improve energy performance.

To address these trade-offs and establish which specification and design decisions will have the least environmental impact, it is essential to take a life cycle approach. Conducting an LCA will provide more insight into the development's environmental profile and avoid the common occurrence of simply transferring impacts between the operational and construction stages.

Methodology
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Study Boundary

To undertake an LCA for a building, different elements during various life stages of a building need to be considered, what is and is not considered is generally referred to as the 'boundary'.

The following life stages are considered within the LCA:

- A1–A3: Product stage, includes raw materials supply, transport and manufacturing.
- A4: Transport of the products to the construction site.
- A5: Construction of the building.
- B1: Use.
- B2–B3: Maintenance and repair.
- B4–B5: Material replacement and refurbishment.
- B6: Operational energy use.
- B7: Operational water use.
- C1–C4: Deconstruction/demolition.
- D: Reuse, recovery and recycling potential.

The following elements have been included in the LCA analysis:

- Structural frame (all columns and beams and miscellaneous connections)
- Walls, roof and floor construction
- Windows and frames
- Transport of all the construction materials to the site
- Maintenance of building materials, involving the impact of the replacement of these elements after their service life
- Energy and water usage predicted for the operation of the building over a period of 60 years
- External building works (landscape, pavements, roads)

The following elements have been excluded from the LCA analysis:

- Building services
- Internal fit out items
- Electricity, fuel and water used during the construction of the building
- Finishes for internal and external walls, floors and roofs

Methodology
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Assumptions and standards

Transport distances for materials, energy carbon intensity and energy used for the construction of the building can vary significantly depending on the type of building, the country and the location where the construction takes place. The following values have been applied for this analysis:

- Average transport values for UK, according to eTool software database.
- Grid electricity carbon intensity profile following the 'slow progression decarbonisation scenario' from the National Grid Future Energy Scenarios 2015.

The software used to undertake the analysis is eTool LCD. Verification processes confirmed eTool LCD's compliance with the provisions and requirements with ISO 14040 2006: Environmental management – Life cycle assessment – Principles and framework, and with ISO 14044 2006: Environmental management – Life cycle assessment – Requirements and guidelines. Conformity with the referred standards was confirmed with consideration of the data quality requirements of EN 15978 2011: Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method.

Existing Literature
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Overview

The following page presents typical results and benchmarks from existing Life Cycle Assessments (LCA). These serve to highlight the importance of undertaking an LCA and also to provide context for the results of this study.

Embodied and energy use

The construction industry globally consumes around 40% of global raw stone, gravel, and sand; 20% of virgin wood; and consumes about 40% of total energy. The national share of energy consumption in buildings varies in different countries from between 25 to 50%. In the European Union this share is approximately 50%.

The operational phase of a building has been calculated to have the largest single environmental impact of all of the LCA stages, this is illustrated by Figure 2, which comprises many geographical case studies on life cycle energy consumption for office/commercial buildings. This has been the established breakdown or 'rule of thumb' for embodied vs. operational energy or emissions for numerous LCA studies to date.

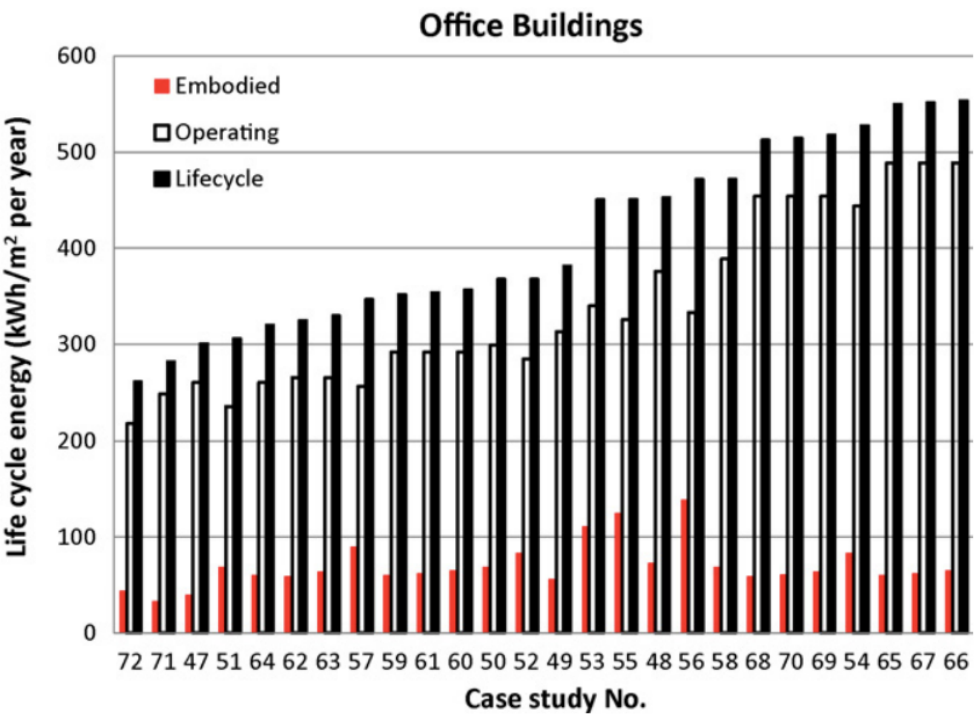

Figure 2: Results of example geographical case studies on life cycle energy consumption for office/commercial buildings

Existing Literature
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Embodied and energy use

It should be noted that more recent, UK-specific LCA studies and data have provided notably different breakdowns of lifecycle impacts; primarily a significant increase in the relative importance of the Stage 1 emissions (embodied energy and construction). This change in emission breakdown is the result of multiple developments in the construction and design of buildings, including:

1) Increased energy efficiency regulations which reduce in-use consumption.
2) The increasing prevalence of highly-engineered, more complex materials and construction systems into the built environment.
3) The ongoing and anticipated future decarbonisation of the national grid significantly reducing the climate CO_2 intensity of energy consumed during operation.

An example of one of the most up to date life cycle benchmarks is shown in Figure 3.

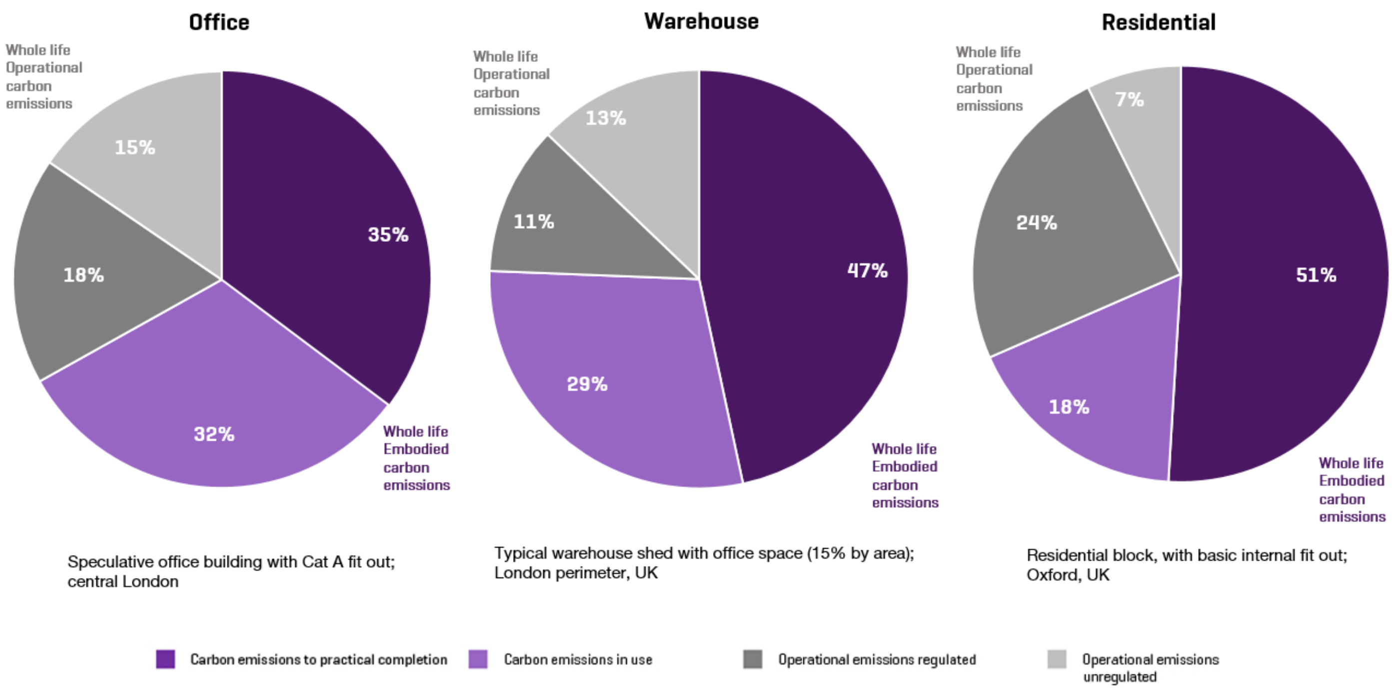

Figure 3: Life cycle benchmarks for office, warehouse and residential building

The data above highlights the increased necessity to undertake LCA studies. Firstly, Stage 1 impacts are seen to be of increasing significance in the lifecycle. Secondly, construction practices and environmental policies are constantly developing in multiple directions, which produces many trade-offs and substantial differences in the calculated environmental impacts.

