Bons Secours Hospital, Cork,
designed, manufactured and installed by Duggan Systems Ltd

Reynaers White Paper

Embodied Carbon in Aluminium Windows, Doors and Curtain Walling Systems

Reynaers Aluminium

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September 2023

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Contents

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Introduction

Buildings account for 35% of the energy used worldwide and reducing this is essential to reducing carbon emissions.

Currently, the extraction of raw materials and associated manufacturing is responsible for 5% to 12% of greenhouse emissions. By making better use of materials and creating circular products this can be drastically cut by up to 80%.

A Government roadmap seeks to gradually reduce carbon emissions by 75% in 2025, reaching net zero in 2050. To support this reduction, Part L of the Building Regulations came into force in the UK in June 2022, stipulating window and door frames must have U-values of 1.4 W/m^2 k in existing dwellings, or 1.6 W/m^2 k in new dwellings and buildings other than dwellings. Please refer to 2021 edition of Approved Document L Volume 1 [12], Table 4.1 and Table 4.2, and Volume 2 [13], Table 4.1.

As part of its building strategy to significantly cut carbon emissions from the UK's 30 million homes and workplaces, the Government is looking into embodied carbon. Calculations performed by Arup[1] showed that around 50% of the whole life emissions of a building could come from the carbon emitted during construction and demolition.

Section 1

What is Embodied Carbon?

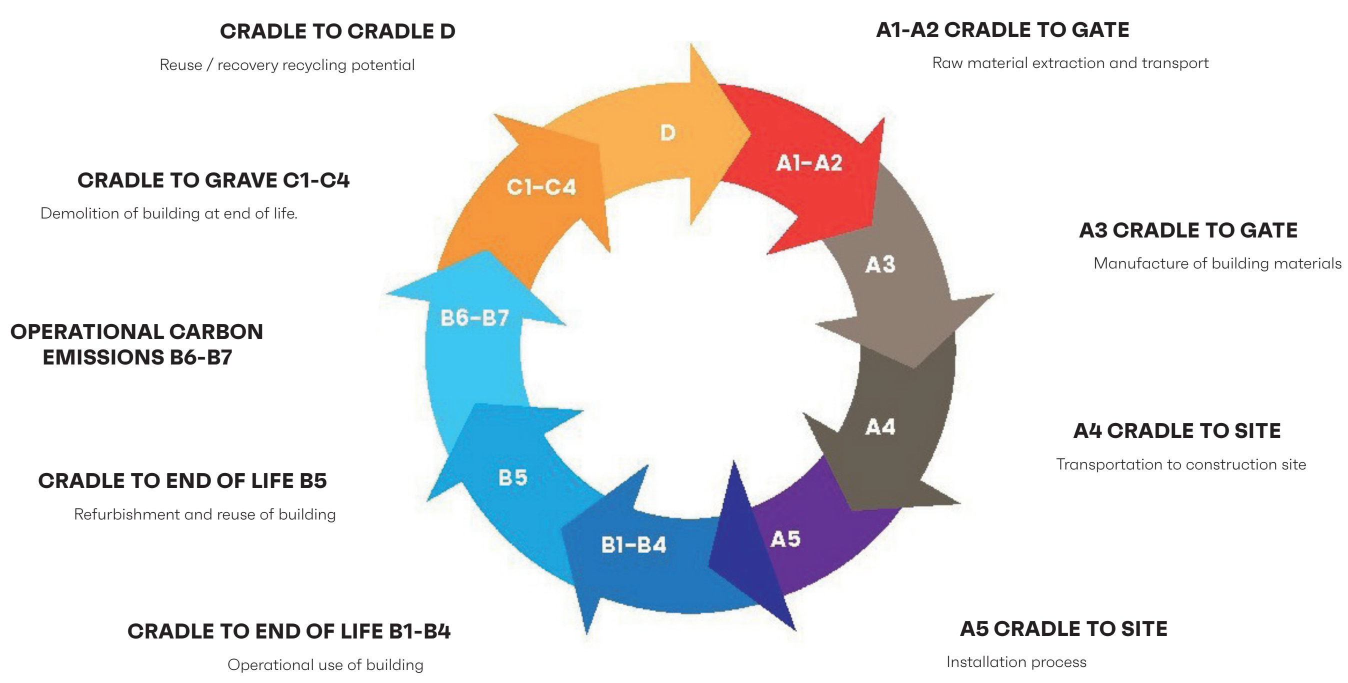
Embodied carbon is the carbon footprint of a material. It considers the amount of carbon dioxide emissions (CO_2) released during extraction, refining, processing, fabrication, assembly and transport of materials up to and including onsite building construction.

