ALUCOBOND®, building the future in a sustainable and efficient way

Selecting building materials to limit the impact on the environment has become a major task. The construction is the most energy-consuming sector and second in producing the most Global Warming Potential (GWP) after the transport sector.

However, it is difficult to know which products have the least impact on the environment, because many elements must be taken into account.

As an expert in aluminum composite facade cladding (ACM) with our product ALUCOBOND®, it is our duty to inform you, to guide you, in a simple and clear way, in order to help you choose the most efficient building solution, with respect for the environment and compliance with standards. The carbon neutrality of materials does not exist. On the other hand, everyone can contribute to reducing the overall carbon footprint, for this, we must facilitate understanding.

Thermal regulations / Environmental regulations

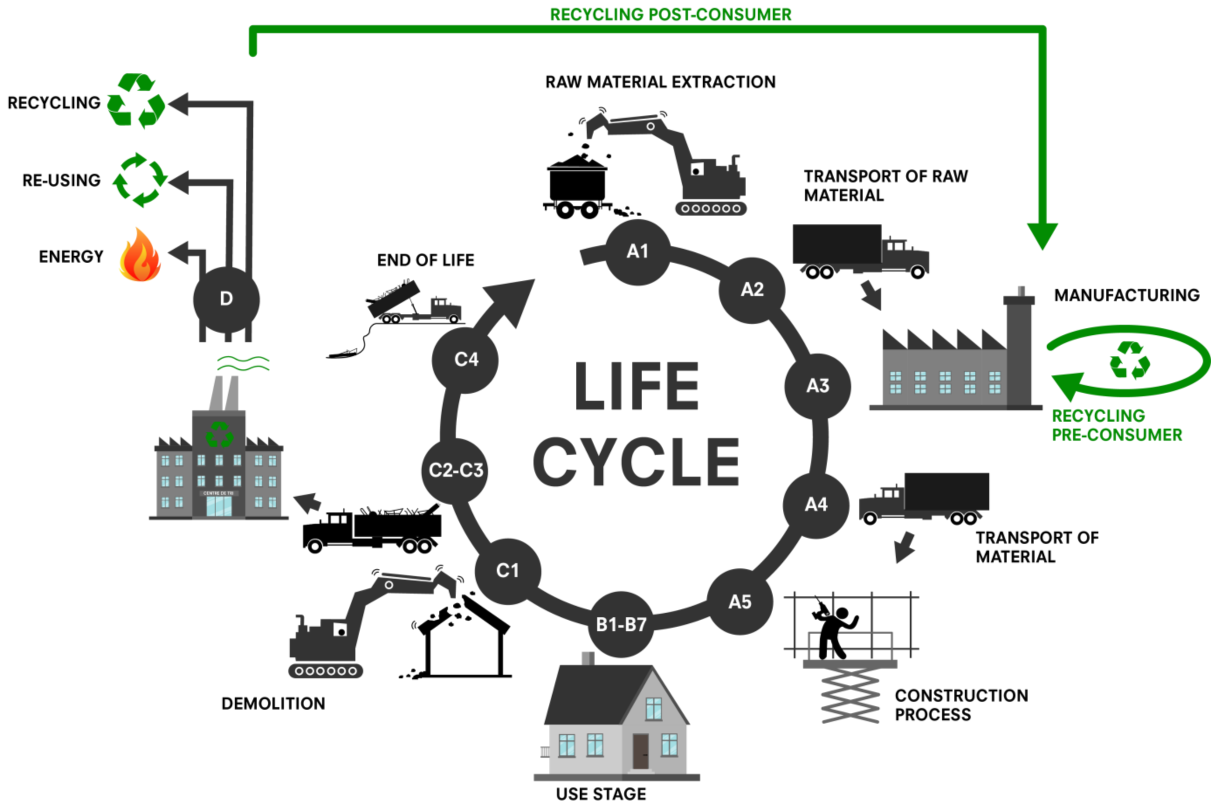
After the oil crisis in 1973, thermal regulations appeared in Europe, reaching nowadays, the level of the "passive house", pioneering concepts for building low-energy houses.

Unfortunately, improving the insulation and the energy efficiency is not enough to reduce the carbon footprint and the global warming. The thermal regulations are becoming environmental regulations, taking in consideration the environmental impact of each building material used on a building, for this a Life Cycle Assessment (LCA) is necessary.

Life Cycle Assessment (LCA)

The "embodied energy" is the energy included in the material, it is not seen, but it helps to demonstrate the environmental impact of a material. It corresponds to the amount of resources and environmental impacts required to produce a material over the entire life cycle.

The life cycle assessment of a material takes this embodied energy into account, from the search for raw materials to the end of the material's service life. This includes: extraction of the raw material, transport, manufacture, installation, maintenance, dismantling and recycling.



A1: Raw material extraction
A2: Transport
A3: Manufacturing
A4: Transport from the gate to the site
A5: Construction process
B1: Use
B2: Maintenance
B3: Repair
B4: Replacement
B5: Refurbishment
B6: Operational energy use
B7: Operational water use
C1: De-construction / demolition
C2: Transport
C3: Waste processing
C4: Disposal
D: Benefits and loads beyond the system boundaries (Reuse-Recovery-Recycling potential)

This material life cycle assessment can be found in each EPD (Environmental Product Declaration) or in each FDES (Environmental and Health Declaration Sheet) in France. There is no limit to be respected as in the case of a certification, but the values found in this analysis can be used as a basis for the certifications.

To compare different EPD's (or FDES), it is necessary to check that the basic data is identical:

1) The service life should be the same. Often it is 50 years, but when comparing with a material that has a shorter or longer lifespan, a coefficient should be applied to all LCA values.
2) The functional unit (ton, kg, m^3, m^2, etc.) must be the same in order to be comparable, the facade/cladding elements must be compared in m^2.
3) Sometimes we find the same unit (m^2) but there is a percentage of openings (windows) included, more than 30% on the facade, this is a trick to reduce the LCA values by more than 30%!
4) These declarations cannot be comparable if they do not comply with standard EN 15804 + A, with same issue date.
5) We cannot precisely compare an FDES and an EPD together, the material database is not the same.
6) Raw data has to be provided by the same data base.
7) Allocations must be on the same national level, respectively the PCR should be equivalent.

Environmental product declarations are the most reliable source of ecological information on building materials, in standardized form according to uniform rules.

Extraction of raw materials

The embodied energy of materials is available on the internet but the values vary a lot between each source. In addition, it is indicated in kWh/ton or in kWh/m^3 in Europe, in GJ/ton or MJ/kg in the USA. The units used do not allow you to compare 2 materials together, since the technical characteristics of each material are different.

Rather, the unit should be converted into the same unit, for example kWh/m^2, depending on the thickness of the material with equivalent technical characteristics. For example, to compare insulation in kWh/m^2, we will use the same thermal resistance R, the thickness of each insulation will then vary.