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The Site
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Description of site

The scheme comprises the construction of a 3–storey office and residential building, with a further 1 storey below ground level. The total gross internal area equates to approximately 1,230 m^2. The LCA have been undertaken for a study period of 60 years. A plan of the ground floor of the proposed scheme is shown below in Figure 4.

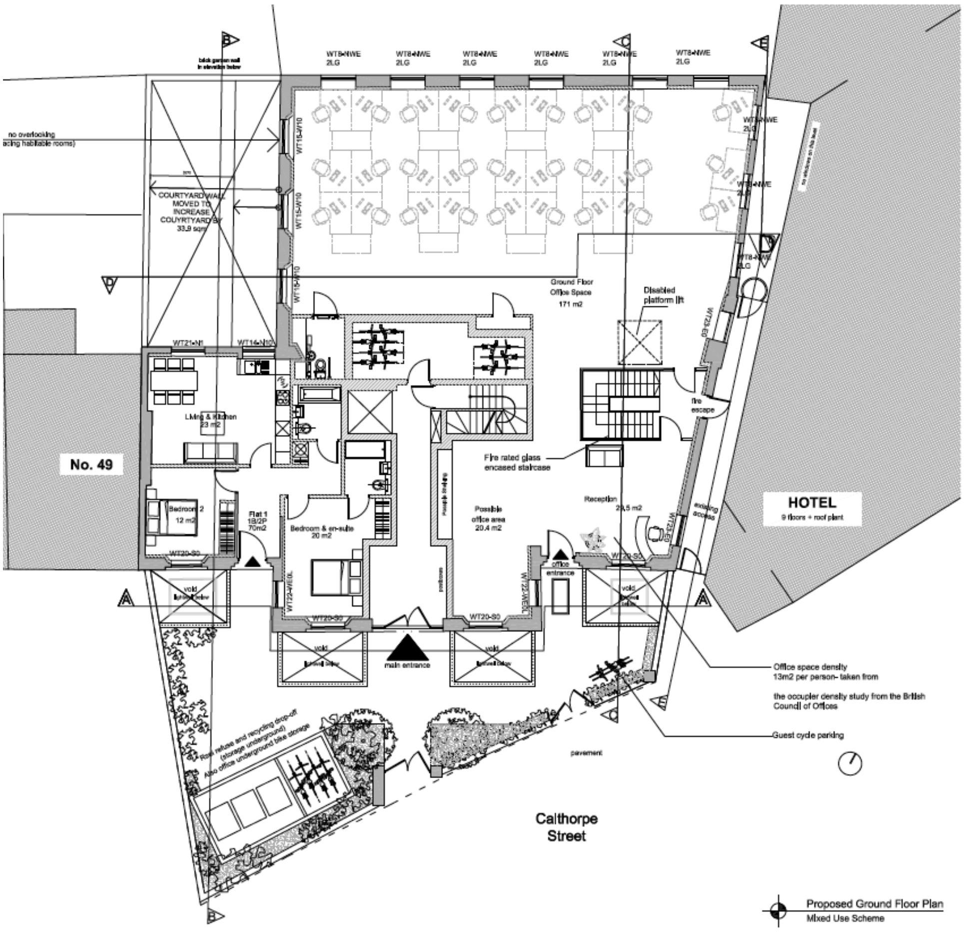

Figure 4: Plan of the proposed ground floor layout

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LCA Results
Life Cycle Assessment
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Overview

The following pages provide details of the results obtained from the lifecycle impact of the proposed scheme. This section includes estimated electricity and water consumption during the operation of the building.

Full life cycle

Figure 5, on the following page, shows the global warming potential (GWP) impact broken down by each of the elements considered within the analysis. The final global warming potential figure for the development is comprised of the following life stages:

- Construction materials: Product stage, includes raw materials supply, transport and manufacturing (A1–A3)
- Transport to site: Transport of the products to the construction site (A4)
- Construction/installation process: Construction of the building (A5)
- Use (B1)
- Maintenance and repair (B2–B3)
- Material replacement and refurbishment (B4–B5)
- Energy use: Operational energy use (B6)
- Water use: Operational water use (B7)
- Deconstruction: Deconstruction/demolition (C1–C4)
- Reuse, recovery and recycling potential (D)

Figure 5 splits this into the various building elements, as well as the predicted energy and water use over a period of 60 years. In doing so, the figure highlights the importance of the operational impacts on the overall global warming potential of the building.

Figure 6 presents a breakdown of each of the life stages, highlighting again the importance of the life stage B6, when the LCA is undertaken over a period of 60 years. The following table presents the numerical values of the GWP per life stage, normalised per m^2 of gross internal floor area.

Life stage	GWP ($kgCO_2e/m^2$)
A1– A3. Construction materials	479
A4. Transport to site	31
A5. Construction/installation process	28
B1. Use	-4
B2–B3. Maintenance and repair	0
B4–B5. Material replacement and refurbishment	13
B6. Energy use	749
B7. Water use	24
C1– C4. Deconstruction	1
D. Reuse, recovery and recycling potential	0

Note that the embodied carbon includes manufacturing, transport, construction and deconstruction of the materials, therefore, the total embodied carbon for the building is the sum of A1–A3, A4, A5 and C1–C4 life stages, with a total value of 539 $kgCO_2e/m^2$.

LCA Results
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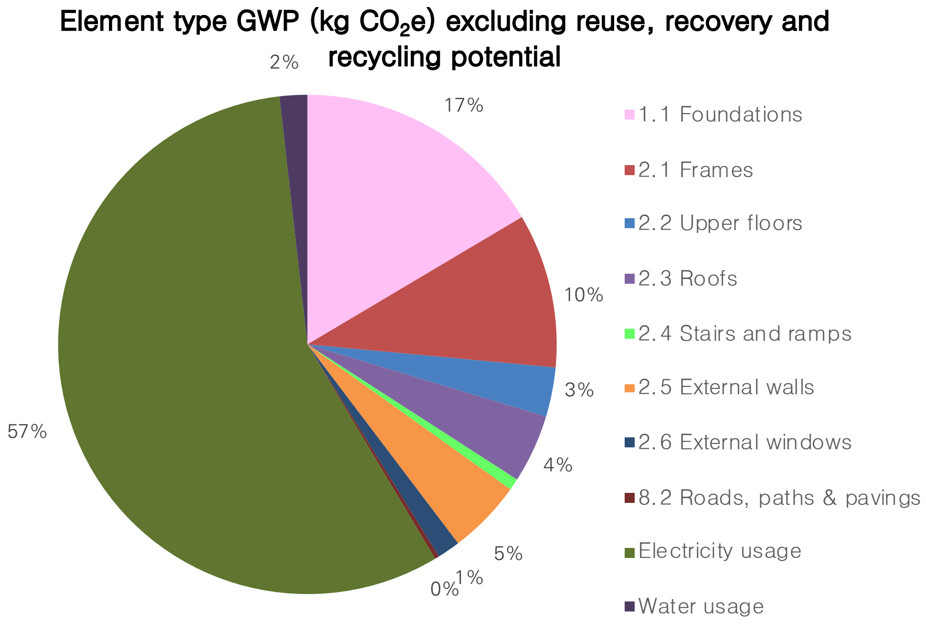

Figure 5: Elemental GWP breakdown

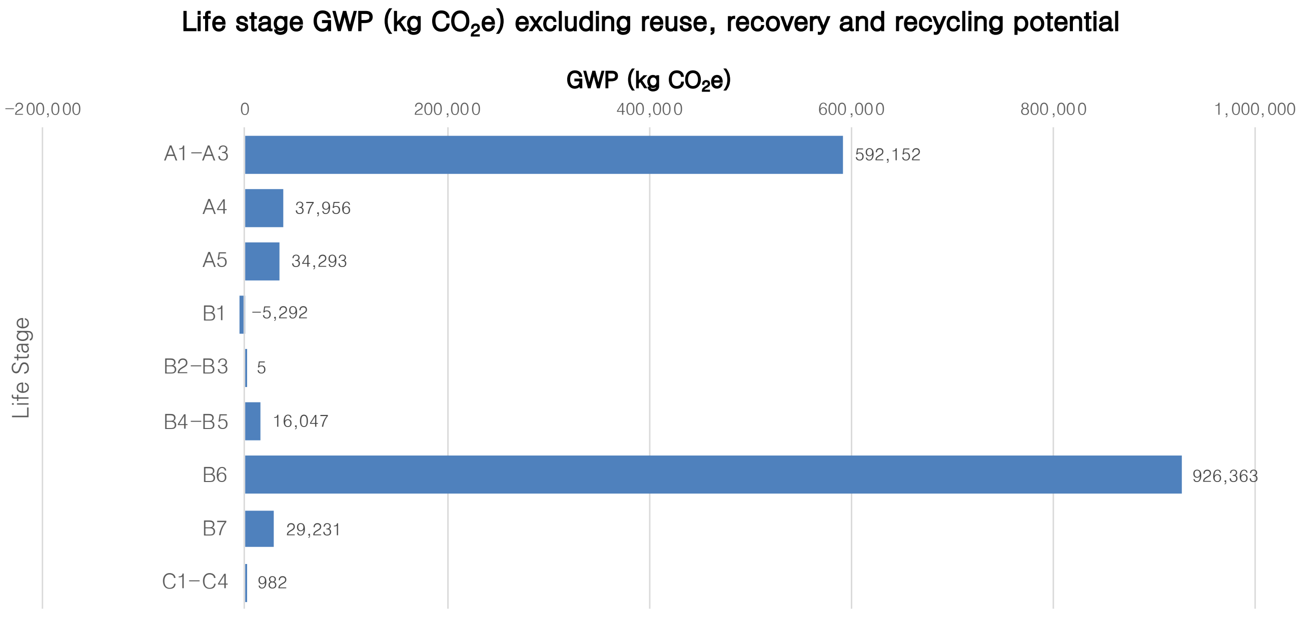

Figure 6: Life stage GWP breakdown

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Options Appraisal
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Overview

Having established the environmental impacts of the scheme, the next step is to undertake an options appraisal, establishing how different factors will affect the results and present potential improvements to reduce the global warming potential of the scheme.