By incorporating recycled aluminium, the carbon intensity of primary aluminium production in Europe using bauxite ore has been reduced by 21% versus 2010 and by 55% compared to 1990, from 15kg CO_2e/kg to less than 7kg CO_2e/kg in 2018 compared to a global average of 18kg CO_2e/kg and a Chinese average of 20kg CO_2e/kg.

This makes it a sustainable material choice for building construction. [(2)]

What is Embodied Carbon

Carbon Life Cycle of a Building



Section 2

Approved methodologies for calculating embodied carbon [(3)] Life Cycle Framework

Life Cycle Framework
BS EN 15978 breaks the life cycle framework into 5 stages.

Product Stage: A1 - A3, includes the emissions associated with raw material extraction, processing, transportation to the manufacturer and manufacturing including facade mock-ups and any spare materials or products.

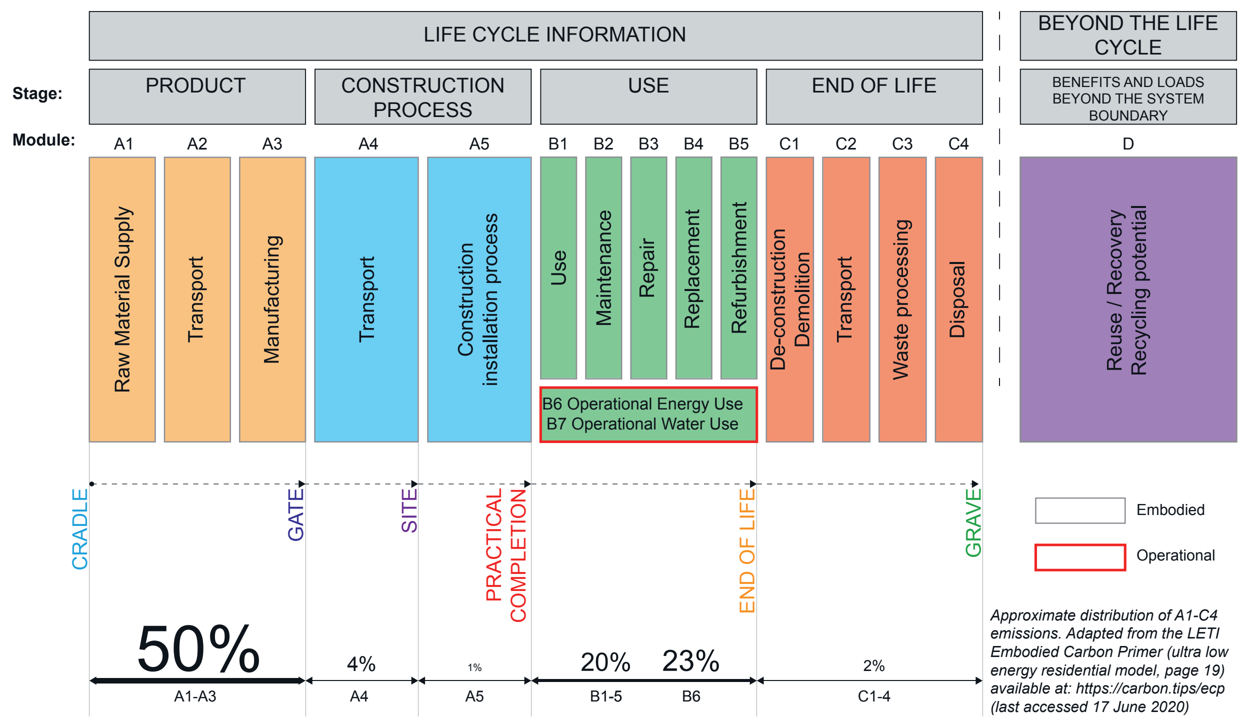
Construction Process Stage: A4 - A5, includes any emissions associated with transportation of the products to the building site and the installation into the building, including emission from on-site testing.

