Composite Frames = CO_2 Reduction

Introduction

This report presents a comparative analysis of composite and aluminium frames based on energy intensity across materials and manufacturing processes. The data is drawn from a Life Cycle Assessment (LCA) published by Elsevier. The findings reveal that composite frames, produced through energy-efficient methods, require significantly less energy over their lifecycle and result in substantially lower CO_2 emissions. These results position composite as a viable and more sustainable alternative within solar frame applications.
The aim of CBAM is to reduce global CO_2 emissions and avoid "carbon leakage" (the relocation of production to regions with weaker climate policies).

Energy Intensity

This section presents an analysis of the energy intensities of materials and manufacturing processes, followed by a comparison between composite and aluminium.

Materials	Energy intensity (MJ/kg)
Polymers	
Polyester	63-78
Epoxy	76-80
LDPE	65-92
PP	72-112
PVC	53-80
PS	71-118
PC	80-115
Fibers	
Glass fiber	13-32
Carbon fiber	183-286
China reed fiber	3,6
Flax fiber	6,5
Metals	
Aluminum	196-257
Steel	30-60
Stainless steel	110-210
Copper	95-115
Zinc	67-73
Cast iron	60-260

Source: Glass fiber: 30 ,32,33 Aluminium: 2,36,37

As shown in Table 1, glass fiber (13–32 MJ/kg) has a significantly lower energy than aluminium (196–257 MJ/kg)

Manufacturing methods	Energy intensity (MJ/kg)
Autoclave molding	21,9[a]
Spray up	14,9[a]
Resin transfer molding (RTM)	12,8[b]
Vacuum assisted resin infusion (VARI)	10,2[b]
Cold press	11,8[b]
Preform matched die	10,1[b]
Sheet moulding compound (SMC)	3,5[b]
Filament winding	2,7[b]
Pultrusion	3,1[b]
Prepreg production	40,0[b]
Injection moulding (hydraulic)	19,0[c]
Glass fabric manufacturing	2,6[d]
Iron casting (Cupola)	13,6[e]

Source: 5 (Pultrusion and Cold press)
**note that the energy intensities represent energy associated only with processes not relevant materials*

Table 2 shows the energy intensity of manufacturing processes. The composite frame is produced using pultrusion, with an energy intensity of 3.1 MJ/kg, compared to 11.8 MJ/kg for aluminium frames manufactured by cold pressing.

	Direct fossil (MJ/kg)	Electricity (kWh/kg)	Total energy (MJ/kg)
Process analysis			
Fiber production	9,86	0,66	12,24
Fabric production	0,056	0,199	0,772
Fabric production	n/a	n/a	34,2
Fabric production		n/a	3,1
Sub-total			50,31
Additive analysis			
Submaterial	25,87	1,02	29,35

Compression of Composite and Aluminum	Composite (MJ/kg)	Aluminum (MJ/kg)
Mean materials	Glass Fiber (13+32)/2 = 22,5	Aluminum (196+257)/2 = 226,5
	Sub-total table 3: 79,66	Cold press = 11,8
Total	102,16	238,3

Composite emits 57.1% less CO_2 than aluminium

Explanation

- 102.16 = CO_2 of composite
- 238.2 = CO_2 of aluminium
- CO_2 reduction (%) = 100 × (1 - 102.16 / 238.2) = **57.1%**

Recycling

Composite materials have long been seen as less sustainable due to the lack of effective recycling methods. Foremost has overcome this limitation by developing its own recycling process, making the composite frame fully recyclable. Learn more in Xilia's 'Find Out More: Recycling' section.

ESG

Cutting CO_2 emissions is one of the most measurable ways to advance the ESG goals.

Conclusion

The comparative data demonstrates that composite frames have a significantly lower carbon footprint than aluminium, both in material production and manufacturing processes. With a total energy intensity of 102.16 MJ/kg compared to 238.3 MJ/kg for aluminium, composite frames generate approximately 57.1% less CO_2 emissions over their lifecycle.

Combined with their full recyclability, made possible through Foremost's recycling process, composite frames now present a credible and sustainable alternative for solar frame applications.

References

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CBAM = The Carbon Cost at the EU Border

Carbon Border Adjustment Mechanism

Introduction

The Carbon Border Adjustment Mechanism (CBAM) is a carbon pricing system for imported goods, effective as of 1 January 2026. It ensures that certain goods produced outside the EU are subject to a carbon cost equivalent to that within the EU, based on the emissions released during their production.

CBAM aims to reduce global CO_2 emissions and avoid "carbon leakage" (the relocation of production to regions with weaker climate policies).

CBAM currently covers high-emission sectors, including aluminium, iron and steel, cement, fertilizers, hydrogen, and electricity. This directly affects solar module manufacturers that use carbon-intensive materials, such as aluminum frames.

Cost

During the transitional phase (2023–2025), only emissions reporting was required. From 2026, financial obligations will begin, gradually increasing until 100% of emissions are covered by 2034. Manufacturers sourcing low-emission materials, such as composite frames, could avoid CBAM costs and improve their competitiveness in the EU market.

Rate of Reduction

Year	% of emissions you must pay for
2026	2,5%
2027	5%
2028	10%
2029	22,5%
2030	48,5%
2031	61%
2032	73,5%
2033	86%
2034	100% (fully charged)

Reference

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