Options Appraisal

An options appraisal demonstrates how particular factors or inputs affect the final results or outputs of the system. In the table and graph below, seven different options have been analysed, with all iterations demonstrating a decrease in the GWP against the proposed scheme. As presented below, Options 6 and 7 significantly reduce the environmental impact of the development over a period of 60 years, and therefore should be considered by the design team, and the feasibility of their implementation evaluated.

The proposed iterations investigate the GWP change when alterations are made to the superstructure, substructure, and hard landscaping. The results of this analysis are presented in Figure 7 on the next page, and confirm the effect of each option against the proposed scheme ('the baseline'), outlined in the LCA Results section of this report.

Figure 7 displays a number of options which would improve the GWP of the building as a whole, however, it should be noted that the corresponding change in embodied carbon is not proportional. This is because there are a number of other factors such as, but not limited to, the recyclability, durability and lifetime of the material.

Option modelled	Description	BREEAM Mat01 Tool	Change in GWP (kg CO_2e)
Option 1	Substitution of 40% of the volume of Portland cement in the foundation slab for Ground Granulated Blast Slag (GGBS)	Mat01_CD_SubS_HL_Opt4	−300
Option 2	Substitution of bricks in footpaths for concrete paving slabs	Mat01_CD_SubS_HL_Opt6	−500
Option 3	Substitution of 40% of the volume of Portland cement in the foundation slab for Pulverised Fuel Ash (PFA)	Mat01_CD_SubS_HL_Opt3	−2,600
Option 4	Substitution of cement in foundation concrete RC 40% for RC 35%	Mat01_CD_SubS_HL_Opt5	−5,800
Option 5	Substitution of aluminium window frames for composite window frames	Mat01_CD_SuperS_Opt2	−6,700
Option 6	Substitution of EPS insulation in external wall to mineral insulation	Mat01_CD_SuperS_Opt3	−10,700
Option 7	Substitution of upper floor composite concrete for precast concrete slabs	Mat01_CD_SuperS_Opt4	−39,100

Options Appraisal (continued)

The options demonstrating the greatest sensitivity to change are Options 6 and 7. They correspond to the substitution of EPS insulation in external wall to mineral insulation and the substitution of upper floor composite concrete for precast concrete slabs. Therefore, of all options considered, Options 6 and 7 should be given the most consideration.

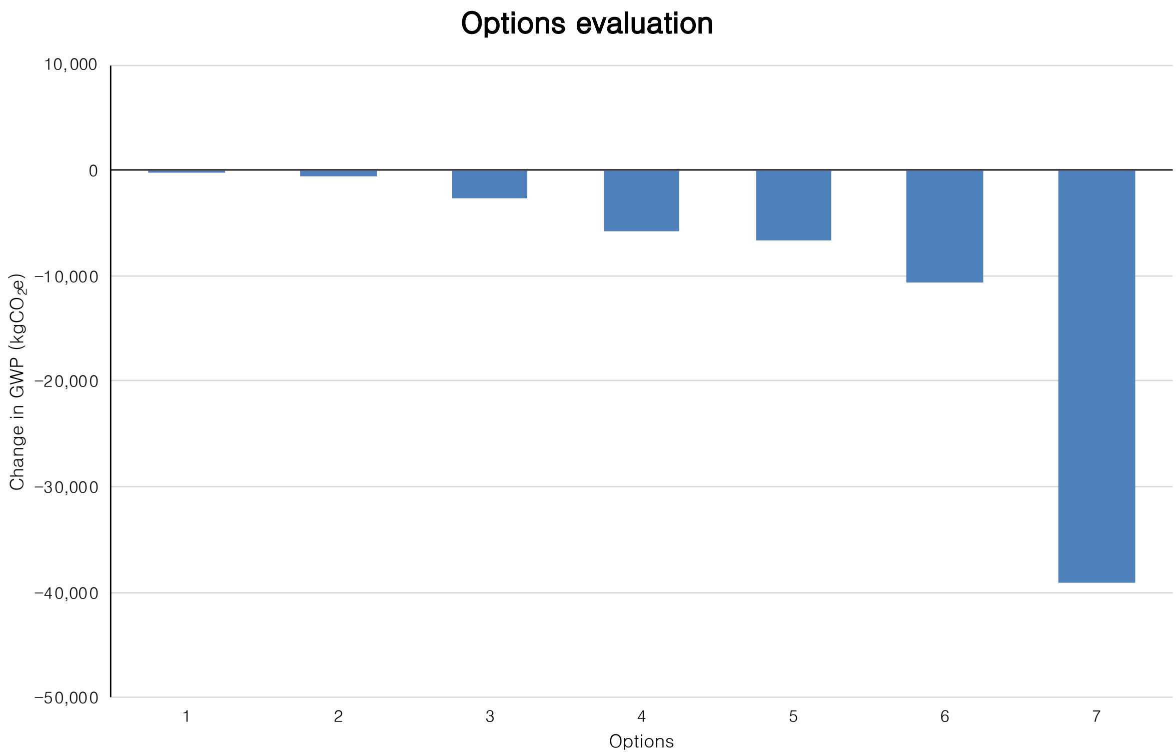

Figure 7: GWP change for each of the options

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Conclusions
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Conclusions

The life cycle assessment (LCA) concludes that the main global warming potential (GWP) impact over a period of 60 years will come from the construction and operational life stages of the building.

Through the implementation of more sustainable construction materials, a trade-off may arise due to the typically shorter life-spans. Therefore, it is important to reach a compromise between the GWP at construction, and the projected life-cycle and replacement rate.

The options detailed in the options appraisal provide an insight into potential methods that could reduce the embodied carbon of the development within its construction. It is important that these scenarios are given consideration by the design team in order to optimise the carbon footprint of the building. In particular, the substitution of EPS insulation in external wall to mineral insulation and the substitution of upper floor composite concrete for precast concrete slabs. Decisions should be made by the design team whether the options detailed are pursuable whilst simultaneously being financially viable. Where changes to the structure are being considered, a structural engineer should also be consulted to confirm structural viability.

This report demonstrates that four credits may be awarded for Mat 01, as a result of undertaking the LCA during the concept design stage.

In addition to the BREEAM Mat 01 results, results for other elements that are not included within the Mat 01 Results Submission tool, i.e. estimated energy and water consumption during the operation of the building, are given in this report.

Recommendations for further work

It would be beneficial to undertake additional analyses as the design of the development progresses, to identify and optimise further opportunities for reducing life cycle environmental impact and costing. An updated LCA should be undertaken during the technical design stage to quantify any design changes that may result, as well as a life costing exercise to fully explore the economic implications of some of the options proposed. Other analyses may include evaluating the full viability of implementing the options discussed.