Use: B1 - B7, includes emissions associated with the use, maintenance, repair, replacement and refurbishment of the asset.

Modules B1 to B5 consider the embodied carbon emissions within the use stage. Modules B6 and B7 consider the operational carbon emissions associated with the operational energy and water use of the asset being assessed.

End of Life: C1 - C4, includes the emissions associated with the deconstruction, transportation away from site and end of life scenarios.

Beyond the Building Life Cycle: D, this accounts for outside the life cycle of the asset and considers the emissions and sequestration of carbon associated with recycling, recovery and reuse of materials:



The Structural Engineer. Org 'A brief guide to calculating embodied carbon' Positional only

Section 2: *Continued*

Approved methodologies for calculating embodied carbon [3]

Materials have a given Carbon Factor, usually measured in $kgCO_2e$ per kg of material. The embodied carbon (carbon footprint) for each material used in a project can be calculated by using the formula:

Quantity of material (kg) x Carbon Factor ($kgCO_2e$)

For example, Carbon Factors for aluminium are quoted as:

Type	Specification/ details	A1 – A3 ECF* ($kgCO_2e$/kg) [1]
Sheet	European consumption (31% recycled content)	6.58
	Worldwide consumption (31% recycled content)	13.0
Extruded Profiles	European consumption (31% recycled content)	6.83
	Worldwide consumption (31% recycled content)	13.2

[1] The Institute of Structural Engineers
**A1-A3 refers to the stages of a life cycle assessment (LCA) of a product or service, known as the "cradle to gate" stages of a product's life cycle. Embodied carbon associated with these modules is the largest contributor to the embodied carbon of a structure.*

The assessment must include the following minimum life cycle modules:

- Product stage [A1 – A3];
- Construction process stage [A4 – A5];
- Replacement stage [B4];
- End of life [C1 – C4].

Embodied carbon calculation for aluminium windows, doors and curtain walling

Embodied carbon = quantity of aluminium in product (kg) (refer to manufacturer) x 6.83 (carbon factor quoted by Institute of Structural Engineers)

Reynaers will shortly be offering a simple CO_2 calculator linked to their estimating software.

In accordance with BS EN 15978 section 9.4.3 and BS EN 15804 section 6.3.6 [11], all the components in a facade system must be considered if they meet the following criteria:

- The component is greater than 1% of the total facade system mass; and
- The sum of neglected components is not greater than 5% of the total facade system carbon equivalent or mass.

The Centre for Window and Cladding Technology (CWCT)[4] describe a facade as

"...an external wall or part of a building envelope."

The CWCT document, "How to calculate the embodied carbon of facades: A methodology"[4] provides the first detailed methodology for calculating embodied carbon for facades. The document is aligned with the calculation method set out in BS EN 15978 providing specific guidance and interpretation for life cycle assessment (LCA) of facades and cladding systems.

Windows and doors, curtain walling and vertical and horizontal glazing systems are included in the facade, and therefore need to be included in the life cycle assessment calculation.

Section 3

When should the embodied carbon be calculated?

CWCT[4] recommends that the embodied carbon of facades should be assessed at all key project stages to enable targeted carbon reductions.

According to the Institution of Structural Engineers (ISE)[3], the most important time to calculate embodied carbon within a construction project is in the early design stages, providing time and scope to make any required changes to a design as a result of the embodied carbon assessment.

The assessment should cover[5]:

i. The development's carbon emissions over its lifetime, taking into account its operational carbon emissions (both regulated and unregulated).

ii. Embodied carbon emissions, and any further potential carbon emissions 'benefits', post 'end of life', including any benefits from reuse and recycling of the building structure and materials.