Here are the gray energy values of building materials, source Wikipedia FR/ecoconso.be:

Metal	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
Steel	60 000	0,75	45
Recycled steel	24 000	0,75	18
Copper	140 000	1	140
Zinc	180 000	1	180
Aluminium	190 000	1	190
Recycled aluminium	9 500	1	9,5

Bearing walls	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
Hollow brick	450	300	135
Brick	1 200	65	78
Aerated concrete	200	300	60
Concrete	500	180	90
Reinforced concrete	1 850	180	333

Plasters	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
clay-based plaster	30	10	0,3
Lime plaster	450	10	4,5
Gypsum plaster	750	8	6
Cement plaster	1 100	18	19,8
Synthetic plaster	3 300	15	49,5

Substructure	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m)
aluminium (30% recycled) T 60x100x2,0mm	135 850	2	38,0
Timber 80x45mm	180	45	0,6
Laminated timber 80x45mm	2 200	45	7,9

Lightweight walls	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
Gypsum plaster board	850	10	8,5
Fibre-reinforced gypsum board	900	12	10,8
Chipboard panel	2 200	12	26,4
Wood-fibre board (hard)	3 800	12	45,6
Plywood	4 000	12	48

Thermal insulation (R=4,2 K.m^2/W)	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
Linen fibers	30	160	4,8
Hemp fibres	40	160	6,4
Wood cellulose	50	230	11,5
Sheep's wool	55	150	8,25
Straw-bale	1	220	0,22
Stone wool	150	160	24
Perlite	230	220	50,6
Glass wool	250	160	40
Expanded clay	300	500	150
Cork panel	450	170	76,5
Expanded polystyrene	450	160	72
Polyesters	600	160	96
Extruded polystyrene	850	160	136
Polyurethane foam	100 à 120	140	140 à 168
Wood fiber boards (soft)	1 400	180	252
Foam glass	700 à 1 300	210	147 à 273

Roofing	embodied energy (kWh/m^3)	thickness (mm)	embodied energy (kWh/m^2)
Concrete roof tile	500	12	6
Terracotta roof tile	1 400	12	16,8
Fibre cement roof tile	4 000	12	48

The example of aluminum is interesting because it is considered to be the raw material requiring the most energy during its extraction. The values for the extraction of aluminum vary between 130 000 kWh/m^3 and 190 000 kWh/m^3 depending on the source, production process and region, the difference is huge. By using these raw values, we therefore forget that materials can have a large part of recycled content in their composition, metals for example.

In this table, we can note that recycled aluminum consumes almost as much energy as sheep wool insulation on a facade (unit in kWh/m^2)!

75% of the aluminum produced since its discovery in the 19th century continues to be used today, aluminum is 100% recyclable without deterioration in quality.

The unique characteristics of aluminum, strength/weight ratio, make aluminum essential for the time being, even in ecological solutions:

- Wind turbine blades are largely made of aluminum to produce more green energy.
- Electric cars have an aluminum structure that reduces the capacity of the batteries and increases their range.
- Electric bikes are made of aluminum for the same purpose.
- The satellites are made largely of aluminum to be able to reach orbit.
- Lightened duplex TGVs (French fast train) with the significant use of aluminum have increased passenger capacity by 45%.
- “Zero emissions” buses and trams are made of aluminum

Modern means of transport such as airplanes, boats, trains and aluminum buses are distinguished by a positive energy balance after only two years of operation. For example, reducing the weight of the vehicle by 100 kg reduces carbon dioxide emissions by about 9 g per km.

This does not prevent aluminum-based materials from being made more environmentally friendly:

- By using aluminum produced with hydropower energy plants
- By increasing the proportion of recycled material in the material, in fact recycled aluminum only needs 5% of the energy required for its extraction from bauxite
- By optimizing the mass of aluminum required for each project

The aluminum used for the ALUCOBOND® panels has very low thickness and weight, two cover sheets only 0.5mm thick, which contain 30% to 100% recycled aluminum!

This considerably reduces the embodied energy required to manufacture the ALUCOBOND® panel.

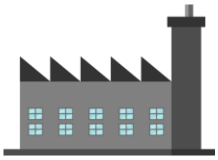
The table concerning the embodied energy consumption of building materials gives an idea of the raw materials that consume more or less energy, but this only concerns the extraction of the material, without taking into account the rate of recycled and recyclable material, nor of the quantity of energy needed at every stage of his life.

To get a more precise idea, it is necessary to study the life cycle assessment of each material. This allows you to know the energy consumption at each stage of material’s life, "from cradle to grave", but also its impact on the environment.

Transport of raw material

The aluminum sheets, manufactured at the same production site as our ALUCOBOND® panels, make it possible to avoid long and numerous transportations.

Building materials require varying amounts of raw material. Using a lightweight panel, such as an ALUCOBOND® aluminum composite, requires a smaller amount of raw material than heavier panels, such as terracotta or stone. Thus helping to reduce the carbon footprint due to transport.



Manufacturing of the building material

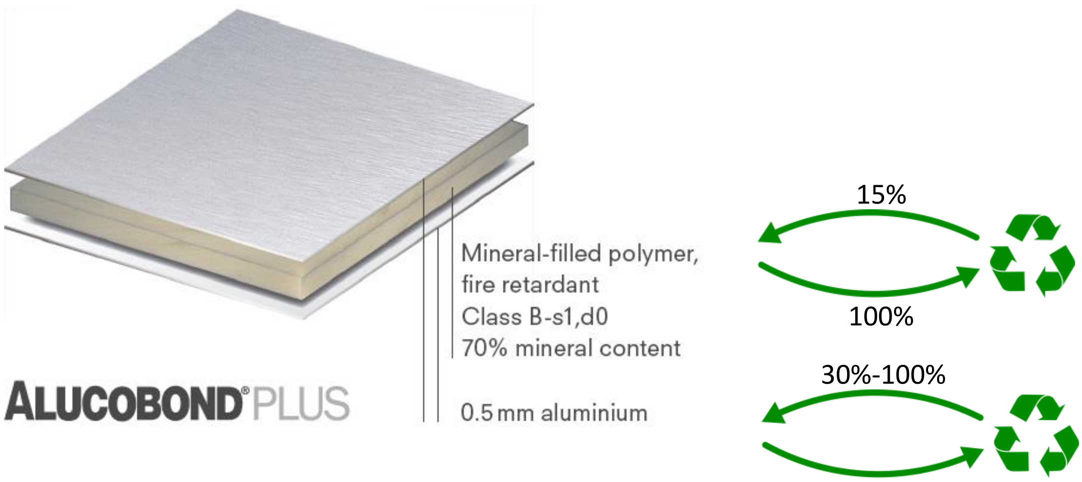
During the manufacture of the material, part of the raw material used can come from recycling:

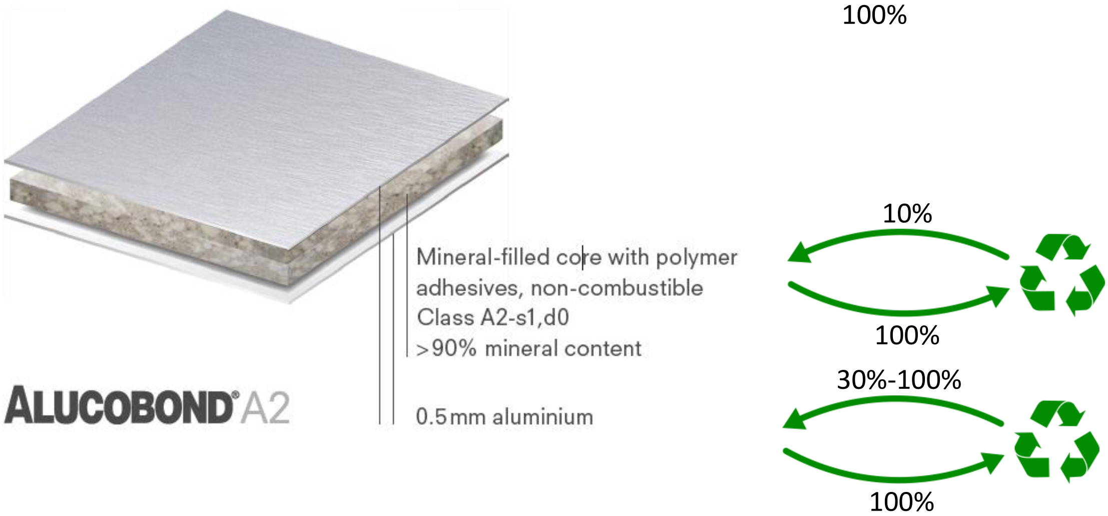
- Pre-consumer recycling: recycling of waste and scraps during manufacture