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Appendix – Results

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LCA Analysis

51 Calthorpe Street

Life stage	Resource	Quantity	Unit	Global warming (kg CO_2e)	Acidification (kg SO_2e)	Eutrophication (kg PO_4e)	Ozone depletion potential (kg $CFC_{11}e$)	Photochemical Ozone Creation Potential, POCP	RICS category number	Category Name	Service Life	Resource type/description
Total				**1,631,739**	**37,751**	**9,330**	**0.46**	**2,548**				
A1A3	Retaining wall	184,809.0	m2	20,231.38	70.38	21.94	0.00	8.72	1.1	Substructure	80	Block, concrete (dense)
A1A3	Concrete Foundation slab	79.8	m3	24,431.96	49.29	12.16	0.00	4.67	1.1	Substructure	80	Structure, concrete (in-situ, RC25, excl. reinforcement)
A1A3	Concrete Foundation slab	78.0	m3	25,613.43	51.28	12.64	0.00	4.85	1.1	Substructure	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A1A3	Steel reinforcement	14,818.6	kg	32,165.64	145.22	71.52	0.00	40.17	1.1	Substructure	80	Reinforcement for RC, steel
A1A3	Steel reinforcement (12.32kg/m2)	68,250.0	kg	148,145.27	668.83	329.38	0.01	185.01	1.1	Substructure	80	Reinforcement for RC, steel
A1A3	Steel reinforcement	373.6	kg	810.95	3.66	1.80	0.00	1.01	2.1	Frame	80	Reinforcement for RC, steel
A1A3	Concrete core wall	36,390.0	m2	7,204.25	17.78	4.28	0.00	1.46	2.1	Frame	80	Structure, concrete (precast, RC40)
A1A3	Steel frame	74,239.2	kg	133,578.95	658.85	451.57	0.01	140.01	2.1	Frame	80	Structure, steel (hot rolled)
A1A3	Insulation internal floor	1,038.3	m2	6,639.28	19.82	3.36	0.00	3.80	2.2	Upper floors	80	Insulation (rigid sheet), XPS (HFC blown)
A1A3	Precast	213,595.2	m2	42,286.13	104.39	25.15	0.00	8.55	2.2	Upper floors	80	Structure, concrete (precast, RC40)
A1A3	18mm Plywood	1,684.8	m2	-4,776.84	7.76	2.56	0.00	2.09	2.3	Roof	80	General sheet, plywood (softwood)
A1A3	0.3mm Vapour control membrane	36.0	m2	88.40	0.32	0.07	0.00	0.09	2.3	Roof	70	Vapour control layer, polypropylene
A1A3	0.3mm Vapour control membrane	36.0	m2	88.40	0.32	0.07	0.00	0.09	2.3	Roof	70	Vapour control layer, polypropylene
A1A3	120mm PUR Insulation	144.0	kg	746.09	3.21	0.84	0.00	0.48	2.3	Roof	80	Insulation (rigid sheet), polyurethane
A1A3	70mm Screed	18,144.0	m2	3,187.93	7.52	1.99	0.00	0.68	2.3	Roof	80	Floor (screed, bonded), concrete (1:4 cement:sand)
A1A3	PC concrete slab	144.0	m3	68,419.55	168.90	40.69	0.00	13.83	2.3	Roof	80	Structure, concrete (precast, RC40)
A1A3	Handrail	0.1	m3	836.23	4.12	2.83	0.00	0.88	2.4	Stairs and ramps	80	Structure, steel (hot rolled)
A1A3	concrete stairs	31.6	m3	10,363.59	20.75	5.12	0.00	1.96	2.4	Stairs and ramps	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A1A3	70mm EPS layer	44.4	m3	6,297.48	23.98	4.02	0.00	13.71	2.5	External walls	80	Insulation (rigid sheet), EPS
A1A3	70mm EPS layer	44.4	m3	6,297.48	23.98	4.02	0.00	13.71	2.5	External walls	80	Insulation (rigid sheet), EPS
A1A3	RC Concrete Ext. Walls	3,905.1	kg	8,476.58	38.27	18.85	0.00	10.59	2.5	External walls	80	Reinforcement for RC, steel
A1A3	Poured concrete	126.8	m3	41,634.95	83.35	20.55	0.00	7.88	2.5	External walls	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A1A3	Timber door	109.8	m2	-431.88	0.17	0.05	0.00	0.04	2.6	Windows and external doors	20	Door leaf (solid), timber (softwood)
A1A3	Timber Door Frame	46.9	m	-163.28	0.07	0.02	0.00	0.01	2.6	Windows and external doors	20	Door frame, timber (softwood)
A1A3	Door Handle	3.7	kg	9.35	0.16	0.05	0.00	0.01	2.6	Windows and external doors	15	Door furniture/hardware, steel (coated/protected)
A1A3	Glazing	45.3	m2	53.44	0.51	0.06	0.00	0.03	2.6	Windows and external doors	80	General glazing, glass (toughened)
A1A3	Double glazing	3,058.2	m2	3,749.35	33.23	4.56	0.00	2.38	2.6	Windows and external doors	20	Glazing (double glazed, sealed unit), glass
A1A3	aluminium frame glazing	217.9	m	5,221.12	35.59	8.18	0.00	2.66	2.6	Windows and external doors	40	Window frame, aluminium (coated/protected)
A1A3	Laying course, sand	5,148.0	m2	20.53	0.13	0.03	0.00	0.02	8.2	Roads, paths and pavings	60	Landscape hard surfacing (laying course), sand (30mm grit)
A1A3	Stone aggregate underlay for tarmac	3.1	m3	27.64	0.18	0.05	0.00	0.02	8.2	Roads, paths and pavings	80	Aggregate/fill, aggregate (UK typical)
A1A3	Surface course for tarmac	0.5	m3	71.94	0.60	0.15	0.00	0.10	8.2	Roads, paths and pavings	35	Landscape hard surfacing (surface course), asphalt
A1A3	Binder course for tarmac	1.1	m3	133.67	1.08	0.26	0.00	0.17	8.2	Roads, paths and pavings	35	Landscape hard surfacing (binder course), asphalt
A1A3	Brick parking	2,695.7	m2	692.79	1.88	0.42	0.00	0.34	8.2	Roads, paths and pavings	60	Brick, clay
A4	100m3/hr	0.8	Hours	3.94	0.01	0.00	0.00	0.00	1.1	Substructure	80	No available information
A4	Electrical equipment	3.2	Hours	25.84	0.08	0.02	0.00	0.01	1.1	Substructure	150	No available information
A4	100m3/hr	0.8	Hours	87.78	0.29	0.08	0.00	0.05	1.1	Substructure	80	No available information
A4	People substructure	322.6	Hours	155.02	0.51	0.14	0.00	0.09	1.1	Substructure	150	No available information
A4	concrete pump	130.7	Hours	1,492.29	4.99	1.32	0.00	0.87	1.1	Substructure	150	No available information
A4	Steel reinforcement	14,818.6	kg	645.82	3.07	0.57	0.00	0.41	1.1	Substructure	80	Reinforcement for RC, steel
A4	Retaining wall	184,809.0	m2	2,673.89	8.76	2.37	0.00	1.49	1.1	Substructure	80	Block, concrete (dense)
A4	Concrete Foundation slab	78.0	m3	2,708.48	8.87	2.40	0.00	1.51	1.1	Substructure	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A4	Concrete Foundation slab	79.8	m3	2,769.79	9.07	2.45	0.00	1.55	1.1	Substructure	80	Structure, concrete (in-situ, RC25, excl. reinforcement)
A4	Steel reinforcement (12.32kg/m2)	68,250.0	kg	2,974.43	14.14	2.63	0.00	1.87	1.1	Substructure	80	Reinforcement for RC, steel
A4	People	2.3	Hours	25.84	0.08	0.02	0.00	0.01	2.1	Frame	150	No available information
A4	People	563.7	Hours	917.19	3.00	0.81	0.00	0.51	2.1	Frame	150	No available information
A4	Steel reinforcement	373.6	kg	16.28	0.08	0.01	0.00	0.01	2.1	Frame	80	Reinforcement for RC, steel
A4	Concrete core wall	36,390.0	m2	506.45	1.66	0.45	0.00	0.28	2.1	Frame	80	Structure, concrete (precast, RC40)
A4	Install Beam (structural steel - 7hrs/t)	519.7	Hours	839.68	2.75	0.74	0.00	0.47	2.1	Frame	150	No available information
A4	Crane install of steel	173.2	Hours	1,304.19	4.36	1.15	0.00	0.76	2.1	Frame	150	No available information
A4	Steel frame	74,239.2	kg	3,112.19	14.80	2.75	0.00	1.95	2.1	Frame	80	Structure, steel (hot rolled)
A4	Insulation internal floor	1,038.3	m2	20.89	0.07	0.02	0.00	0.01	2.2	Upper floors	80	Insulation (rigid sheet), XPS (HFC blown)
A4	Precast	213,595.2	m2	2,972.65	9.73	2.63	0.00	1.66	2.2	Upper floors	80	Structure, concrete (precast, RC40)
A4	0.3mm Vapour control membrane	36.0	m2	0.73	0.00	0.00	0.00	0.00	2.3	Roof	70	Vapour control layer, polypropylene
A4	0.3mm Vapour control membrane	36.0	m2	0.73	0.00	0.00	0.00	0.00	2.3	Roof	70	Vapour control layer, polypropylene
A4	120mm PUR Insulation	144.0	kg	2.90	0.01	0.00	0.00	0.00	2.3	Roof	80	Insulation (rigid sheet), polyurethane
A4	18mm Plywood	1,684.8	m2	174.02	1.46	0.18	0.00	0.14	2.3	Roof	80	General sheet, plywood (softwood)
A4	70mm Screed	18,144.0	m2	268.76	0.88	0.24	0.00	0.15	2.3	Roof	80	Floor (screed, bonded), concrete (1:4 cement:sand)
A4	PC concrete slab	144.0	m3	4,809.78	15.75	4.26	0.00	2.69	2.3	Roof	80	Structure, concrete (precast, RC40)
A4	Handrail	0.1	m3	19.48	0.09	0.02	0.00	0.01	2.4	Stairs and ramps	80	Structure, steel (hot rolled)
A4	concrete stairs	31.6	m3	1,095.89	3.59	0.97	0.00	0.61	2.4	Stairs and ramps	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A4	Electrical equipment	0.8	Hours	12.92	0.04	0.01	0.00	0.01	2.5	External walls	150	No available information
A4	70mm EPS layer	44.4	m3	27.30	0.09	0.02	0.00	0.02	2.5	External walls	80	Insulation (rigid sheet), EPS
A4	70mm EPS layer	44.4	m3	27.30	0.09	0.02	0.00	0.02	2.5	External walls	80	Insulation (rigid sheet), EPS
A4	concrete pump	0.3	Hours	87.78	0.29	0.08	0.00	0.05	2.5	External walls	150	No available information
A4	RC Concrete Ext. Walls	3,905.1	kg	170.19	0.81	0.15	0.00	0.11	2.5	External walls	80	Reinforcement for RC, steel
A4	Concrete pump operation	380.4	Hours	620.07	2.03	0.55	0.00	0.35	2.5	External walls	80	No available information
A4	Concrete pump	126.8	Hours	1,404.51	4.70	1.24	0.00	0.82	2.5	External walls	80	No available information
A4	Poured concrete	126.8	m3	4,402.67	14.42	3.90	0.00	2.46	2.5	External walls	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A4	Door Handle	3.7	kg	0.16	0.00	0.00	0.00	0.00	2.6	Windows and external doors	15	Door furniture/hardware, steel (coated/protected)
A4	Glazing	45.3	m2	1.15	0.00	0.00	0.00	0.00	2.6	Windows and external doors	80	General glazing, glass (toughened)
A4	Timber Door Frame	46.9	m	5.79	0.03	0.00	0.00	0.00	2.6	Windows and external doors	20	Door frame, timber (softwood)
A4	aluminium frame glazing	217.9	m	10.84	0.06	0.01	0.00	0.01	2.6	Windows and external doors	40	Window frame, aluminium (coated/protected)
A4	Timber door	109.8	m2	13.55	0.08	0.01	0.00	0.01	2.6	Windows and external doors	20	Door leaf (solid), timber (softwood)
A4	Double glazing	3,058.2	m2	74.37	0.25	0.07	0.00	0.04	2.6	Windows and external doors	20	Glazing (double glazed, sealed unit), glass
A4	Install windows	16.4	Hours	217.36	0.73	0.19	0.00	0.13	2.6	Windows and external doors	40	No available information
A4	mortar	1.5	Hours	21.53	0.07	0.02	0.00	0.01	8.2	Roads, paths and pavings	80	No available information
A4	Compaction	0.0	Hours	376.21	1.26	0.33	0.00	0.22	8.2	Roads, paths and pavings	25	No available information
A4	Grader supporting compaction works	0.1	Hours	627.01	2.10	0.55	0.00	0.37	8.2	Roads, paths and pavings	25	No available information
A4	Surface course for tarmac	0.5	m3	17.18	0.06	0.02	0.00	0.01	8.2	Roads, paths and pavings	35	Landscape hard surfacing (surface course), asphalt
A4	Binder course for tarmac	1.1	m3	34.05	0.11	0.03	0.00	0.02	8.2	Roads, paths and pavings	35	Landscape hard surfacing (binder course), asphalt
A4	Brick parking	2,695.7	m2	39.37	0.13	0.03	0.00	0.02	8.2	Roads, paths and pavings	60	Brick, clay