Section 4

Reynaers *Act*[6]

Reynaers *Act* was published in alignment with the UK signing up to the Paris Climate Agreement which set out goals to keep global warming well below 2°C and pursue efforts to limit temperature increase to 1.5°C. It lays out the company's specific sustainability targets to reduce emissions in line with the UK Government's pledge to reach net zero greenhouse gas emissions by 2050.

The publication details the company's commitment to reducing direct carbon emissions by 46% and indirect emissions by 55% by 2030 with a view to reaching net zero by 2050.

Reynaers Aluminium is looking to achieve this by reducing the primary aluminium content in its products and continued development of circular products in addition to reducing the carbon footprint in its operations, value chain and product portfolio.

The company also details its commitment to working with its workforce to make sustainability second nature.

Reynaers products have already met, and in some instances improved upon the requirements of Part L of the Building Regulations which came into force in June 2022 to improve thermal efficiency of doors and windows.

Reynaers *Act*

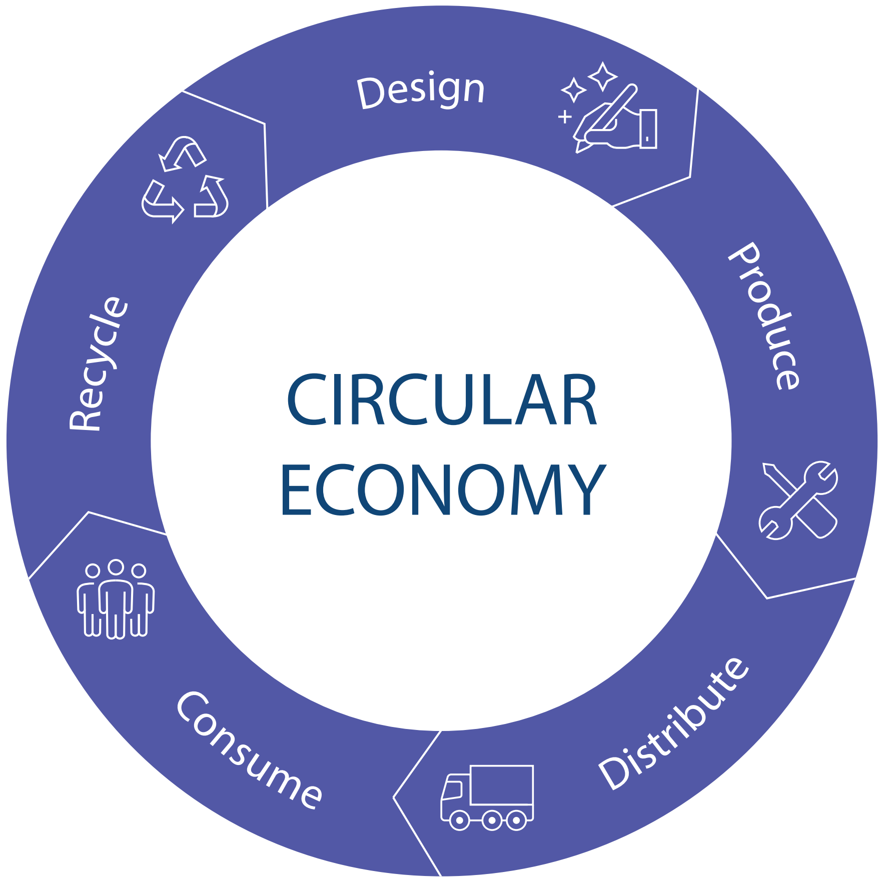
Section 5

The future of aluminium as a sustainable material choice

The strength, durability and long life of aluminium gives it strong sustainability credentials. Aluminium components can be easily replaced and are easily dismantled for reuse or recycling.

The material is infinitely recyclable and can also be reused endlessly without downcycling, enabling the creation of circular products that operate within the circular economy model. Aluminium is in fact a front runner of the circular economy.

"Aluminium is produced by an industry that is actively reducing its emissions and has a clear plan to meet global climate goals along with a commitment to transparent and data-driven approaches, increasingly in demand from stakeholders. aluminium is an essential material for sustainable solutions and to ensure this continues, the aluminium industry is committed to delivering a sustainable material."[7]



Reynaers Group *"Our Sustainability Strategy 2022 - 2025"*

Section 6

The advantages of aluminium[8]

The use of aluminium building components offers the following advantages which contribute to the overall environmental performance and improved Life Cycle Analysis of a building.