- Post-consumer recycling: recycling after consumer use

Energy consumption is reduced thanks to the sandwich concept, in fact the proportion of aluminum required for the manufacture of ALUCOBOND® is significantly lower than that of solid sheet metal. As a result, the energy consumption required to manufacture a square meter while maintaining the same stiffness is significantly reduced.

Panel compositions :





Reduction of CO_2 emissions

In the production of ALUCOBOND®, we have made great efforts to reduce our CO_2 emissions. The first initiative we implemented was aimed at minimising CO_2 emissions in the supply chain of the core material used for ALUCOBOND® PLUS and ALUCOBOND® A2. By changing the means of transport from truck to rail, we were able to reduce the distance travelled by trucks by 54%, which corresponds to a 17% reduction in CO_2 emissions for ALUCOBOND® deliveries.

Coil coating

We are a member of the European Coil Coating Association (ECCA) and a leader in coil coating standards and emission control. In the coil coating process, 99% of all volatile organic compounds (VOCs) are captured. The coil coating of ALUCOBOND® composite panels is therefore ecologically safe and sound. This is certified by the VOC classification A+. The manufacturing process complies with the strict European and German regulations of Directive 2010/75/EU (Industrial Emissions, IE Directive, comprising the German Solvent Ordinance (31. BImSchV)).

3AC invests in a heat exchanger to provide electricity for the production.

Excess paint is recovered during the process and not incinerated as waste; all solvents used to clean the machines are collected and recycled.

Transport of the building material

The use of a light weight panel (weight per m²) makes it possible to transport more m² in the same truck.

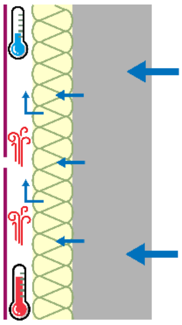
Construction process

When installing the material, the weight of the panel consumes more or less energy. Since the ALUCOBOND® composite panel is very light and very rigid, installation does not require any specific equipment.

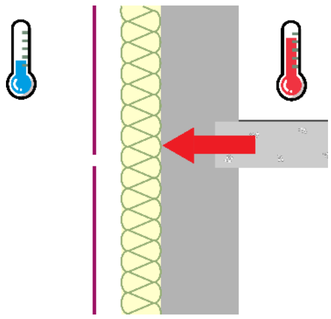
Use stage

The advantages of rainscreen claddings

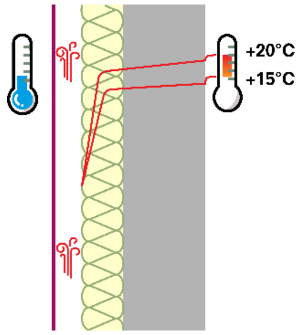
Protection against condensation and mould: There is nothing to prevent the diffusion of steam, there are no problems with mould and humidity, because the facade is "self-breathing".



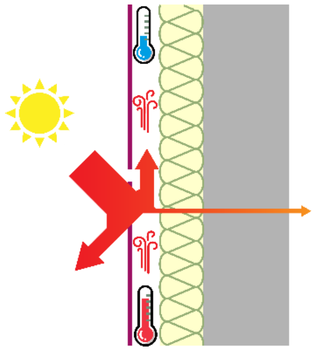
Thermal protection in winter: The thermal insulation located outside the building allows complete insulation, without thermal bridges at the slab's level and the partition walls. The brackets penetrating the insulation, creates only point thermal bridges instead of linear ones, limited by lighter cladding, less brackets therefore less cold bridging.



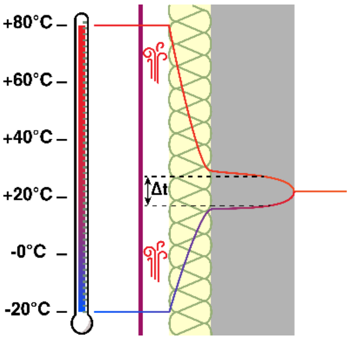
Indoor heat storage: The mass of thermal storage in walls and ceilings dampens temperature variations, thus improving comfort in rooms.



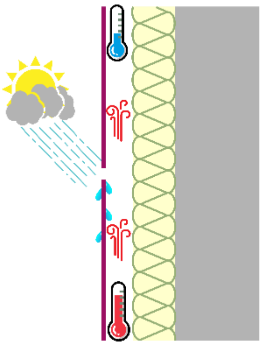
Thermal protection in summer: The external thermal insulation protects against summer heat. The air gap allows excessive heat to be vented upwards.



Protection of the load-bearing wall: The external thermal insulation protects from cracks due to temperature fluctuations. The cladding expands freely and avoids direct contact between the wall and climate change, thereby improving the durability of the building.



Protection against rain: The evacuation of water in the cavity and the evaporation of all other humidity is carried out by the rear ventilation zone. If the facade is wet in the air gap due to the open joints, then the humidity evaporates naturally thanks to the ventilation.



Cleaning and maintenance

Facade cleaning is limited to once a year and the lifespan of an ALUCOBOND® cladding is very long (up to 70 years), with no replacement required during this period.

50 years are the basis for LCAs in the building sector, but the actual service life of building materials according to the German Construction Research Institute is slightly different:

Material	Service life in years according to BNB*	Replacement in 50 years
ALUCOBOND® aluminium composite material	≥ 50	0
Solid aluminium material	≥ 50	0
Thermal insulation composite system: mineral wool insulating panels, polystyrene insulating panels, polyurethane insulating panels, wood fibre insulating panels, wood wool lightweight construction panels and cork panels	40	1
Fibre cement	≥ 50	0
Thermal insulation composite system with render	30	1
Galvanized steel	30	1
Glass facing shell	≥ 50	0
Polycarbonate plastic panels	30	1
Resin composite panels (HPL)	30	1
Rock wool panels	N/A	--
Render on porous base layer	40	1
Ceramic plates	≥ 50	0
Glass fibre concrete	N/A	--
Untreated coniferous wood	30	1
Natural stone	≥ 50	0

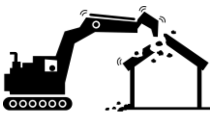
* Assessment System for Sustainable Building of the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR)

Toxicity of materials

The toxicity of materials relates to health-related evaluation of indoor construction products (AgBB, version June 2012) for the emissions VOC (volatile organic compounds) and SVOC (semi-volatile organic compounds). Throughout its service life, ALUCOBOND® panels are not toxic to living beings and, also, not dangerous for the environment.