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Life stage	Resource	Quantity	Unit	Global warming (kg CO_2e)	Acidification (kg SO_2e)	Eutrophication (kg PO_4e)	Ozone depletion potential (kg $CFC_{11}e$)	Photochemical Ozone Creation Potential, POCP	RICS category number	Category Name	Service Life	Resource type/description
A4	Laying course, sand	5,148.0	m2	59.74	0.20	0.05	0.00	0.03	8.2	Roads, paths and pavings	60	Landscape hard surfacing (laying course), sand (30mm grit)
A4	Stone aggregate underlay for tarmac	3.1	m3	80.42	0.26	0.07	0.00	0.04	8.2	Roads, paths and pavings	80	Aggregate/fill, aggregate (UK typical)
A5	Electrical equipment	3.2	Hours	0.17	0.00	0.00	0.00	0.00	1.1	Substructure	150	No available information
A5	People substructure	322.6	Hours	17.44	0.09	0.02	0.00	0.01	1.1	Substructure	150	No available information
A5	100m3/hr	0.8	Hours	52.11	0.40	0.10	0.00	0.07	1.1	Substructure	80	No available information
A5	100m3/hr	0.8	Hours	53.34	0.41	0.10	0.00	0.07	1.1	Substructure	80	No available information
A5	concrete pump	130.7	Hours	8,934.50	68.35	17.00	0.00	11.75	1.1	Substructure	150	No available information
A5	Steel reinforcement	14,818.6	kg	0.39	0.00	0.00	0.00	0.00	1.1	Substructure	80	Reinforcement for RC, steel
A5	Steel reinforcement (12.32kg/m2)	68,250.0	kg	1.77	0.01	0.00	0.00	0.00	1.1	Substructure	80	Reinforcement for RC, steel
A5	Retaining wall	184,809.0	m2	2.40	0.02	0.00	0.00	0.00	1.1	Substructure	80	Block, concrete (dense)
A5	Concrete Foundation slab	78.0	m3	2.43	0.02	0.00	0.00	0.00	1.1	Substructure	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A5	Concrete Foundation slab	79.8	m3	2.48	0.02	0.00	0.00	0.00	1.1	Substructure	80	Structure, concrete (in-situ, RC25, excl. reinforcement)
A5	People	2.3	Hours	0.12	0.00	0.00	0.00	0.00	2.1	Frame	150	No available information
A5	People	563.7	Hours	30.48	0.17	0.04	0.00	0.01	2.1	Frame	150	No available information
A5	Steel reinforcement	373.6	kg	0.01	0.00	0.00	0.00	0.00	2.1	Frame	80	Reinforcement for RC, steel
A5	Concrete core wall	36,390.0	m2	0.09	0.00	0.00	0.00	0.00	2.1	Frame	80	Structure, concrete (precast, RC40)
A5	Steel frame	74,239.2	kg	0.39	0.00	0.00	0.00	0.00	2.1	Frame	80	Structure, steel (hot rolled)
A5	Install Beam (structural steel - 7hrs/t)	519.7	Hours	28.10	0.15	0.03	0.00	0.01	2.1	Frame	150	No available information
A5	Crane install of steel	173.2	Hours	14,212.18	108.72	27.05	0.00	18.69	2.1	Frame	150	No available information
A5	Steel fabrication	1,707.5	kWh	482.20	2.61	0.60	0.00	0.15	2.1	Frame	150	No available information
A5	Precast	213,595.2	m2	0.55	0.00	0.00	0.00	0.00	2.2	Upper floors	80	Structure, concrete (precast, RC40)
A5	Insulation internal floor	1,038.3	m2	5.43	0.00	0.35	0.00	0.00	2.2	Upper floors	80	Insulation (rigid sheet), XPS (HFC blown)
A5	0.3mm Vapour control membrane	36.0	m2	0.07	0.00	0.01	0.00	0.00	2.3	Roof	70	Vapour control layer, polypropylene
A5	0.3mm Vapour control membrane	36.0	m2	0.07	0.00	0.01	0.00	0.00	2.3	Roof	70	Vapour control layer, polypropylene
A5	70mm Screed	18,144.0	m2	0.35	0.00	0.00	0.00	0.00	2.3	Roof	80	Floor (screed, bonded), concrete (1:4 cement:sand)
A5	120mm PUR Insulation	144.0	kg	0.62	0.00	0.20	0.00	0.00	2.3	Roof	80	Insulation (rigid sheet), polyurethane
A5	PC concrete slab	144.0	m3	0.90	0.01	0.00	0.00	0.00	2.3	Roof	80	Structure, concrete (precast, RC40)
A5	18mm Plywood	1,684.8	m2	4.59	0.00	0.19	0.00	0.00	2.3	Roof	80	General sheet, plywood (softwood)
A5	Handrail	0.1	m3	0.00	0.00	0.00	0.00	0.00	2.4	Stairs and ramps	80	Structure, steel (hot rolled)
A5	concrete stairs	31.6	m3	0.98	0.01	0.00	0.00	0.00	2.4	Stairs and ramps	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A5	Electrical equipment	0.8	Hours	0.04	0.00	0.00	0.00	0.00	2.5	External walls	150	No available information
A5	RC Concrete Ext. Walls	3,905.1	kg	0.10	0.00	0.00	0.00	0.00	2.5	External walls	80	Reinforcement for RC, steel
A5	Poured concrete	126.8	m3	3.95	0.03	0.01	0.00	0.01	2.5	External walls	80	Structure, concrete (in-situ, RC40, excl. reinforcement)
A5	70mm EPS layer	44.4	m3	8.01	0.01	2.55	0.00	0.00	2.5	External walls	80	Insulation (rigid sheet), EPS
A5	70mm EPS layer	44.4	m3	8.01	0.01	2.55	0.00	0.00	2.5	External walls	80	Insulation (rigid sheet), EPS
A5	concrete pump	0.3	Hours	17.42	0.13	0.03	0.00	0.02	2.5	External walls	150	No available information
A5	Concrete pump operation	380.4	Hours	20.57	0.11	0.03	0.00	0.01	2.5	External walls	80	No available information
A5	Concrete pump	126.8	Hours	8,669.95	66.32	16.50	0.00	11.40	2.5	External walls	80	No available information
A5	Door Handle	3.7	kg	0.00	0.00	0.00	0.00	0.00	2.6	Windows and external doors	15	Door furniture/hardware, steel (coated/protected)
A5	aluminium frame glazing	217.9	m	0.00	0.00	0.00	0.00	0.00	2.6	Windows and external doors	40	Window frame, aluminium (coated/protected)
A5	Glazing	45.3	m2	0.00	0.00	0.00	0.00	0.00	2.6	Windows and external doors	80	General glazing, glass (toughened)
A5	Timber Door Frame	46.9	m	0.01	0.00	0.00	0.00	0.00	2.6	Windows and external doors	20	Door frame, timber (softwood)
A5	Timber door	109.8	m2	0.01	0.00	0.00	0.00	0.00	2.6	Windows and external doors	20	Door leaf (solid), timber (softwood)
A5	Double glazing	3,058.2	m2	0.05	0.00	0.00	0.00	0.00	2.6	Windows and external doors	20	Glazing (double glazed, sealed unit), glass
A5	Install windows	123.1	Hours	6.66	0.04	0.01	0.00	0.00	2.6	Windows and external doors	20	No available information
A5	manufacture	1,230.9	kWh	347.61	1.88	0.43	0.00	0.11	2.6	Windows and external doors	40	No available information
A5	Install windows	16.4	Hours	1,346.71	10.30	2.56	0.00	1.77	2.6	Windows and external doors	40	No available information
A5	mortar	1.5	Hours	0.83	0.00	0.00	0.00	0.00	8.2	Roads, paths and pavings	80	No available information
A5	labourer	52.0	Hours	2.81	0.02	0.00	0.00	0.00	8.2	Roads, paths and pavings	80	No available information
A5	Re-laying bricks	52.0	Hours	2.81	0.02	0.00	0.00	0.00	8.2	Roads, paths and pavings	5	No available information
A5	Compaction	0.0	Hours	3.15	0.02	0.01	0.00	0.00	8.2	Roads, paths and pavings	25	No available information
A5	Labour	113.4	Hours	6.13	0.03	0.01	0.00	0.00	8.2	Roads, paths and pavings	25	No available information
A5	Grader supporting compaction works	0.1	Hours	12.41	0.09	0.02	0.00	0.02	8.2	Roads, paths and pavings	25	No available information
A5	Brick parking	2,695.7	m2	0.21	0.00	0.00	0.00	0.00	8.2	Roads, paths and pavings	60	Brick, clay
A5	Surface course for tarmac	0.5	m3	0.32	0.00	0.01	0.00	0.00	8.2	Roads, paths and pavings	35	Landscape hard surfacing (surface course), asphalt
A5	Laying course, sand	5,148.0	m2	0.40	0.00	0.00	0.00	0.00	8.2	Roads, paths and pavings	60	Landscape hard surfacing (laying course), sand (30mm grit)
A5	Stone aggregate underlay for tarmac	3.1	m3	0.54	0.00	0.00	0.00	0.00	8.2	Roads, paths and pavings	80	Aggregate/fill, aggregate (UK typical)
A5	Binder course for tarmac	1.1	m3	0.55	0.00	0.02	0.00	0.00	8.2	Roads, paths and pavings	35	Landscape hard surfacing (binder course), asphalt

