SUSTAINABLE CEILINGS

Reducing Carbon Footprint with Aluminium Ceiling Systems

Network Architectural

Introduction

Aluminium is one of the most recent metals discovered by humans, with its practical use only emerging in the 19th century thanks to advances in chemistry and the advent of electricity. In 1825, Danish chemist Hans Christian Ørsted made a breakthrough by producing a small lump of metal that he described as resembling tin. Ørsted's relatively unknown discovery was monumental, on par with the discovery of electromagnetism in terms of its impact on society.

Initially, aluminium was so rare that in the mid-19th century, it was more expensive than gold. Napoleon III famously used aluminium dinnerware for himself and visiting dignitaries, while less important guests had to settle for gold plates. By the 1930s, aluminium began to be used as a building material due to its lightweight and durable nature, with the spire of the Empire State Building being one of its first architectural applications.

This versatile material continues to shape modern engineering and construction. Aluminium is widely used in ceiling systems due to its lightweight nature and durability, making it easy to install and maintain while providing long-term structural support. Its corrosion resistance and sleek appearance also make it an ideal choice for modern, aesthetic ceiling designs in both commercial and residential spaces.

Aluminium's sustainability credentials are often overlooked due to its high energy consumption to produce. This paper will explore how aluminium ceiling systems, with their recyclability and long lifespan, can reduce the embodied and operational carbon impact of construction projects.

ENVIRONMENTAL IMPACT OF ALUMINIUM

Aluminium is the third most abundant element in the Earth's crust, making up 8.2% after oxygen and silicon, and it is the most plentiful metal on the planet.[1] The production of aluminium begins with the extraction of bauxite. In 2022, Australia, one of the leading producers of bauxite globally, mined 100 million tonnes of this primary ore.[2]

The main drawback of aluminium is its energy-intensive production process, which remains a challenge for reducing its overall carbon footprint. As you can see from the below table, aluminium uses the most carbon and energy to produce and has high embodied energy levels.

Over the past decade, the global average of direct emissions from aluminium production has been steadily decreasing at a rate of about 2% per year.[3] However, in order to meet the zero emissions by 2050 target, this reduction needs to accelerate to nearly 4% per year by 2030.[4] To achieve this, the aluminium industry must adopt and implement near-zero emission technologies to significantly reduce emissions from both alumina refining and the production of primary and recycled aluminium. Additionally, the industry and its customers must prioritise increasing the collection, sorting, and recycling of scrap aluminium.

Table 1. Global warming impact of aluminium

	material	group	impact / m3
1	Aluminium sheet	metal	28242 kg $CO_{2\,eq}$/m3
2	Galvanised steel	metal	22923.1 kg $CO_{2\,eq}$/m3
3	Structural steel	metal	8831.2 kg $CO_{2\,eq}$/m3
4	Paint, matte	andet	2851 kg $CO_{2\,eq}$/m3
5	Fibre cement boards	mineralsk	699 kg $CO_{2\,eq}$/m3
6	PIR insulation	kunststof	781.4 kg $CO_{2\,eq}$/m3
7	Brick, red, single-fired	andet	565.2 kg $CO_{2\,eq}$/m3
8	Concrete C30/37	mineralsk	288 kg $CO_{2\,eq}$/m3
9	Gypsum board	mineralsk	169.6 kg $CO_{2\,eq}$/m3
10	Plywood	trae	-649 kg $CO_{2\,eq}$/m3
11	Cross-laminated-timber CLT	trae	-664 kg $CO_{2\,eq}$/m3
12	Construction timber	trae	-680 kg $CO_{2\,eq}$/m3

