

Embodied Carbon of Materials: A Guide

Disclaimer

All carbon data presented in this guide has been derived from 3rd party Environmental Product Declarations (EPDs) provided by UK and European manufacturers, which were correct at the time of publication. This guide does not provide commentary on the performance of products, or what constitutes a 'good' or 'bad' product. Envision cannot be held liable for a design change or material change resulting from the information provided in this guide. A Life Cycle Assessment should always be used to inform a building's overall carbon impact.

If you have any comments or queries about this guide, please email contact@envisioneco.com with subject title; "Embodied Carbon Design Guide".

Foreword



We are in a climate crisis. And all stakeholders in the built environment have a role to play.

The 2015 Paris Agreement on climate change calls for holding eventual warming “well below” 2°C, and for the pursuit of efforts to limit the increase even further, to 1.5°C. To achieve this, every individual, company and industry has a role to play.

In the UK, the Whole Life Carbon Roadmap¹ produced by the UK Green Building Council (UKGBC) illustrates that the UK built environment is currently responsible for (i.e. has direct control over) 25% of total UK greenhouse gas emissions (from buildings and infrastructure). If surface transport (i.e. vehicle emissions) is included within the scope of the built environment, the total contribution to UK emissions increases to 42%.

Within the built environment, every material used in the construction or refurbishment of a building has a carbon impact, as do the activities associated with its construction, including transport to site and energy used through construction. Taken together, all carbon emissions associated with the construction of a building are referred to as ‘embodied carbon’. Research by the UKGBC shows that in many cases, embodied carbon accounts for up to 75% of the carbon associated with a building over its lifetime².

But in many cases, embodied carbon remains a blind spot, with designers and developers unaware or unsure how to approach it, design for it, and reduce it. This ‘knowledge gap’ is a complex issue to address.

Envision have developed this guide to begin closing that gap.

Building on robust data derived from manufacturer’s Environmental Product Declarations (EPDs), this guide has been developed as a resource for stakeholders involved in the design, construction and refurbishment of buildings, to enable them to begin understanding and comparing the ‘construction-stage’ embodied carbon impact of different design options and building materials.

We believe the more aware that all stakeholders are regarding the carbon impact of building materials, the sooner robust reduction and mitigation practices can be embedded into everyday building design, construction and refurbishment.

This does not replace the important Life Cycle Assessment work required as part of a robust carbon reduction strategy, but is meant as a ‘first step’ guide to make this complex topic more accessible, approachable and user-friendly.

With it, we hope all stakeholders in the built environment can begin considering the carbon impact of the design decisions and material choices they make, as we all seek to address the climate challenges facing the built environment.