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LCA Analysis

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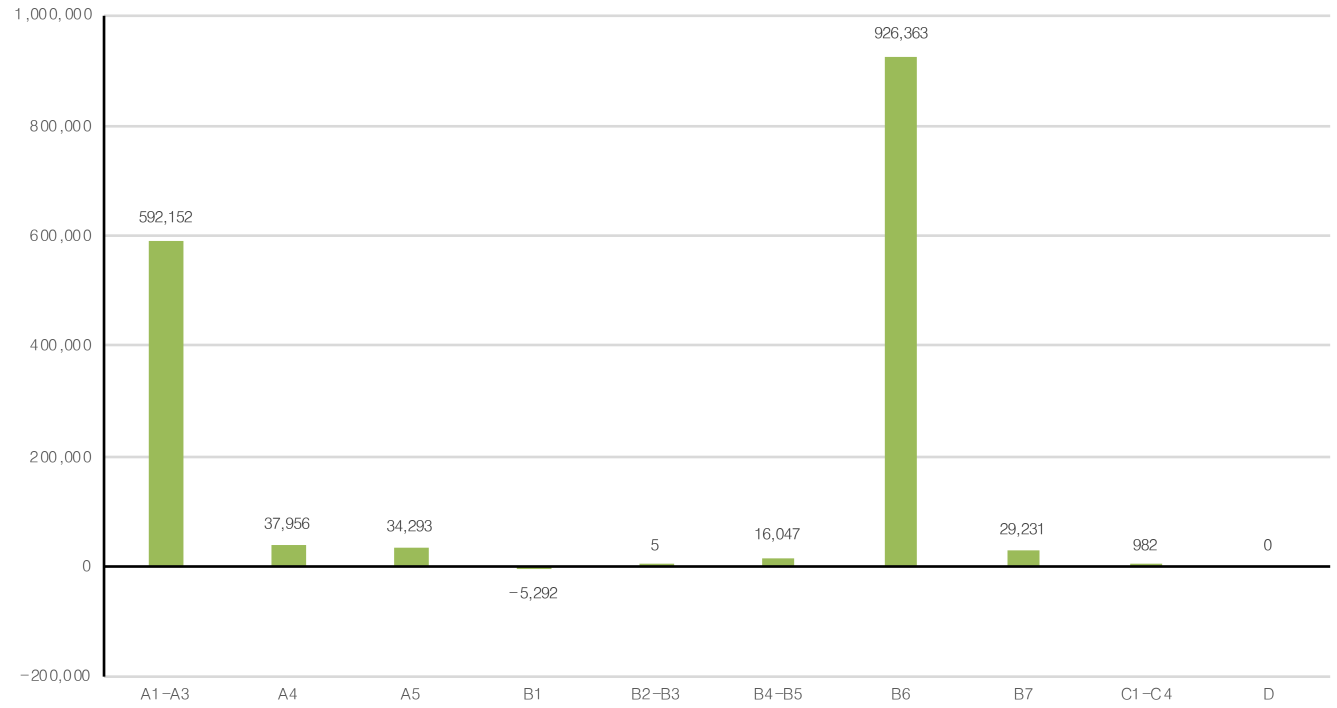
Calculation Parameters			
Service life values for materials			Technical service
Transportation distance values for materials			United Kingdom
Local compensation target region			London
Global Warming Potential per life stage	**Life Stage**	**Sector**	**Global Warming Potential (kg CO_2e)**
Construction Impact	A1–A3	Construction materials	592,152
	A4	Transportation to site	37,956
	A5	Construction/installation process	34,293
Operation Impact	B1	Use	−5,292
	B2–B3	Maintenance and repair	5
	B4–B5	Material replacement and refurbishment	16,047
	B6	Electricity usage	926,363
	B7	Water usage	29,231
Deconstruction impact	C1–C4	Deconstruction	982
Reuse, recovery, and recycling potential	D	Reuse, recovery, and recycling potential	0
TOTAL (Excluding reuse, recovery and recycling potential)			**1,631,739**
TOTAL			**1,631,739**

Global Warming Potential (kg CO_2e) per Life Cycle Stage



	0	A1A3	A4	A5	B1	B2B3	B4B5	B6	C
Global Warming Potential (kg CO_2e) Breakdown	**Total (Excluding D)**	**A1–A3**	**A4**	**A5**	**B1**	**B2–B3**	**B4–B5**	**B6–B7**	**C1–C4**
1.1 Foundations	268,930	250,588	13,537	9,067	−4,451	–	–	–	189
2.1 Frames	163,123	141,594	6,722	14,754	–	5	–	–	48
2.2 Upper floors	52,089	48,925	2,994	6	–	–	–	–	164
2.3 Roofs	72,377	67,754	5,257	7	−841	–	–	–	200
2.4 Stairs and ramps	12,336	11,200	1,115	1	–	–	–	–	20
2.5 External walls	78,497	62,706	6,753	8,728	–	–	–	–	310
2.6 External windows	24,164	8,438	323	1,701	–	–	13,695	–	7
8.2 Roads, paths & pavings	4,628	947	1,256	30	–	–	2,352	–	43
Electricity usage	926,363	–	–	–	–	–	–	926,363	–
Water usage	29,231	–	–		–	–	–	29,231	–
TOTAL	**1,631,739**	**592,152**	**37,956**	**34,293**	**−5,292**	**5**	**16,047**	**955,594**	**982**
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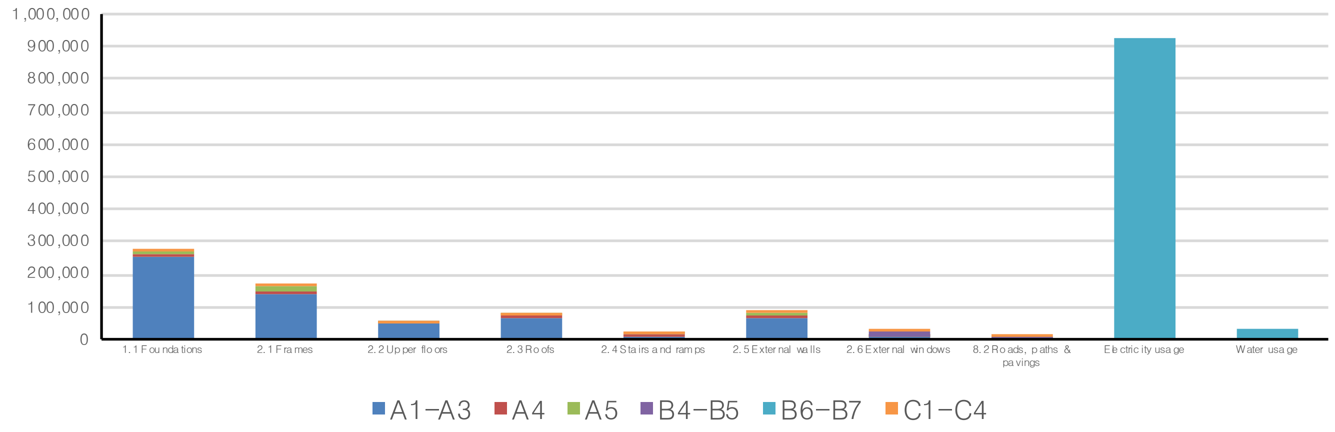
Global Warming Potential (kg CO_2e) per RICS Category and Life Cycle Stage