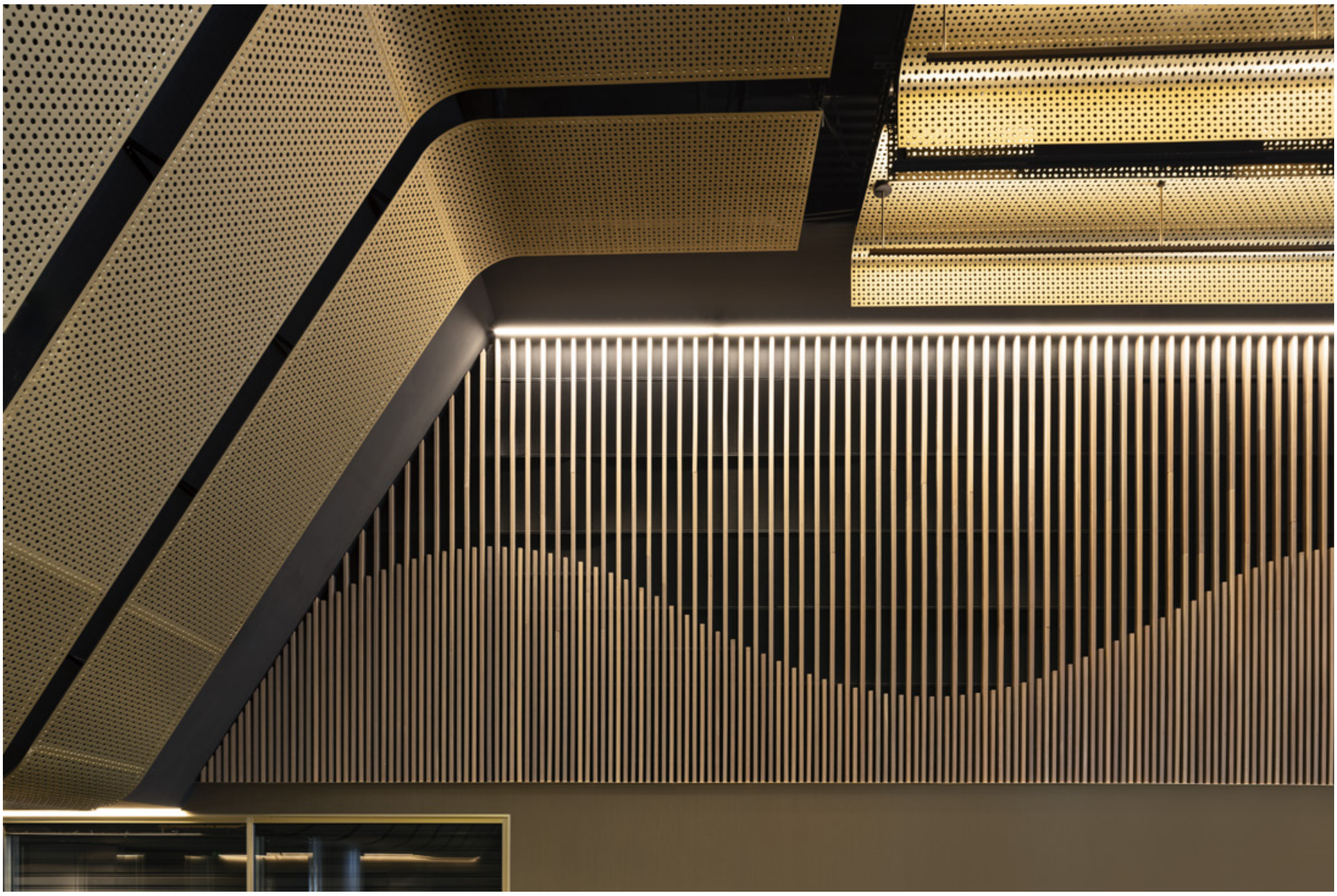
By recycling aluminium, we eliminate the need for energy-intensive mining and chemical extraction processes, as the metal can be melted down and reformed with relatively low energy consumption.

WHY USE ALUMINIUM IF IT IS SO CARBON INTENSIVE?

Despite its carbon emissions footprint during production, aluminium offers numerous benefits as a construction material. When combined with small amounts of metals like magnesium, aluminium forms strong alloys that are as durable as steel. Aluminium is only one-third the weight of steel, giving it an exceptional strength-to-weight ratio—allowing aluminium structures to support the same load as steel while being significantly lighter. Unlike steel, aluminium retains its ductility across extreme temperatures, which is why it is currently being used for space shuttle applications.

Aluminium is also highly resistant to corrosion. Rather than rust, which can compromise the structural integrity of steel, aluminium forms a stable oxide layer that protects the material from further damage. Processes like anodising enhance this protective layer, increasing wear and UV resistance, while powder coating, a more environmentally friendly alternative to traditional paint, adds further durability without the use of harmful chemicals.

Aluminium provides architects with extensive design flexibility due to its lightweight nature, strength, ease of shaping, and its finishes, which come in an unlimited range of colours and textures. With excellent surface properties, aluminium is a practical and long-lasting material for modern construction projects that can outlast most other materials, reducing the need to replace.