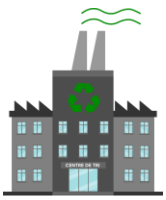
According to the French VOC regulation, ALUCOBOND® PLUS and ALUCOBOND® A2 fulfills the requirements of the best category: class A+.

In extreme situations, such as in a fire, most materials burn and/or emit toxic fumes. ALUCOBOND® A2, complies with the requirements for railway coaches and tunnels (e.g. LUL). It is a building material nontoxic to living beings and therefore not dangerous for the environment, even in the event of fire.



Demolition

Recycling and reuse: The ventilated facade allows each component to be well separated, the materials used are therefore also separable during dismantling, thus facilitating their recycling.



End of life of the building material

Energy

After separating the aluminum sheets, the binder contained in the core is used to melt the aluminum into ingots.

Re-using

The re-use of panels after dismantling is varied, for example garden sheds, fences, formwork for concrete slabs, etc.

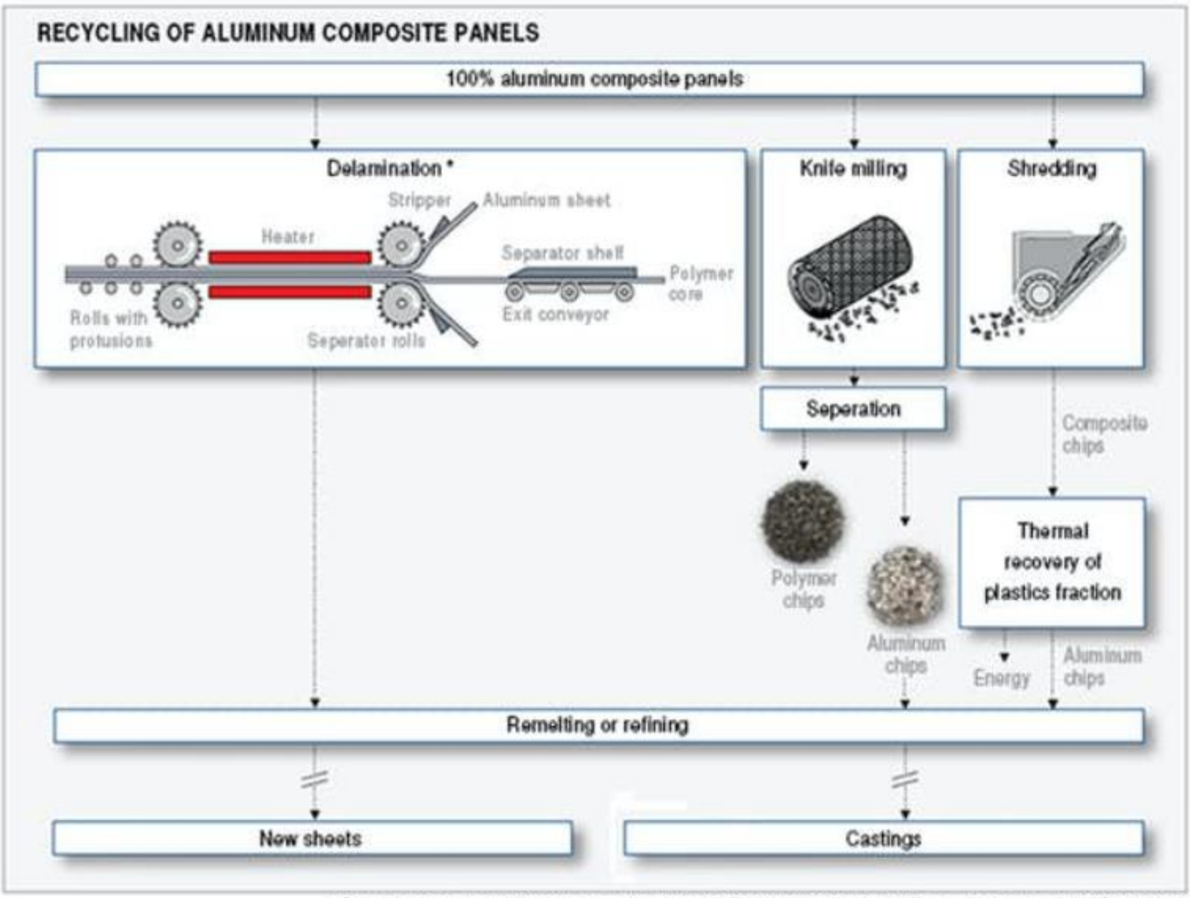
Recycling

The high material value of aluminum from an economic point of view encourages recycling. Without losing any of its properties, aluminum is infinitely recyclable.

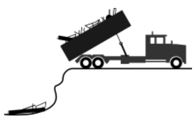
Melting scrap only requires 5% of the energy that would be required for primary production. The benefit of recycling for the environment is obvious. By using the core to melt aluminum, the additional energy is greatly reduced.

During the manufacture of the material, part of the raw material used may come from post-consumer recycling.

ALUCOBOND® is fully recyclable, i.e. the core material and the aluminum skins can be returned to the material cycle and reused for the production of new material. For example, knife milling can be used to separate the composite panels into the different individual components.



*Drawing based on US patent application 2007/0028432 A1: http://ip.com/patapp/US20070028432



Landfill

Then the core is buried in the ground and thus returns to its initial mineral state in its original environment, without endangering the environment.

Collecting & Recycling centers for ALUCOBOND® panels in Europe:

Bio-based materials

Bio-based materials, which have an undeniable sympathetic capital, are systematically considered to be beneficial for the environment. However, this is far from always being the case, our comparison of the life cycle of different materials shows it: a bio-based material undergoing a treatment (fire retardant or against bad weather) is not necessarily better for the environment or for the health of building occupants.

If we compare with a 60% bio-based product, type HPL 2 (see table 10), ALUCOBOND® has much less impact on the environment!

We should not rely only on the bio-based product labels, we must also compare the EPD/FDES and Life Cycle Assessments in particular, for an environmentally friendly construction.

Wood labels

Forests cover 4 billion hectares in the world, which corresponds to 3000 billion trees on earth. There is a potential of free land to plant an additional 1200 billion trees, which is equivalent to 200 Giga Tons of sequestered CO_2, 2/3 of current global CO_2 emissions. Reforestation and the sustainable management of existing forests are essential for future generations.

According to WWF, 65% of world wood production comes from illegal logging. Unsustainably managed forests cause deforestation and, consequently, a loss of global CO_2 sequestration capacity.

The basic principles of sustainable forest management are:

- Soil protection, ecosystem balance (limitation of clear cuts and phytosanitary products, good management of water resources, etc.) and respect for biodiversity (flora and fauna)

- Maintenance of forest productivity and economic viability (for example replanting to compensate for logging)

- Respect for the rights of indigenous populations to the property, use and management of land resources

- Social and economic well-being of forestry workers

There are 2 labels recognized in the world:

- FSC certification imposes an initial level of quality on the forest as well as annual audits during the contract period (valid for 5 years).

- PEFC certification rather requires a commitment to continuous improvement on the part of forest operators.

FSC

Founded in 1993, FSC (Forest Stewardship Council) is an independent, non-governmental organization supported by WWF and Greenpeace. Globally, 225 million hectares are FSC certified in 2021, or 5,6% of exploited forests.

FSC mainly concerns exotic woods, such as teak, mahogany, ebony, rosewood, azobé, bangkiraï, merbau or moabi, from forests and plantations in Indonesia, Africa, Vietnam, from Brazil.