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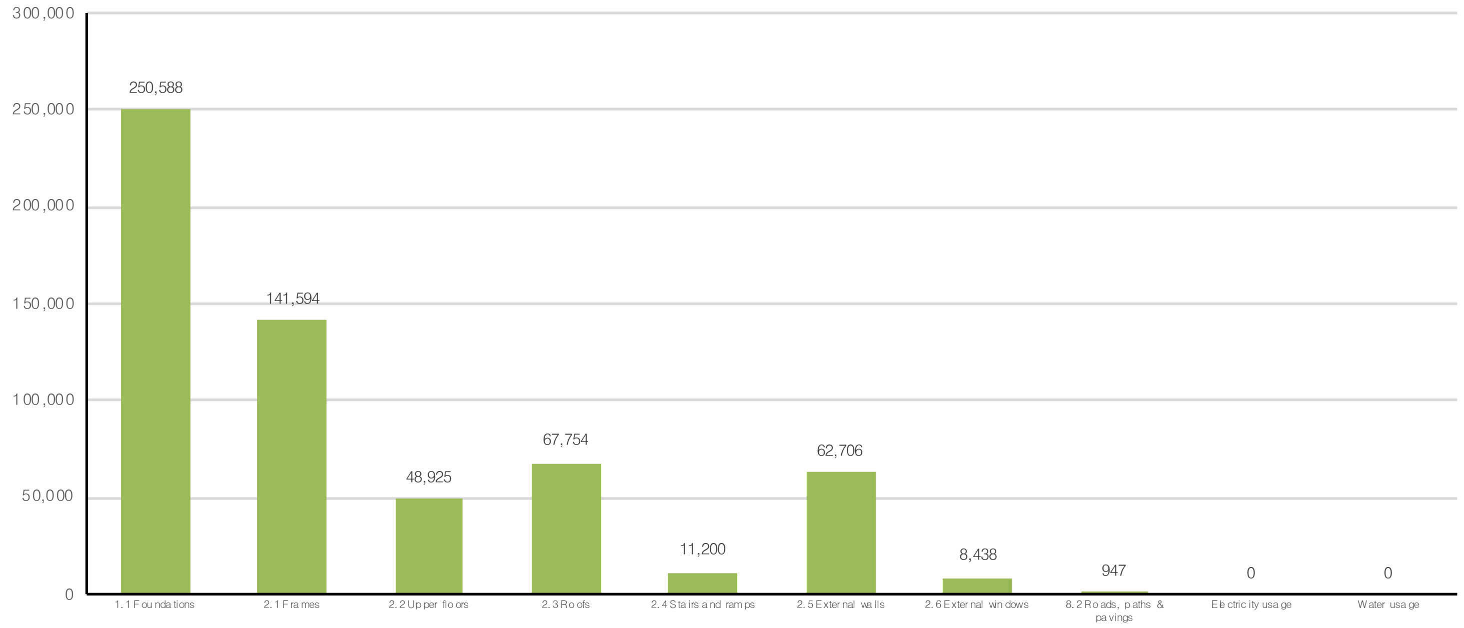
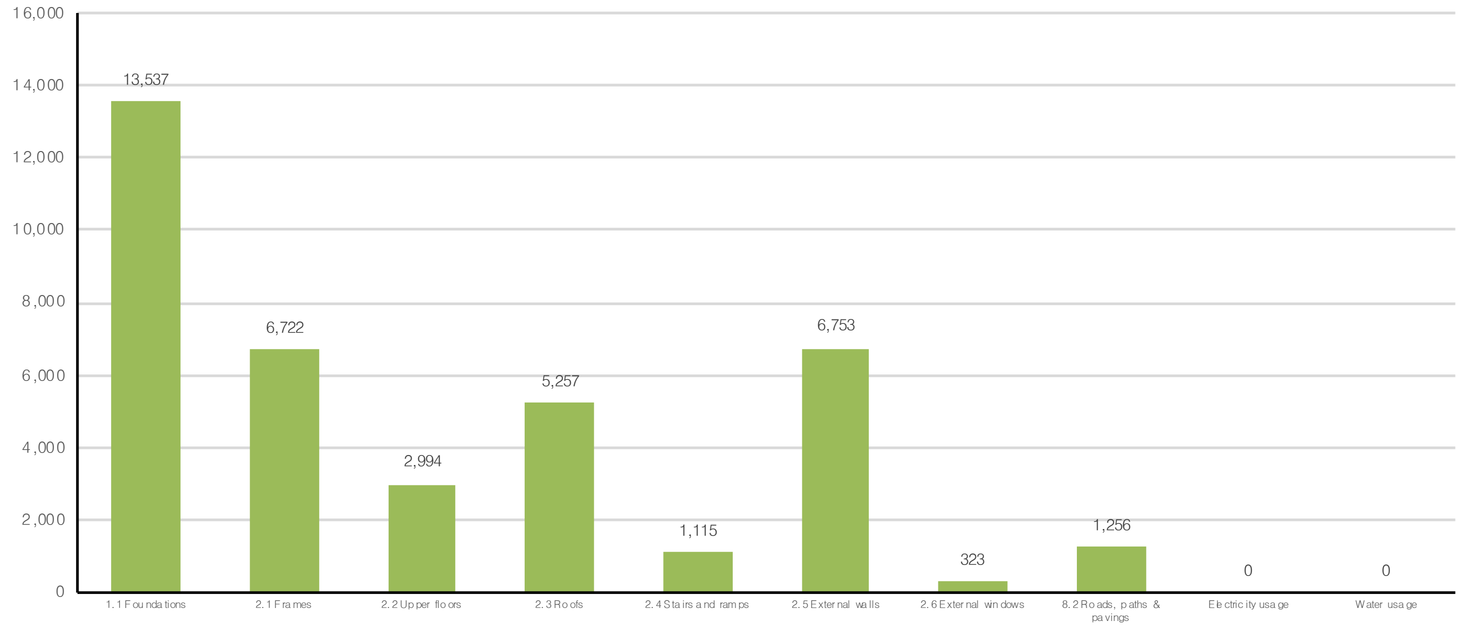
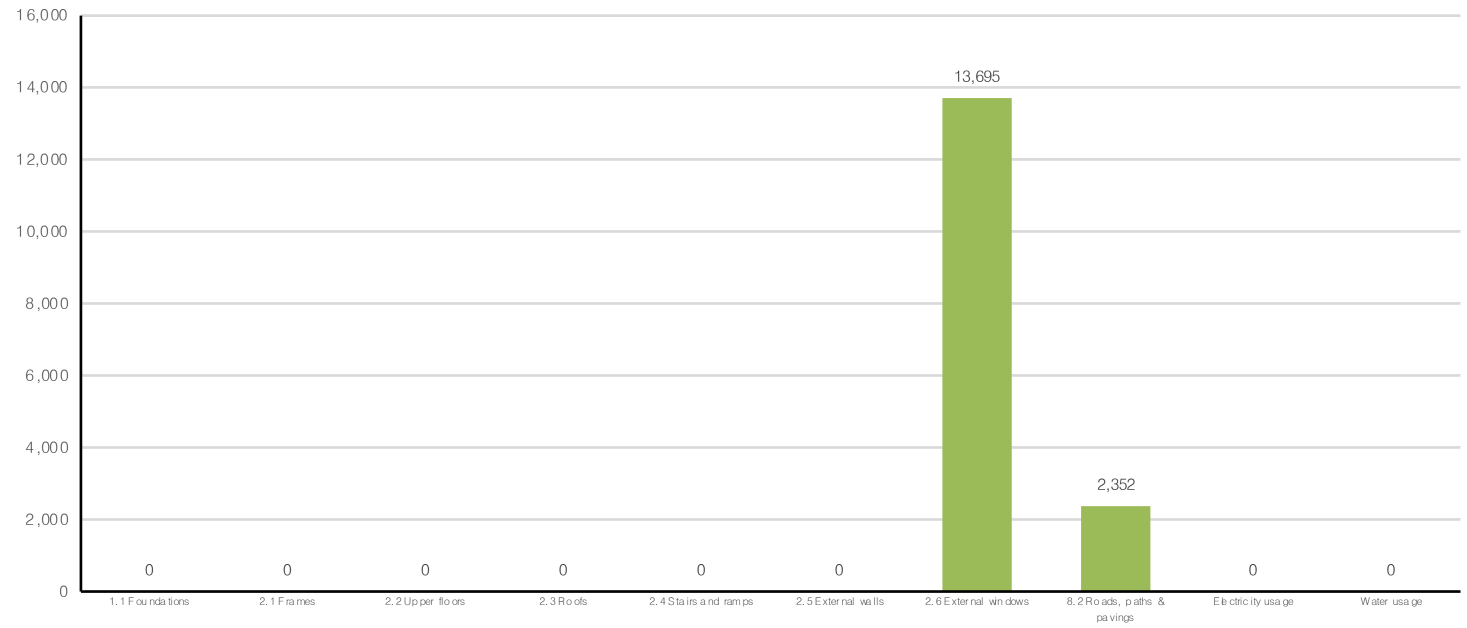
Global Warming Potential (kg CO_2e) for Life Cycle Stage A1–A3