ALUMINIUM PRODUCTION AND THE CIRCULAR ECONOMY

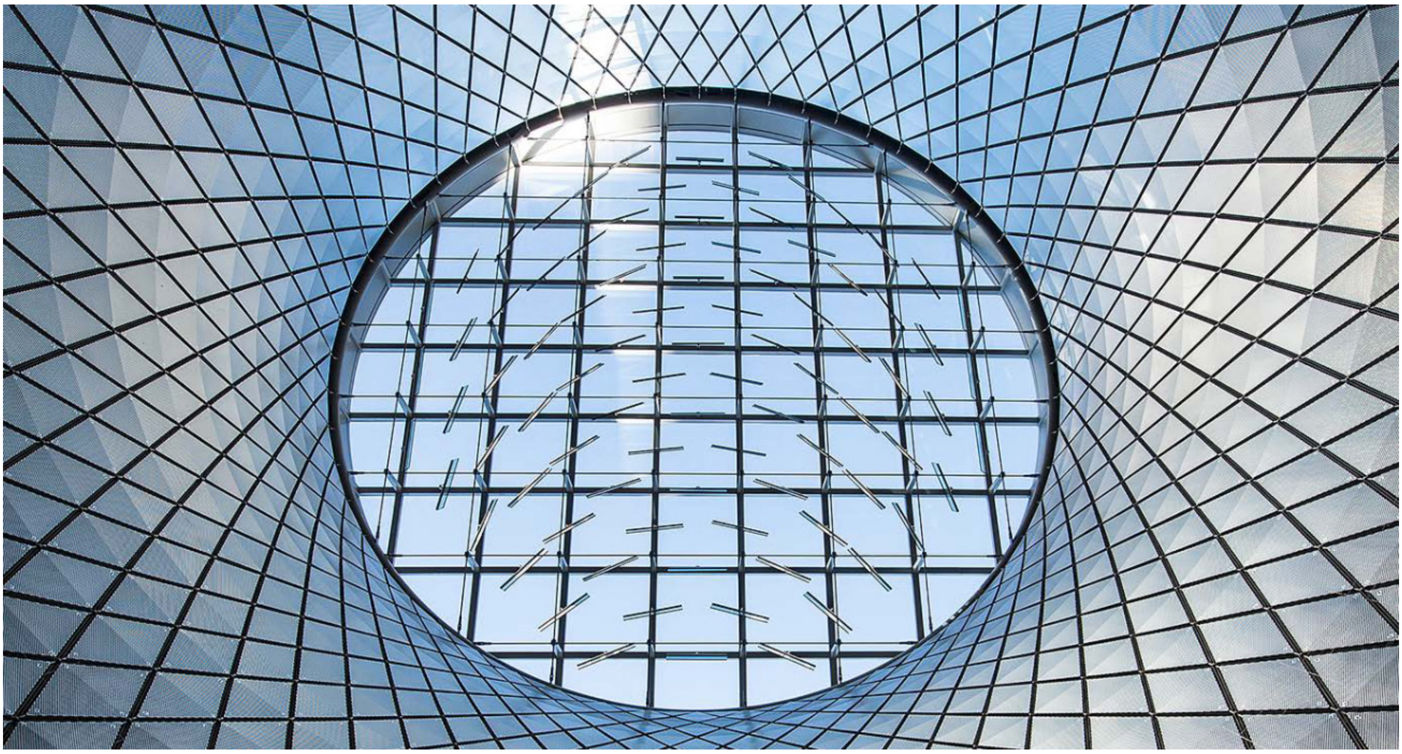
Unlike metals like gold, lead, copper, iron, and zinc, aluminium is not found in nature in a usable form and must be extracted from bauxite ore. Mining of bauxite, however, can have significant environmental impacts. It often leads to habitat destruction, affecting local ecosystems and wildlife. Additionally, the process can contaminate nearby water and soil, posing risks to both the environment and local communities. Mining operations also typically increase water usage, adding further strain on local resources.

One of the key advantages of aluminium is that it can be reused and infinitely recycled. By recycling aluminium, we eliminate the need for energy-intensive mining and chemical extraction processes, as the metal can be melted down and reformed with relatively low energy consumption. In fact, recycled aluminium requires only 5% of the energy needed to produce it from raw materials.[5] This makes aluminium a prime choice for sustainable construction, with an estimated 60% of all aluminium used in building projects coming from recycled sources.[6]

When the collection, transportation, and re-smelting of recycled aluminium are powered by renewable energy sources such as solar, nuclear, or hydroelectric power, the carbon footprint is further minimised. These clean energy sources significantly reduce greenhouse gas emissions compared to traditional fossil fuels. This combination of recycling and renewable energy helps create a more sustainable cycle for aluminium production.