Foreword author



Sam Wallis

Director – Energy & Sustainability

Contributors



Monisha Selvaraju

Energy & Sustainability Consultant



Jake Broad

LCA Consultant



Clara Sibaud

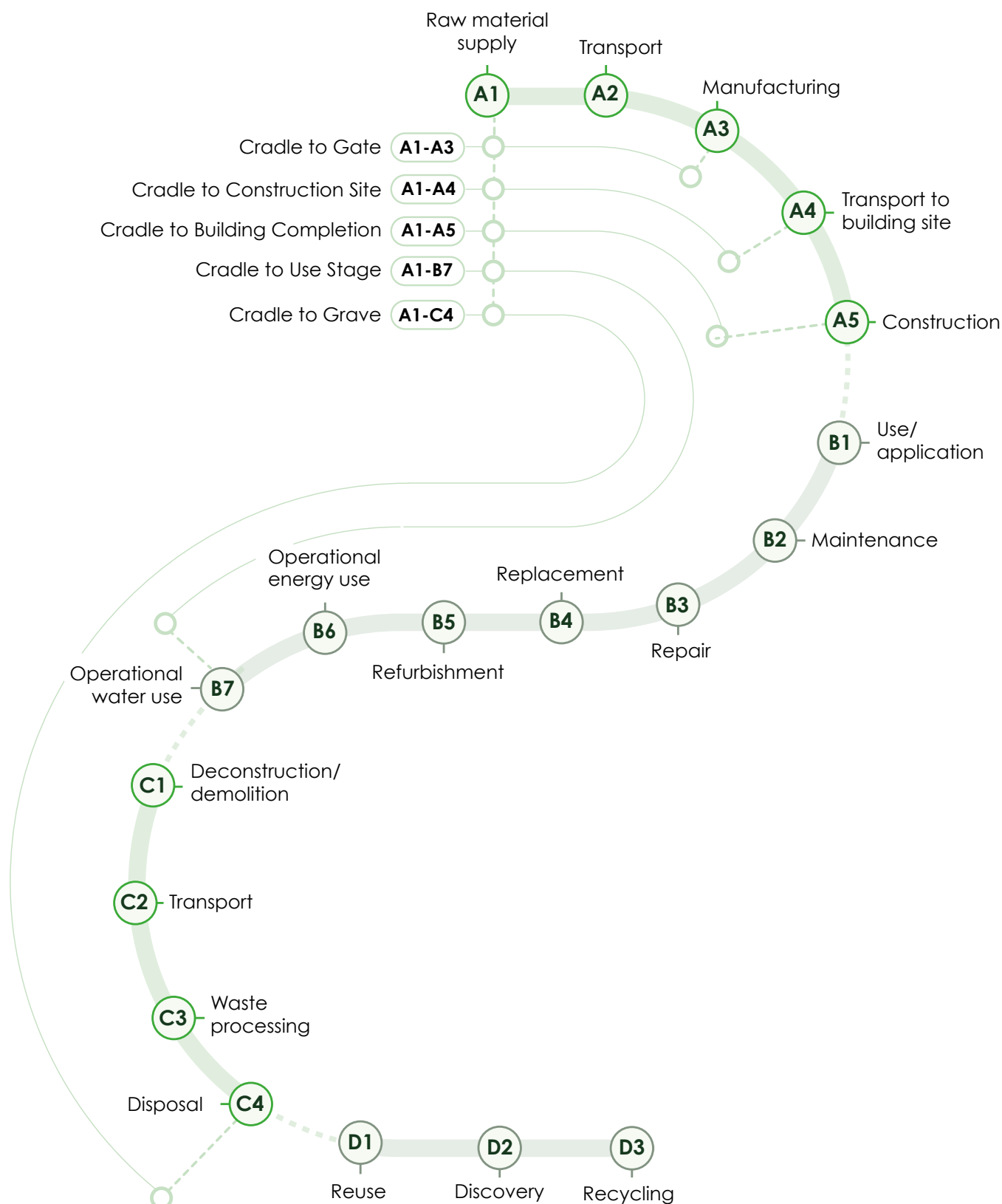
Energy & Sustainability Consultant

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Life Cycle Assessment (LCA)

A methodology for quantifying the environmental impacts associated with a building or development across its whole life.



Structure of the Guide

This guide presents the carbon impact of a range of materials, each organised under key building categories, as detailed on the next page.

All carbon data presented in this guide has been derived from Environmental Product Declarations (EPDs) provided by manufacturers. An EPD is a document which details the environmental impact (including carbon) of any product or material over its lifetime.

Within the construction industry, EPDs support carbon emission reduction by making it possible to compare the impacts of different materials and products in order to select the most sustainable option. This guide has collated data from over a hundred EPDs to educate and inform on the embodied carbon of building materials.

As detailed within the graph on the previous page, the life cycle of a building is broken down into key use stages; A (Product & Construction Stage), B (In-Use Stage), C (End-of-Life) and D (Beyond the Life-Cycle). Within this guide the carbon impact for each material has been provided for the 'product & construction stages' only (i.e. A1-A5 emissions as defined by RICS Professional Statement 'Whole life carbon assessment for the built environment')³ – reported in kgCO₂e. Whole life carbon emissions are not included. This is for three key reasons:

1. We want to keep this guide as simple as possible;
2. The UK building industry currently rarely measures or reports on embodied carbon impacts for the