The FSC standard is often considered to be more stringent than is PEFC.

3A Composites owns Balsa wood plantations, FSC certified in Ecuador (FSC-C019065) since 2009 and Papua New Guinea (FSC-C125018) since November 2020.

PEFC (Program of the Endorsement of Forest Certification) was created in 1999 on the initiative of European forest owners. Globally, 330 million hectares are PEFC certified in 2021, i.e. 8,25% of exploited forests.

PEFC applies to wood (and derived products) from Europe and North America. The PEFC standard is more suitable for European forests than is FSC.

Comparison of different tree species

Deforestation is not the only problem, the impact of the development of wood species for construction, such as Douglas-fir, is already having consequences on biodiversity and natural forest environments.

This tree which grows quickly, resists time, and has recognised mechanical performance, these criteria allowing to sell a maximum of raw material. Douglas fir is therefore cultivated intensively, with the same procedures as in agriculture. This monoculture is very damaging in terms of forestry:

- Acidification of the upper layers of the soil
- Leaching of nutrients due to runoff
- Thinner layer of humus

We must therefore find a balance between the different species of trees.

It is important to plant trees that absorb no less CO_2 than the one being replaced and keep a variety of species to limit runoff. Here is a comparison of tree species, under the same living conditions, over a period of 40 years (Source i-Tree):

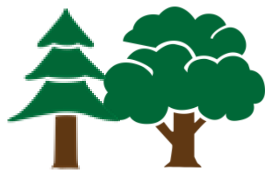
Tree species	Groupe	CO2 Sequestered (kg)	O3 Removed (kg)	NO2 Removed (kg)	SO2 Removed (kg)	VOC (kg)	PM2.5 Removed (kg)	Tree Biomass (tonne)	Rainfall Interception (m3)	Avoided Runoff (m3)
Beech, European *(Fagus sylvatica)*	deciduous	819,6	7,7	1,2	0,1	0	0,4	0,4	147,3	20,6
Spruce, Norway *(Picea abies)*	conifer	920,8	5,8	1,1	0,1	0,1	0,3	0,5	78,3	11
Fir, Douglas *(Pseudotsuga menziesii)*	conifer	974,5	8,4	1,5	0,2	0,1	0,4	0,5	122	17,1
Pine, Austrian *(Pinus nigra)*	conifer	1 124,4	6,7	1,2	0,1	0	0,4	0,6	90,1	12,6
Walnut, English *(Juglans regia)*	deciduous	1 350,1	10,4	1,6	0,2	0	0,4	0,7	222,1	31,1
Larch, European *(Larix decidua)*	conifer	1 438,2	8,7	1,3	0,2	0	0,3	0,7	199,1	27,9
Hornbeam, European *(Carpinus betulus)*	deciduous	1 559,6	6,8	1,1	0,1	0	0,3	0,8	130,6	18,3
Linden, Littleleaf *(Tilia cordata)*	deciduous	1 707,4	6,9	1,1	0,1	0	0,3	0,9	137,8	19,3
Cedar, Atlas *(Cedrus atlantica)*	conifer	1 869,9	6,6	1,2	0,1	0	0,3	0,9	95,8	13,4
Oak, English *(Quercus robur)*	deciduous	2 017,4	10,1	1,5	0,2	0	0,4	1	212,7	29,8
Pine, Scotch *(Pinus sylvestris)*	conifer	2 148,8	15,5	2,7	0,3	0,1	0,7	1,1	247,1	34,6
Ash, White *(Fraxinus americana)*	deciduous	2 202,3	8,2	1,3	0,1	0	0,4	1,1	154,8	21,7
Poplar, Black *(Populus nigra)*	deciduous	2 561,0	8,7	1,4	0,2	0	0,4	1,3	158,2	22,2
Maple, Norway *(Acer platanoides)*	deciduous	2 617,1	5,5	0,9	0,1	0	0,3	1,3	90,9	12,7
Willow *(Salix species)*	deciduous	2 812,5	6,8	1	0,1	0	0,3	1,4	152,8	21,4
Chestnut, American *(Castanea dentata)*	deciduous	2 858,7	12,4	1,9	0,2	0	0,6	1,4	240	33,6
Elm *(Ulmus species)*	deciduous	3 370,4	7,6	1,2	0,1	0	0,3	1,7	163,9	23
Birch, European white *(Betula pendula)*	deciduous	4 360,9	10,9	1,7	0,2	0	0,5	2,2	218,1	30,6

We can note a significant difference in CO_2 sequestration between deciduous and coniferous trees, the same is true for the volume of rain captured by the leaves.

The VOCs (volatile organic compounds) produced by the leaves of trees, in the form of gas, have a very positive influence on global warming. When it's warm enough, trees emit these VOCs, which react with other elements in the air, then clump together to form cloud droplets. Those shine and reflect sunlight, they have a cooling effect on the climate.

PM2.5 relates to fine particles in the air.

Monoculture coniferous plantations are much less efficient than a traditional mixed forest:

Type of Forest	**Coniferous forest (cypress, cedar, pine)** 	**Deciduous forest (birch, chestnut, oak, maple)** 	**Mixed forest (conifers and deciduous trees)** 
CO_2 sequestration per hectare	**2,4 tons of CO_2 / year**	**4,6 tons of CO_2 / year**	**4,9 tons of CO_2 / year**

Source : https://climate.selectra.com/

It will always be beneficial to create a plantation on virgin land, because we increase the overall CO_2 sequestration capacity, it is the same for a plantation of conifers in a coniferous forest, because there is no loss of capacity. and a positive exploitation of the raw material. On the other hand, replacing a mixed forest with a plantation of conifers, results in the loss of overall CO_2 sequestration capacity.

How to compare Life Cycle Assessment (LCA)

The comparison of building materials is not always relevant at the product level. It is however possible on condition of using a suitable unit of comparison (for example the m² for the cladding), and taking into account the technical characteristics (U coefficient, center distance between frames, etc.), aesthetic and economic characteristics of the building solution, as well than the lifetime used for this comparison.

In addition, it is not easy to understand the life cycle assessment of materials, the values are in scientific notation, and must be added together in order to be able to be compared to other materials, the service life and the functional unit (ton , kg, m³, m², etc…) are not often the same.

Reading example : -4,0 E -03 = -4,0 x 10-3= - 0,004

The following display rules apply:

- When the inventory calculation result is zero, then the zero value is displayed.
- When the module is not declared, then the value "MNA" is displayed.