It is important to note that recycling post-consumer waste is more environmentally beneficial than pre-consumer waste. While both types of recycling are valuable, pre-consumer waste, like factory off-cuts, has never been used, meaning the full embodied energy must still be accounted for as if it were virgin material. In contrast, post-consumer waste has already gone through its initial life cycle, and reusing it helps reduce the overall carbon footprint by avoiding further extraction and production processes.

Architects and designers play a critical role in promoting sustainable practices across the design and construction process. By encouraging the reuse and recycling of aluminium, they can help reduce the demand for newly sourced material. Architects can also avoid over-specification of primary aluminium in projects, opting instead for recycled materials wherever possible. Additionally, selecting high-performance aluminium building cladding ensures that aluminium's sustainability benefits are maximised throughout the lifecycle of a project.



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ALUMINIUM IN ACTION—METAL CEILINGS

Aluminium ceilings can have a significant impact on reducing both operational and embodied carbon emissions in building projects, as seen in notable examples like Changi Airport's Terminal 3 in Singapore and the Fulton Centre subway station in New York.

In the case of Changi Airport, the use of thousands of aluminium butterfly panels and light wells demonstrates how aluminium can be integrated into a building's ceiling system to enhance natural lighting and minimise energy consumption. By using aluminium reflectors to guide daylight into the terminal, this system significantly reduces the need for artificial lighting during the day, saving approximately 2,400 tons of CO2 annually. The dynamic, sensor-controlled shading and lighting system ensures that a controlled amount of daylight enters while minimising harsh sunlight and glare.

This system, planned by Bartenbach LichtLabor [Lighting Laboratory] and implemented by durlum, highlights the advantages of aluminium in ceiling systems. Aluminium's lightweight and reflective properties make it ideal for directing natural light. By using aluminium panels, architects and engineers managed to balance embodied carbon emissions from material production and transportation with significant reductions in operational emissions during the building's lifetime.

Similarly, the Fulton Centre subway station in New York demonstrates how aluminium can be used creatively to reduce energy consumption. The station's ceiling comprises 953 unique perforated aluminium panels, each designed to reflect natural light based on its specific position. This custom design, developed in collaboration with Arup, James Carpenter, and Grimshaw Architects, not only enhances the aesthetics of the station but also optimises natural light and reduces the need for artificial lighting. The use of aluminium in the ceiling system played a key role in the station achieving LEED Silver certification.

DURLUM METAL CEILINGS AND LIGHTING SOLUTIONS

durlum is a leading manufacturer of versatile, sustainable metal ceilings and integrated lighting solutions, known for creating bespoke designs for various commercial projects such as airports, railway stations, and office buildings. Their flexible ceiling systems offer a wide range of colours, textures, perforations, and finishes, allowing for creative customisation to meet any design requirement. durlum's ceilings are engineered for durability and resistant to water damage, mould, and fire, making them a low-maintenance and safe choice for long-term use.

Committed to sustainability, durlum holds an Environmental Product Declaration for its steel, aluminium, and chilled/heated ceilings and operates under ISO 14001 and ISO 50001 certifications. Their focus on sustainable practices aligns with their exclusive distributor, Network Architectural, and their regional Product Stewardship Policy in Australia.

REFERENCES

1 Australian Government. “Aluminium.” Geoscience Australia. https://www.ga.gov.au/education/minerals-energy/australian-mineral-facts/aluminium (accessed 7 October 2024).

2 Australian Aluminium Council. “Australian Bauxite.” AAC. https://aluminium.org.au/australian-industry/australian-bauxite (accessed 7 October 2024).

3 International Energy Agency. “Aluminium.” IEA. https://www.iea.org/energy-system/industry/aluminium (accessed 7 October 2024).

4 Ibid.

5 Aluminium Association. “Infinitely Recycleable.” AA. https://www.aluminum.org/Recycling (accessed 7 October 2024).

6 Aluminium Association. “Building & Construction.” AA. https://www.aluminum.org/building-construction (accessed 7 October 2024).

All information provided correct as of October 2024.

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