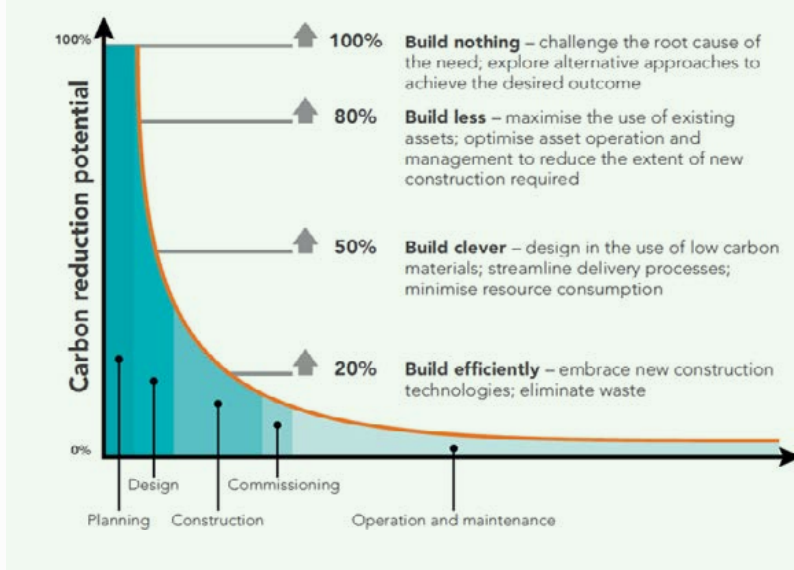
maintenance, repair, refurbishment and end-of-life stages of a building's lifecycle (B & C). This is due to a lack of reliable data being available for such stages, which would result in them being based on modelled estimates alone, and;

3. As detailed by the UK Green Building Council, the carbon impacts related to the product and construction stages of a building are significant, in some cases accounting for half of a new building's whole life carbon impacts, and as shown on the graph below the greatest reduction can be made in early design stages.

Each product presented in this guide has its carbon reported in kgCO₂e and has a standardised reporting metric, i.e. each product category will have each listed product reported in either per m², per m³, or per kg to allow for fair comparison.

We have standardised the life-cycle reporting stage(s) for each product depending on the scope of each EPD to allow for fair comparison. For example, if three window EPDs report A1-A5, but the fourth only reports A1-A3, all four will be reported A1-A3. Where A4 and A5 are included, there will be differences between the EPDs, however these emissions represent a negligible amount compared to the A1-A3 and will be project-dependent. To accurately represent A4 and A5 emissions, a Life Cycle Assessment should be undertaken.

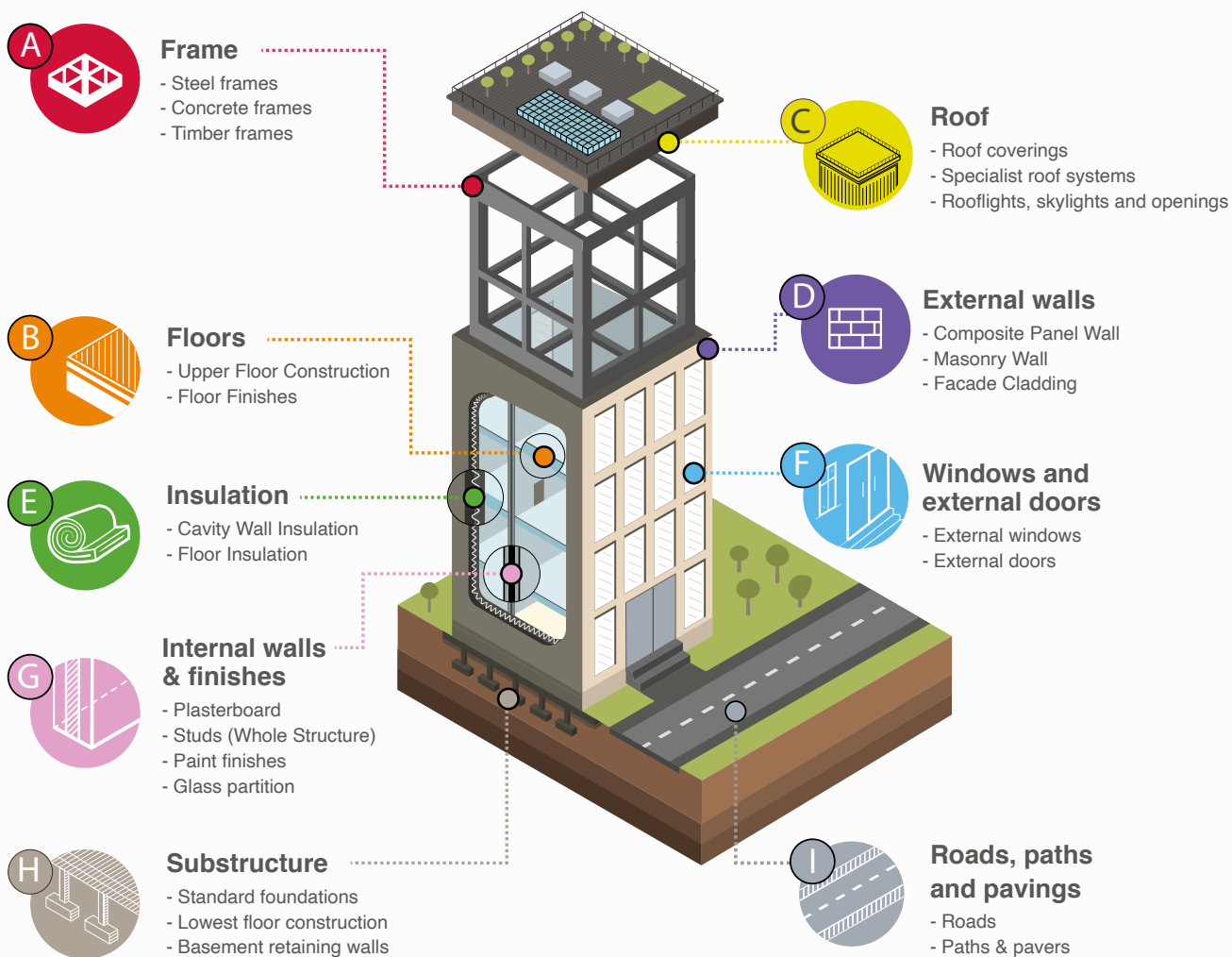
Figure 1 - C HM Treasury, Green Construction Board