Taking the example of the carbon footprint, you must simply add the values of the line "Global warming potential GWP":

RÉSULTATS DE L'ACV - IMPACT ENVIRONNEMENTALE : 1 m² panneau composite en aluminium

	Unit	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	D
GWP	[kg CO_2-Eq.]	2.67E+01	0,414	1.41E+00	0,0719	2.31E-05	0,0406	9.46E+00	8.79E-03	-1.51E+01
ODP	[kg CFC11-Eq.]	2.44E-10	5E-014	4.45E-13	4,67E-014	2.18E-15	4,9E-015	4.78E-13	2.00E-15	-1.96E-10
AP	[kg SO_2-Eq.]	1.00E-01	0,00181	7.74E-03	0,000307	7.67E-08	0,000177	1.84E-03	5.20E-05	-6.63E-02
EP	[kg $(PO_4)^{3-}$-Eq.]	7.43E-03	0,000451	4.75E-04	6,2E-005	1.00E-08	4,42E-005	3.62E-04	7.18E-06	-4.47E-03
POCP	[kg ethene-Eq.]	6.11E-03	-0,000647	4.13E-04	2,12E-005	4.98E-09	-6,34E-005	1.17E-04	4.04E-06	-3.64E-03
ADPE	[kg Sb-Eq.]	1.13E-05	4,93E-008	6.05E-05	1,08E-006	4.84E-11	4,83E-009	2.90E-07	3.28E-09	-6.60E-06
ADPF	[MJ]	4.20E+02	5,61	1.70E+01	0,769	2.59E-04	0,55	1.66E+00	1.14E-01	-1.71E+02
AirP	[m³]	1.90E+03	0,142	1.61E+02	0,0735	1.53E-03	0,0139	3.84E+01	1.03E+00	-1.08E+03
WaterP	[m³]	3.02E+00	19,4	1.74E-01	7,22	7.51E-06	1,9	1.62E-02	1.85E-03	-1.11E+00
légende	GWP = Potentiel de réchauffement global ; ODP = Potentiel d'appauvrissement de la couche d'ozone stratosphérique ; AP = Potentiel d'acidification du sol et de l'eau ; EP = Potentiel d'eutrophisation ; POCP = Potentiel de formation de l'ozone troposphérique ; ADPE = Potentiel d'épuisement abiotique des ressources non fossiles ; ADPF = Potentiel d'épuisement abiotique des ressources fossiles ; AirP = Pollution de l'air ; EauP = Pollution de l'eau ;									

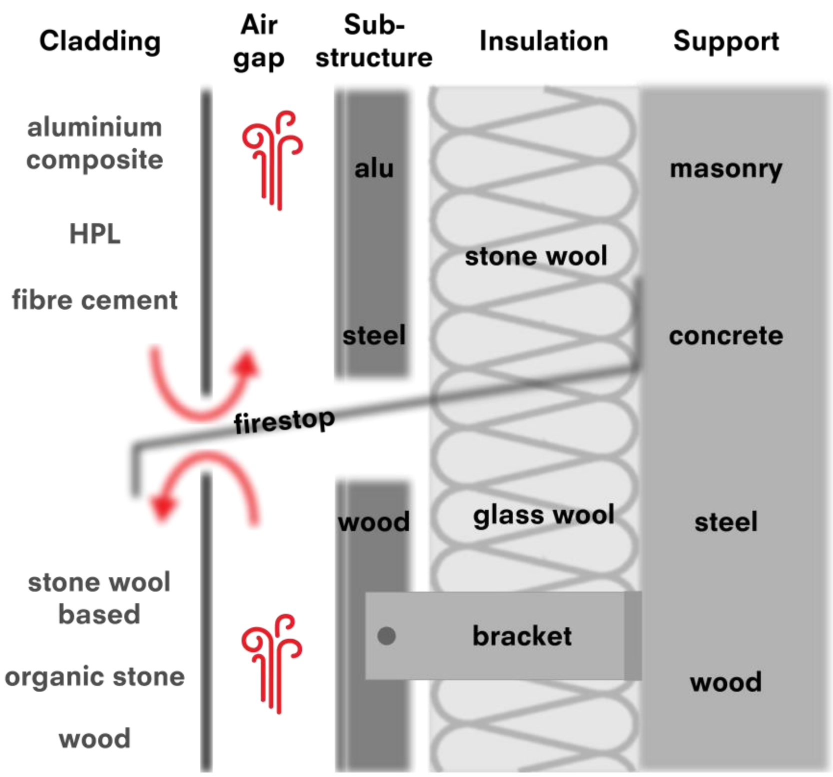
In this example, the total is 23,01 kg CO_2-eq per m². To be able to compare this value with another product, it is therefore necessary to do the same thing using the same unit and the same lifetime (70 years).

If an ALUCOBOND® panel has a service life of 70 years and an HPL panel only 50 years, then a multiplication factor of 1.4 should be applied to all of the ACV values of the HPL panel, from this point , the values can be compared.

Comparison of building materials

The comparison of LCA is complex, to facilitate their reading, we have made the totals and removed the indicators close to zero which are, in fact, insignificant for this comparison. We also compared the French EPD called FDES because there are interesting values about air and water pollution, in addition. The values used are in per m² for a more realistic comparison.

Composition of a ventilated facade (rainscreen cladding)



Supporting substrate frame (support)

The supporting substrate frame is the load-bearing structure of the building. It takes the loads applied by the facade. The substructure is anchored to the supporting structure.

Material		Reinforced Concrete	Concrete of hemp	Concrete of wood	Rammed earth wall	Building block	Hollow brick	wood wall	CLT 1	CLT 2	CLT 3	steel tray
Thickness	[mm]	180	300	300	500	150	200	145	200	200	200	0,75
Reaction to fire EN13501-1	[class]	A1	B-s1,d0	B-s1,d0	A2	A1	A1	D-s2,d0	D-s2,d0	D-s2,d0	D-s2,d0	A1
Service life	[year]	100	100	100	100	100	100	100	100	100	100	50
Source	Source	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES
Global warming potential	[kg CO2-Eq.]	46,27	0,89	-70,90	20,80	25,87	28,70	5,25	-8,60	-23,72	35,98	15,00
Abiotic depletion potential for fossil resources	[MJ]	309,18	444,00	446,00	365,00	148,95	306,00		266,00	102,40	511,85	174,88
Air pollution	[m3]	2 144,29	4 040,00	4 600,00	2 460,00	1 593,00	2 960,00	1 205,90	7 064,00	980,00	3 709,04	380,40
Water pollution	[m3]	335,91	13,50	12,00	8,36	4,15	5,28	10,88	44,60	5,94	41,30	0,51
Total use of renewable primary energy resources	[MJ]	4,93	761,00	1 610,00	9,59	9,95	33,00	170,20	1 530,00	3 858,00	2 774,77	1,64
Total use of non-renewable primary energy resources	[MJ]	435,46	760,00	673,00	450,00	289,90	416,00	157,70	218,00	196,00	703,93	178,00
Use of secondary material	[MJ]	9,03	0,00	2,96	0,00	1,39	14,60	0,00	0,02	0,00	0,00	0,75
Use of renewable secondary fuels	[MJ]	24,83	0,00	42,40	0,00	20,40	202,00		0,00	0,00	14,55	0,00
Use of non-renewable secondary fuels	[MJ]	36,72	0,00	62,60	0,00	30,20	6,03		0,00	0,00	0,00	0,00
Use of net fresh water	[M³]	0,19	0,35	0,27	0,29	0,13	0,12	0,06	1,16	-0,03	0,25	0,04

Note the lower carbon footprint of Timber wall / CLT solutions (Cross Laminated Timber), as well as the steel cladding trays, which, despite a significant energy required in blast furnaces, use a low thickness of material (0.75mm) for high rigidity and infinite recyclability, which greatly improves the carbon footprint in the long term.

The 3 types of CLT solution have very large variations in environmental impact and use of energy resources, which is difficult to explain.