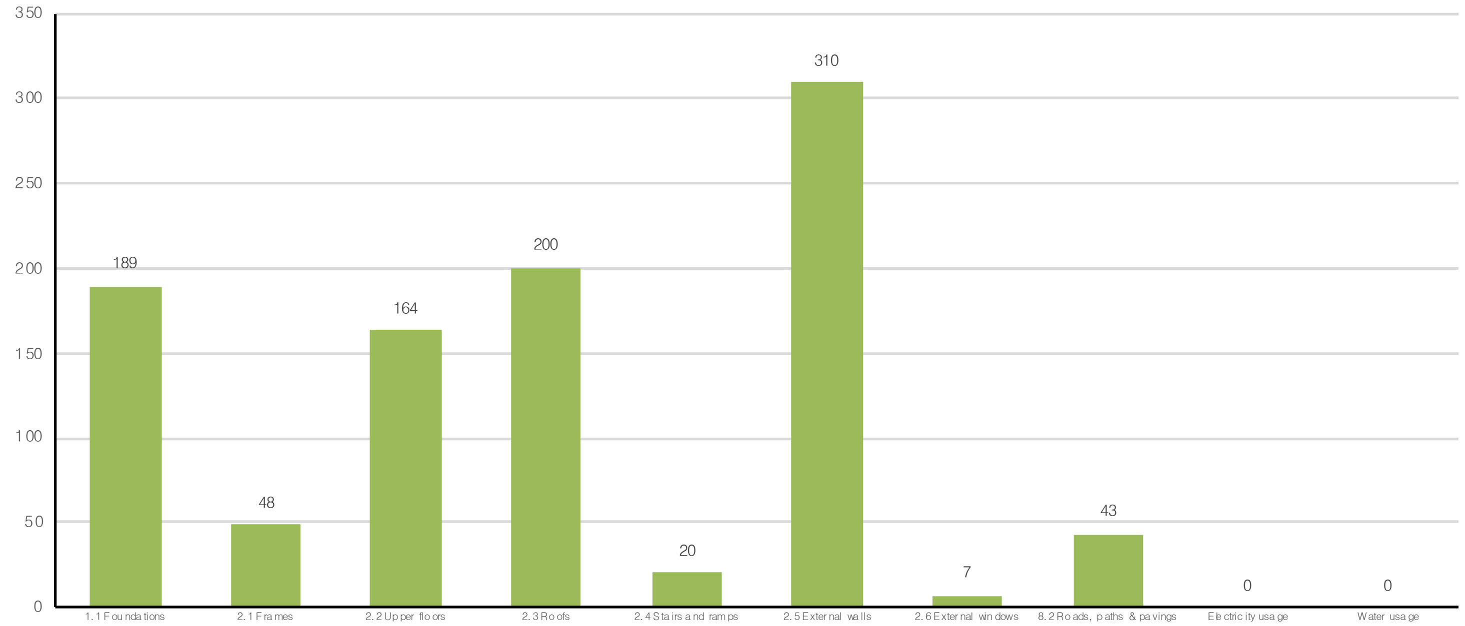
Global Warming Potential (kg CO_2e) for Life Cycle Stage A4



Global Warming Potential (kg CO_2e) for Life Cycle Stage B4–B5



Global Warming Potential (kg CO_2e) for Life Cycle Stage C1–C4



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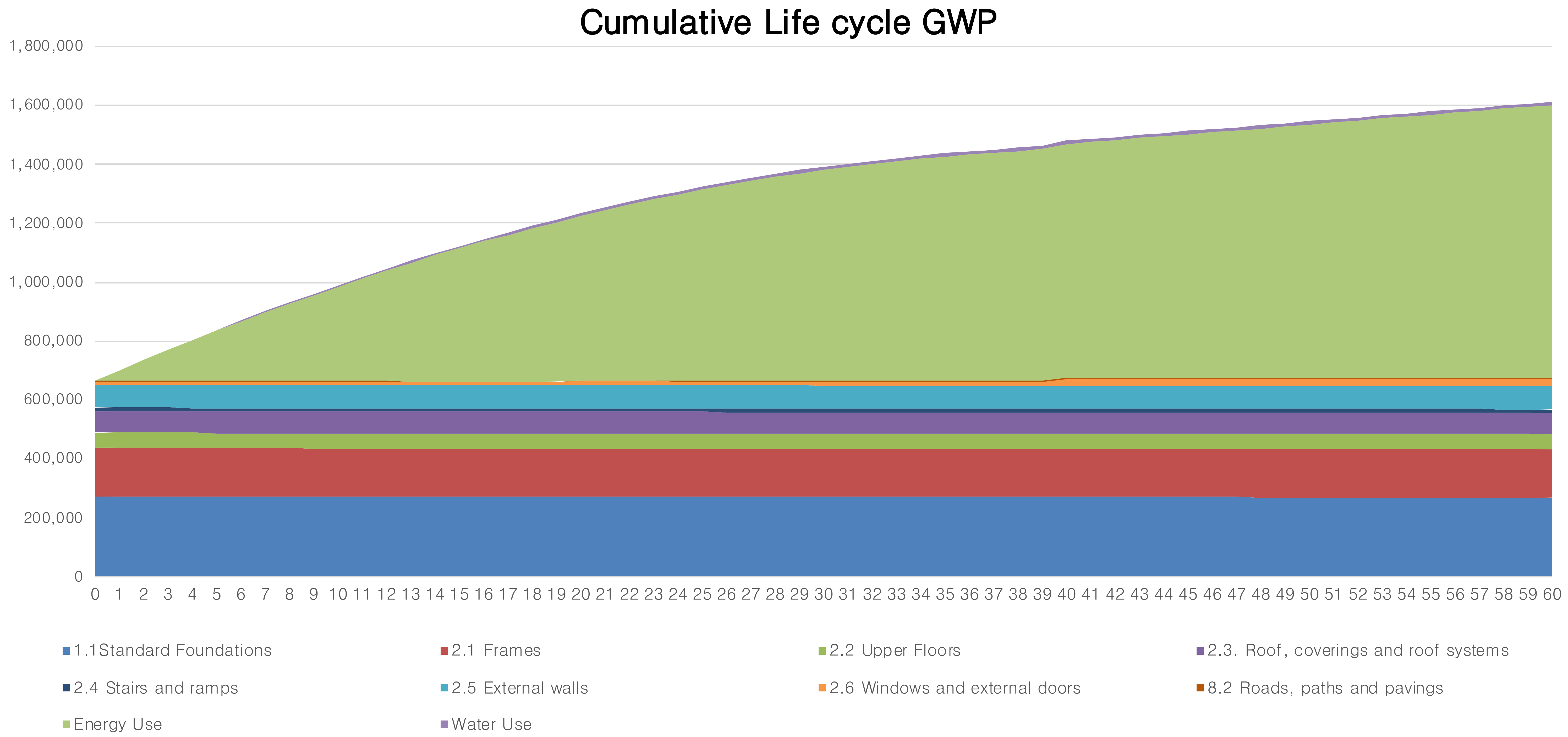
Annual GWP breakdown (kg CO_2e)



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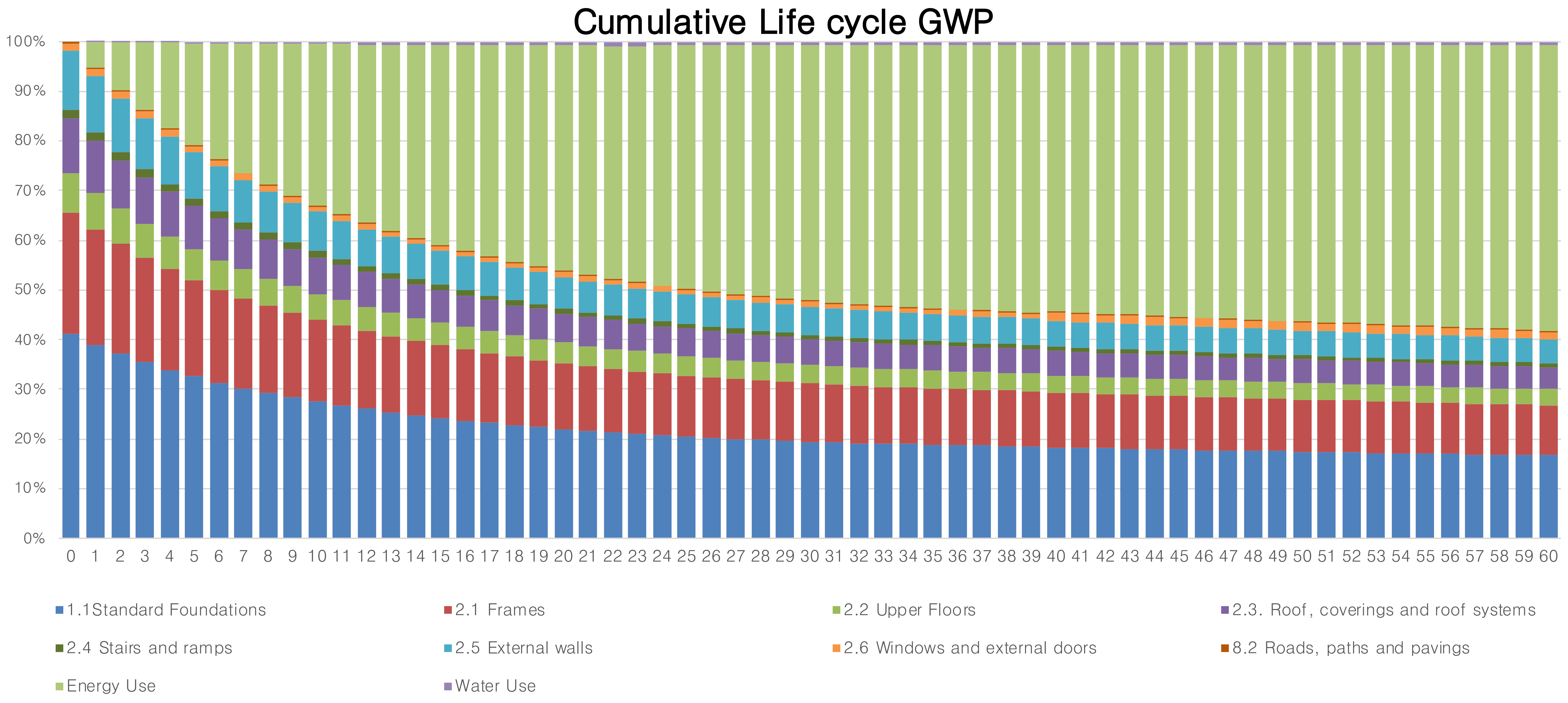
Annual GWP breakdown (%)



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