3 RICS (2017), Whole life carbon assessment for the built environment: <https://www.rics.org/globalassets/rics-website/media/news/whole-life-carbon-assessment-for-the-built-environment-november-2017.pdf>

The Building Breakdown

How we have broken down the carbon impacts of a building into key categories.





1

Re-Used Steel



46.60
kg CO₂e/tonne



A1-A3

2

Galvanized Steel



1050
kg CO₂e/tonne



A1-A3

3

Cold Formed Steel



2440
kg CO₂e/tonne



A1-A3

4

Blast Furnace Steel



2590
kg CO₂e/tonne



A1-A3





Concrete frames



1

HansonC32/40 CIIB Ready Mix Concrete



178.00
kg CO₂e/m³

 **A1-A3**

2

Hanson C32/40 CIIA Ready Mix Concrete



238.00
kg CO₂e/m³

 **A1-A3**

3

Hanson GEN3 CEMI Ready Mix Concrete



245.00
kg CO₂e/m³

 **A1-A3**

4

Hanson C32/40 CEMI Ready Mix Concrete



371.00
kg CO₂e/m³

 **A1-A3**





Timber frames



1

UK Machine sawn structural timber



(-)662.74*  A1-A5
kg CO₂e/m³

2

Cross Laminated Timber



(-)653.80*  A1-A5
kg CO₂e/m³

3

Glulam



(-)630.92*  A1-A5
kg CO₂e/m³

*Sequestration of carbon from timber has not been separated within the EPDs and is included in the A1 calculations. Biogenic carbon should be calculated and presented separately during Life Cycle Assessments as the negative figure can be misleading.





Upper floor construction



1

Cross-Laminated Timber Floor (150mm)



53.30*
kg CO₂e/m²

A1-A3

2

Steel Deck (No Concrete)



32.00
kg CO₂e/m²

A1-A3

3

Pre-Cast Hollowcore Slabs (150mm)



50.20
kg CO₂e/m²

A1-A3

*Sequestration of carbon from timber has not been separated within the EPD and is included in the A1 calculations. Biogenic carbon should be calculated and presented separately during Life Cycle Assessments as the negative figure can be misleading.





Floor finishes



1

Cork Floor tile



4.65
kg CO₂e/m²

A1-A5

2

Engineered Wood Floor



4.90
kg CO₂e/m²

A1-A5

3

PVC Flooring



6.86
kg CO₂e/m²

A1-A5

4

Sika Comfortfloor® PS-27 (Polyurethane flooring)



8.31
kg CO₂e/m²

A1-A5





Floor finishes (continued)