Here is a detailed comparison of the carbon footprint from LCAs to help us understand:

Supporting substrate	Volumic mass	fabrication	Construction process		Use stage	End of life				Benefits and loads beyond the system boundaries	total
		Manufacturing	Transport	Installation		Demolition	Transport	Waste processing	Landfill		
	(kg/m³)	A1-A3	A4	A5	B1-B7	C1	C2	C3	C4	D	
CLT 1	515	-144,80	14,00	2,38	0,00	2,24	0,68	95,40	51,40	-30,00	-8,70
CLT 2	525	-152,00	1,89	0,06	0,00	0,66	0,88	113,40	37,60	-26,20	-23,71
CLT 3	537	-137,11	9,56	1,48	0,00	1,00	0,48	171,88	0,00	-11,30	35,98

A1-A2 : The carbon footprint at the manufacturing level is more or less variable but difficult to detail the manufacturing process.

A4 : CLT 1 being made in Canada, transportation is more important.

C3-C4 : Regarding waste treatment and disposal:

CLT 1 and CLT 2 : Average French scenario for construction wood waste: 67.3% of wood waste reaches a sorting platform (with subsequent recycling of wood into particle board and incineration of grinding fines), 15.4% is incinerated with energy recovery, 17,3% are buried.

CLT 3 : It was considered that the panels, once dismantled, will be 100% recycled as a raw material for the manufacture of new chipboard panels.

The values between similar products can vary greatly depending on:

- The origin of the raw material (sustainable or unsustainable exploitation)
- The manufacturing process
- The manufacture location
- the waste treatment scenario and the chosen disposal.

- One characteristic that plays an important role during the entire life cycle of the material is the material weight. Reducing the mass of raw material is essential.

We cannot therefore generalize a family of products by considering this material more respectful of the environment, we must compare it on a case-by-case basis.

Thermal insulation

The thermal insulation is the thermally insulating layer between supporting substrate frame and rear-ventilation zone. Depending on the material used, the thermal insulation may also fulfil functions related to fire protection and sound insulation.

Product		Stone wool	Glass wool	Foam glass	Phenol Foam	PIR Foam	PIR Foam	Expansed polystyren	Wood fibers	Soil-straw	Straw
Thickness	[mm]	160	160	180	90	100	140	160	180	300	370
Weight	[kg/m²]	5,6	2,978	20,7	3,16	3,37	4,61	2,4	27	137	37
Thermal conductivity du produit	[W/m.K]	0,035	0,035	0,041	0,022	0,023	0,023	0,038	0,041	0,089	0,052
Thermal resistance R	[K.m²/W]	4,55	4,55	4,35	4,05	4,35	6,1	4,2	4,35	3,7	7,1
Reaction to fire EN13501-1	[class]	A1	A1	A1	B-s1, d0	D-s2, d0	D-s2, d0	E	E	C-s1-d0	E
Source		FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES
Service life	[year]	50	50	100	50	50	50	50	50	100	50
Global warming potential	[kg CO2-Eq.]	6,90	3,33	22,14	21,00	16,00	22,90	14,00	-0,08	6,52	-7,37
Abiotic depletion potential for fossil resources	[MJ]	103,00	50,80	331,20	343,51	280,00	411,00	364,00	286,00	50,00	83,70
Air pollution	[m3]	868,00	469,00	1701,00	1817,73	1346,00	1613,00	1404,00	1610,00	617,00	1110,00
Water pollution	[m3]	19,00	3,20	10,75	16,92	5,31	6,65	18,00	3,68	23,70	23,50
Total use of renewable primary energy resources	[MJ]	5,90	14,90	119,70	15,14	16,80	20,70	4,00	438,00	350,00	508,00
Total use of non-renewable primary energy resources	[MJ]	94,00	97,50	342,00	446,11	315,00	463,00	357,00	435,00	65,10	96,80
Use of net fresh water	[M³]	0,03	0,06	0,15	0,11	0,12	0,18	0,02	0,07	0,32	0,10

For the comparison of insulation, the functional unit is m², but an equivalent thermal resistance must also be used, in this example, it is between 4.05 and 4.55 K.m²/W, except for bio-based solutions which have a more limited range of solutions. Mineral insulation has a low carbon footprint but greater than bio-based insulation, on the other hand, the latter have very poor reaction to fire, penalizing them for use on medium or high-rise buildings.

The air gap and the firestop

The air gap (rear-ventilation zone) is a space between the inner face of the cladding and the front face of the wall or the thermal insulation through which outside air flows. Its functions are to protect the layers beneath from moisture, to drain rainwater and condensation, and to reduce heat accumulation in the summer (temperature buffer in both summer and winter). However the ventilation may cause a “chimney effect in case of fire. Firestops prevents the “chimney effect”, it compartmentalises or closes the air gap behind the facade, and limits the spread of smoke and smoke.

Substructure

Light aluminium, steel, wood, compensates for irregularities in the shell and supports the exterior cladding.

Material		Alu/kg mill finished	Alu/kg anodized	Bois/m² durable	Bois/m² non durable
Span between substructure	[mm]			600	600
Source		EPD	EPD	FDES	FDES
Service life	[year]	-	-	100	100
Global warming potential	[kg CO2-Eq.]	2,95	5,19	30,70	49,80
Abiotic depletion potential for fossil resources	[MJ]	35,53	63,63	364,00	364,00
Air pollution	[m3]			2560,00	2560,00
Water pollution	[m3]			22,40	22,40
Total use of renewable primary energy resources	[MJ]	11,91	20,71	519,00	519,00
Total use of non-renewable primary energy resources	[MJ]	40,24	72,24	447,00	447,00
Use of net fresh water	[M³]	0,03	0,03	0,14	0,14

It is very difficult to compare the different substructures since they have different functional units and require specific sizing for each project. The center distance between timber frames is 600/650mm maximum, the aluminum frame can have, in certain cases, a center distance of up to 3000mm.

Cladding

Claddings consist of elements with open or closed/underlaid joints or of abutting or overlapping elements. They function as weather protection and are a feature of the facade design; it offers a multitude of aesthetic possibilities.

Material		Alucobond Plus	Alucobond A2	Stone wool	HPL 1	HPL 2	Fibre cement	Organic stone	Terracotta	Wood Plastic Composite	Plywood	Douglas wood not treated	Douglas wood treated	Solid steel	Solid zinc
Thickness	[mm]	4	4	9	8	8	8	14	24-30	28,5	15	22	22	0,75	1,0
Weight	[kg/m²]	7,60	7,60	11,25	10,80	10,40	14,40	36,00	44,00	8,80	7,80	10,78	10,78	6,39	11,18
Max span aluminium substructure (0,8kN/m²)	[mm]	1000	1000	600	600	650	600	900	1500	600	600	600	600	2900	1200
Reaction to fire EN13501-1	[class]	B-s1,d0	A2-s1,d0	A2-s1,d0	B-s1,d0	B-s2,d0	A2-s1,d0	A2-s1,d0	A1	B-s3,d0	D-s2,d0	D-s2,d0	D-s2,d0	A1	A2-s1,d0
Calorific value	[MJ/m²]	68,90	17,00	31,79	216,00	200,00	15,80	87,00	-	150,83		239,00	239,00	-	-
Semivolatile and Volatile Organic Compounds SVOC/VOC	[class]	A+	A+	A+	E1	E1	-	A+	-	-	B1	B1	B1	-	-
Source		FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES	FDES
Service life	[year]	70	70	60	50	50	50	50	100	50	50	50	50	50	100
Global warming potential	[kg CO2-Eq.]	23,01	23,01	24,76	22,60	42,70	32,66	50,30	50,21	28,60	4,99	-2,74	-2,22	10,52	9,46
Abiotic depletion potential for fossil resources	[MJ]	274,70	274,70	300,86	525,00	556,00	332,20	806,00	763,76	433,00	119,50	-10,39	-2,49	123,58	100,27
Air pollution	[m3]	1 020,66	1020,66	2476,38	10 300,00	3652,50	4971,06	9410,00	3555,54	1560,00	1123,10	505,50	618,50	61,43	4069,32
Water pollution	[m3]	30,62	30,62	14,50	16,80	7,49	80,60	27,40	26,32	5280,00	4,00	0,73	4,32	0,38	762,20
Total use of renewable primary energy resources	[MJ]	29,89	29,89	140,47	337,00	346,24	101,07	197,00	54,99	70,60	171,30	127,10	128,20	1,46	31,70
Total use of non-renewable primary energy resources	[MJ]	261,46	261,46	315,38	565,00	559,30	444,78	1020,00	810,87	564,00	124,90	22,09	31,79	125,40	168,10
Use of non-renewable secondary fuels	[MJ]	0,00	0,00	21,21	26,56	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Use of net fresh water	[M³]	0,13	0,13	0,04	1,93	0,20	0,25	0,60	0,12	2,38	0,02	0,00	0,01	0,05	0,27