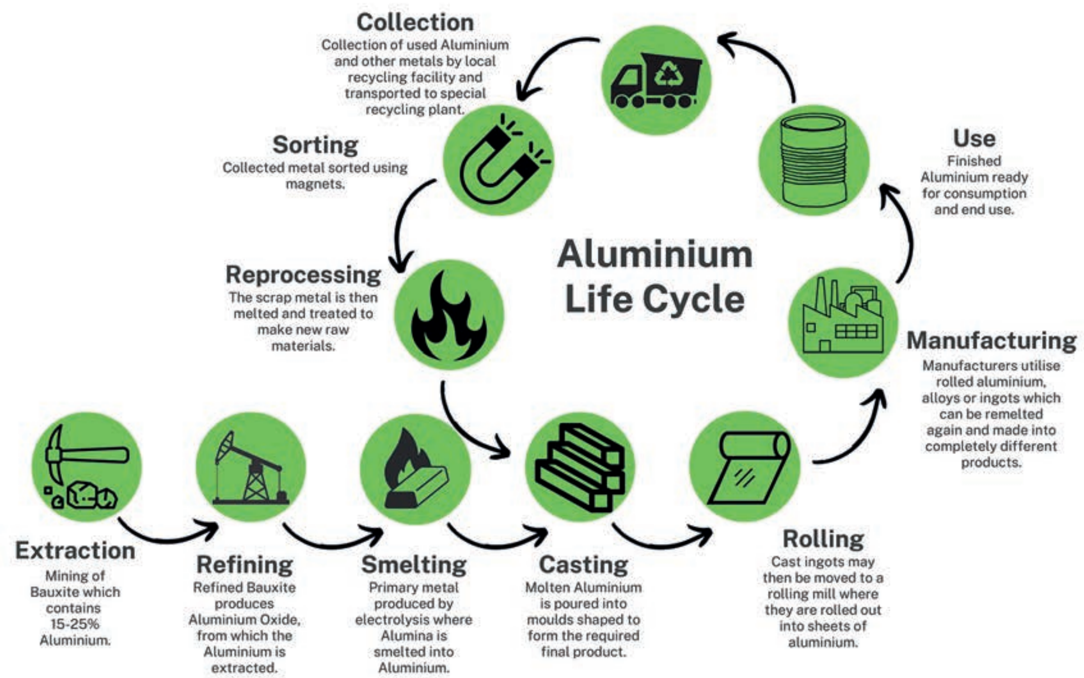
- **Recyclability** - Aluminium can be endlessly recycled with no effect on quality. The recycling process requires only 15% of the energy used to produce primary aluminium giving a significant CO_2 saving benefit.

  It should be noted that aluminium is recognised as being one of the most recycled materials on earth with a current global recycling efficiency rate of 76%.

The International Aluminium Institute reports that Europe has the highest Recycling Efficiency Rate (RER) in the world, recovering 81% of aluminium scrap available in the region.[9]

Although the embodied carbon intensity of recycled aluminium is higher than that of timber (Glued Laminated Timber (Glulam) = 0.28 kg CO_2e/kg; Cross-Laminated Timber CLT) = 0.25 kg CO_2e / kg),[10] it is infinitely recyclable compared to timber which has limited recyclability.

Additionally, trees must be felled to obtain the timber.



Section 6: *Continued*

The advantages of aluminium[8]

- **Lightweight** - Aluminium is one third of the density of steel making it easier to transport and install. It is however extremely strong and can provide the same strength relative to weight ratio as advanced steel and titanium and can carry the largest and heaviest glass panes.
- **High Conductivity** - excellent heat and electricity conductor enabling energy efficient systems for electricity transmission.
- **Corrosion Resistant & Highly Durable** - develops a natural oxide layer which protects it against corrosion, making it virtually maintenance-free.

Aluminium requires much less maintenance than timber and is not affected by extremes in temperature or weather and does not expand, contract or warp in use unlike timber.