5

Vinyl Flooring (Creation 70 CLIC) Gerflor



8.06
kg CO₂e/m²

A1-A5

6

Lightweight screed flooring



0.13
kg CO₂e/m²

A1-A5

7

Johnsons Ceramic wall tile



13.80
kg CO₂e/m²

A1-A5

8

Carpet flooring



10.23
kg CO₂e/m²

A1-A5





Roof coverings



1

Flexible Bitumen Sheets



0.05
kg CO₂e/m²

 A1-A5

2

SikaProof A



4.15
kg CO₂e/m²

 A1-A5

3

Rapid Drying One Coat Surface Damp Proof Membrane



6.04
kgCO₂e/kg

 A1-A5

4

Bitumen-polymer membrane roofing - 2 layer, fully torched (EWA)



6.72
kg CO₂e/m²

 A1-A5





Specialist roof systems



1

Zinco Green Roof



(-)1.50
kg CO₂e/m²



A1-A5

2

Hydrotech Monolithic Membrane (Blue roof)



4.87
kg CO₂e/m²



A1-A5

3

Urbanscape Green Roof



6.31
kg CO₂e/m²



A1-A5

4

Veg Tech Sedumtak (Green Roof)



11.09
kg CO₂e/m²



A1-A5





Rooflights, skylights and openings



1

Lamilux F100 GRP Rooflight



54.60
kg CO₂e/m²

A1-A3

2

Polycarbonate triple skin rooflight



155.00
kg CO₂e/m²

A1-A3

3

Velux Modular Rooflight



198.40
kg CO₂e/m²

A1-A3





Composite panel wall



1

Kingspan KS1000 wall panel



36.35
kg CO₂e/m²

 A1-A5

2

**Tata Steel Trimapanel
90/1000**



42.51
kg CO₂e/m²

 A1-A5

3

Eurobond Rockspan



53.54
kg CO₂e/m²

 A1-A5

4

**Albond Aluminium
Composite Panel**



55.60
kg CO₂e/m²

 A1-A5





Masonry wall



1

Durisol Woodchip Concrete Block



49.80
kg CO₂e/m³

A1-A3

2

Lightweight CMU



91.20
kg CO₂e/m³

A1-A3

3

Aircrete Block



168.00
kg CO₂e/m³

A1-A3

4

Trenwyth Concrete Masonry Unit (Generic)



305.00
kg CO₂e/m³

A1-A3





Facade cladding



1

Fibre Cement Panel



8.94
kg CO₂e/m²

 A1-A3

2

Stoventec Ventilated Rainscreen Cladding with organic plaster (render)



15.74
kg CO₂e/m²

 A1-A3

3

Terracotta Ceramic Facade



90.10
kg CO₂e/m²

 A1-A3

4

StoVentec Composite Glass Panel



92.81
kg CO₂e/m²

 A1-A3





Cavity wall insulation



1

**Saint-Gobain Isover UK -
glass wool**



3.04
kg CO₂e/m²

 A1-A5

2

**PIR Insulation Board
(Ecotherm)**



9.83
kg CO₂e/m²

 A1-A5

3

Rockpanel



15.97
kg CO₂e/m²

 A1-A5

4

**Extruded Polystyrene (EPS)
Foam Insulation**



79.31
kg CO₂e/m²

 A1-A5





Floor insulation



1

Glass wool/Fibre glass



1.35
kg CO₂e/kg

 **A1-A3**

2

Rockwool / Stone wool



1.40
kg CO₂e/kg

 **A1-A3**

3

EPS Insulation (standard)



2.07
kg CO₂e/kg

 **A1-A3**

4

**PIR Insulation Board
(Ecotherm)**



3.00
kg CO₂e/m²

 **A1-A3**

5

XPS Co2 Blowing



9.14
kg CO₂e/kg

 **A1-A3**





External windows



1

Accoya fixed window frame



15.83
kg CO₂e/m²

 **A1-A3**

2

QKE PVC-U



86.79
kg CO₂e/m²

 **A1-A3**

3

**REYNAERS ALUMINIUM
SlimLine 38 Window**



90.48
kg CO₂e/m²

 **A1-A3**

4

**WICONA window series -
WICLINE 75 TOP**



98.25
kg CO₂e/m²

 **A1-A3**

5

**Conservation Timber
Casement Window**



105.00
kg CO₂e/m²

 **A1-A3**





External doors



1

**Roller door, Shutters, Grills,
Garage doors (A4 Germany
manufactured)**



50.68
kg CO₂e/m²

 **A1-A4**

2

Sliding & Folding doors



97.63
kg CO₂e/m²

 **A1-A4**

3

Rolling shutters



117.85
kg CO₂e/m²

 **A1-A4**

4

Steel Door



220.58
kg CO₂e/m²

 **A1-A4**





Plasterboard



1

Breathaboard



TBC*

2

Gyproc - Plasterboard



2.42
kg CO₂e/m²

A1-A5

3

12.5 mm Plasterboard Knauf



2.88
kg CO₂e/m²

A1-A5

4

Gyproc Fireline



3.08
kg CO₂e/m²

A1-A5

*Expected to be lower than other options.





Wall studs



1

Kiln Dried (Planed or Sawn) Timber



(-)1.38*
kg CO₂e/kg



A1-A5

2

Re-Used Steel Stud



0.17
kg CO₂e/kg



A1-A5

3

British Gypsum Metal Stud



2.21
kg CO₂e/kg



A1-A5

*Sequestration of carbon from timber has not been separated within the EPD and is included in the A1 calculations. Biogenic carbon should be calculated and presented separately during Life Cycle Assessments as the negative figure can be misleading.





Paint finishes



1

Emulsion



0.11
kg CO₂e/m²

A1-A5

2

Antibacterial Acrylic Eggshell paint



0.18
kg CO₂e/m²

A1-A5

3

Dulux Trade Flat Matt



0.24
kg CO₂e/m²

A1-A5

4

Dulux Trade Quick dry Satinwood



0.50
kg CO₂e/m²

A1-A5





Glass partition



1

Optima 117 Plus Aluminium-Framed 16.8mm Single-Glazed Partition Systems



61.00
kg CO₂e/m²

A1-A5

2

Planet Aluminium framed single-glazed partition systems



63.14
kg CO₂e/m²

A1-A5

3

Revolution 100 Aluminium-Framed Single-Glazed Partition Systems



70.84
kg CO₂e/m²

A1-A5

4

Radii Aluminium Framed Single-Glazed Partition Systems



93.03
kg CO₂e/m²

A1-A5





Standard foundations



1

**Hanson Concrete C28/35
CEMIIB Ready Mix Concrete**



174.00
kg CO₂e/m³

A1-A3

2

**Hanson Concrete C28/35
CEMIIA Ready Mix Concrete**



213.00
kg CO₂e/m³

A1-A3

3

**Readymix Industries C25/30
READY-MIX CONCRETE**



259.00
kg CO₂e/m³

A1-A3

4

**Hanson Concrete C28/35
CEMI Ready Mix Concrete**



357.00
kg CO₂e/m³

A1-A3





Lowest floor construction



1

Generic ready-mixed concrete



246.00
kg CO₂e/m³

A1-A3

2

Ready-mix concrete (Tarmac)



316.00
kg CO₂e/m³

A1-A3

3

**C28/35 CEMI Ready-Mix
Concrete (Hanson)**



357.17
kg CO₂e/m³

A1-A3





Roads



1

Hudiksvall asphalt



37.00
kg CO₂e/tonne



A1-A3

2

Göteborg asphalt



45.00
kg CO₂e/tonne



A1-A3

3

Tarmac Asphalt



70.00
kg CO₂e/tonne



A1-A3

4

Precast paving product



131.00
kg CO₂e/tonne



A1-A3





Paths & pavers



1

Permeable paving



5.38
kg CO₂e/m²

A1-A5

2

Porcelain Stone Paving



20.17
kg CO₂e/m²

A1-A5

3

Clay brick Paving



36.50
kg CO₂e/m²

A1-A5

4

Tobermore City Pave VS5



48.59
kg CO₂e/m²

A1-A5



References

¹ UKGBC (2021), Net Zero Whole Life Carbon Roadmap for the UK Built Environment: <https://www.ukgbc.org/ukgbc-work/net-zero-whole-life-roadmap-for-the-built-environment/>

² UKGBC (2019), Framework Definition for Net Zero Carbon Buildings: <https://www.ukgbc.org/ukgbc-work/net-zero-carbon-buildings-a-framework-definition/>

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B - Floors

UPPER FLOOR CONSTRUCTION

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C - Roof

ROOF COVERINGS

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SPECIALIST ROOF SYSTEMS

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D - External Walls

COMPOSITE PANEL WALL

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MASONRY WALL

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E - Insulation

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G - Internal Walls & Finishes

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H - Substructure

STANDARD FOUNDATIONS

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I - External Works

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PATHS & PAVERS

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