- **UV resistant**
- **Easy to Work With** - Easy to form, join and work with.
- **Impermeability** - excellent barrier against light, odour and contamination.

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Conclusion

In the Circular Economy, the *"cradle to gate"* stage, which covers the extraction, supply and manufacture of a product, is the largest contributor to the embodied carbon of a structure, it accounts for 50% of the total carbon emissions of a product's lifecycle.

The incorporation of recycled aluminium as a replacement for mined bauxite ore in the manufacturing process, has resulted in a significant reduction of the embodied carbon of aluminium products.

Aluminium is strong, durable, infinitely recyclable and low maintenance, making it an ideal choice for construction products, including windows, doors and curtain walling, where it will contribute to the overall environmental performance of buildings.

The increased use of recycled aluminium, plus the commitment to sustainable production, leading to reduction in embodied carbon, further underlines the environmental credentials of aluminium.

It must be noted however that, even though aluminium is currently a front runner in the creation of a circular economy, it is essential that *"the use of circular products to cut waste and energy as part of an overall focus on sustainable operations"*[6] is maintained and further improved upon to ensure a sustainable circular economy.

Reference Sources:

(1) Arup (www.arup.com)

(2) European Aluminium - *'A Strong, Sustainable & Complete European Value Chain'* (https://european-aluminium.eu/about-aluminium/aluminium-industry/)

(3) The Structural Engineer. Org *'A brief guide to calculating embodied carbon'* https://www.istructe.org/IStructE/media/Public/TSE-Archive/2020/A-brief-guide-to-calculating-embodied-carbon.pdf

(4) Centre for Window and Cladding Technology (CWCT): *'How to calculate the embodied carbon of facades: A methodology'*

(5) Whole Life-Cycle Carbon Assessments guidance | GLA (london.gov.uk)

(6) Reynaers Aluminium: www.reynaers.co.uk/sustainability

(7) World Climate Foundation *'Aluminium: A Sustainable Metal for a Sustainable World'* Aluminium: A Sustainable Metal for a Sustainable World (worldclimatefoundation.org)

(8) European Aluminium: *'Aluminium: A Unique Metal Driving the Green Transition'* https://european-aluminium.eu/about-aluminium/the-material/

(9) International Aluminium: *'Aluminium Recycling Fact Sheet'* https://international-aluminium.org/resource/aluminium-recycling-fact-sheet/

(10) The Institution of Structural Engineers: *'Mass Timber Embodied Carbon Factors'* https://www.istructe.org/resources/blog/mass-timber-embodied-carbon-factors/

(11) The Institution of Structural Engineers: Structural Steel and the Circular Economy CPD: https://www.istructe.org/IStructE/media/Public/TSE-Archive/2021/Industry-CPD-Structural-steel-and-the-circular-economy.pdf

(12) HM Government: *'Approved Document L, Volume 1'*: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1133079/Approved_Document_L__Conservation_of_fuel_and_power__Volume_1_Dwellings__2021_edition_incorporating_2023_amendments.pdf

(13) HM Government: *'Approved Document L, Volume 2'*: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1133081/Approved_Document_L__Conservation_of_fuel_and_power__Volume_2_Buildings_other_than_dwellings__2021_edition_incorporating_2023_amendments.pdf

ABOUT REYNAERS ALUMINIUM

"Our goal is to increase the value of buildings and to enhance the living and working environment of people worldwide."

As part of the Reynaers Group, Reynaers Aluminium is a leading specialist in the development, distribution and commercialization of innovative and sustainable aluminium architectural solutions. These include a wide variety of window and door systems, curtain walls, sliding systems, and conservatories. Besides the extensive range of standard solutions, we also develop customized solutions, tailored to the individual customer or project.

Based in Birmingham, Reynaers is ideally placed to support projects across the UK. Alongside its Knowledge Centre and warehouse, Reynaers' showroom provides a space for customers to explore products and receive hands-on training. Part of Reynaers Group (headquartered in Duffel, Belgium), the building envelope specialist has offices in more than 40 countries and currently employs more than 2,600 people worldwide.

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