By analyzing the comparative table, we realize that metals have the least carbon footprint, but not only this, this is mainly due to the very low thickness required, despite a very high rigidity. As well as a large part of recycled content in their composition, with their recyclability and their very long resistance over time.

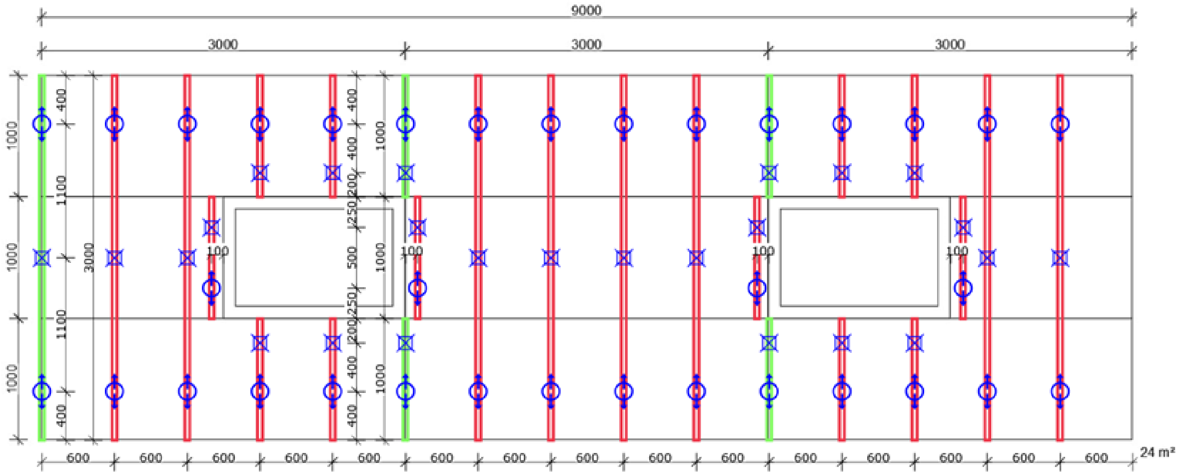
The example of the ALUCOBOND® aluminum composite is interesting, because it has a lower carbon footprint than Stone wool based panels, without even taking into account that it lasts 1.4 times longer: 70 years / 50 years = 1.4.

- ALUCOBOND®: 23,01 kg CO_2-eq. for a period of 70 years
- Stone wool based panels: 24,76 kg CO_2-eq. x 1,4 = 34,66 kg CO_2-eq. for a period of 70 years!

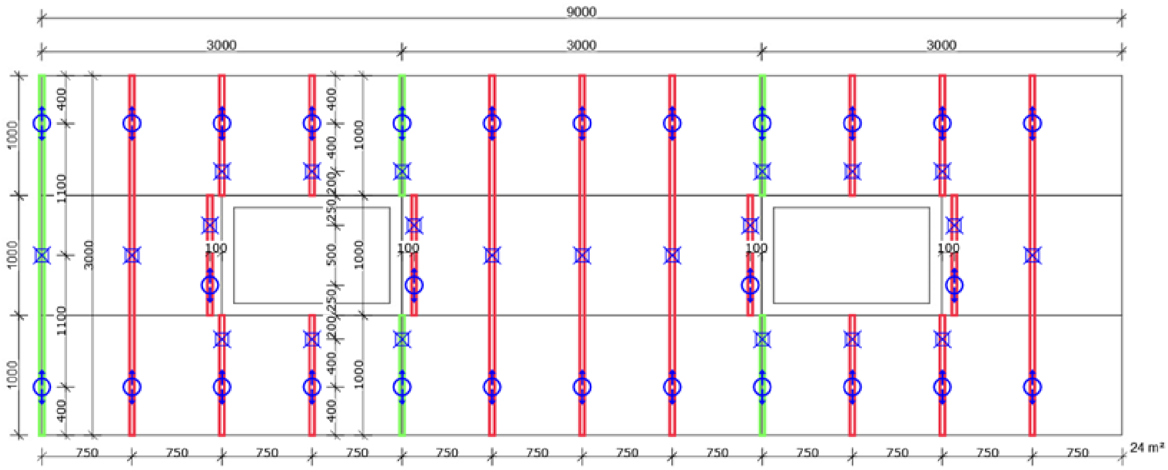
Building energy efficiency

The rigidity of the cladding panels and their center distance between frames is a point often absent from the debate, when choosing the cladding materials for your construction project. Yet this has a very important influence on the energy efficiency of the building and the carbon footprint. Indeed, when using a panel with a maximum center distance of 600mm between the framework, there will systematically be more frameworks but also more brackets to fix the framework to the support wall, than a panel with a center distance of 1000mm. However, brackets are thermal bridges, which reduce the performance of the insulation.

HPL/stone wool based panel/Fibre cement – Panel with span 600mm – wall brackets and substructure :



ALUCOBOND® – Panel with span 750mm – wall brackets and substructure:



Results:

- **U-value:**

- ALUCOBOND®: 0.2907 W/m2K
- HPL/stone wool based panel/Fibre cement: 0.3124 W/m^2K

ALUCOBOND® system solution is 7% more efficient than a HPL/stone wool based panel/Fibre cement panel.

The insulation can be reduced by 12.5% (from 160mm to 140mm) to get a similar U-value.

- **Cost for the substructure (excluding panel cost)**

- ALUCOBOND®: 19,72 €/m2
- HPL/stone wool based panel/Fibre cement: 23,58 €/m^2

ALUCOBOND® system solution is 16.37% cheaper per m^2 than a HPL/stone wool based panel/Fibre cement panel.

- **Installation costs**

- ALUCOBOND® requires 15% less anchors per m^2
- ALUCOBOND® requires 15% less wall brackets per m^2
- ALUCOBOND® requires the same quantity of T-sections per m^2
- ALUCOBOND® requires 25% less L-sections per m^2
- ALUCOBOND® requires 15% less screws per m^2

Different environmental certification

Different systems for evaluating the environmental performance and energy efficiency of buildings exist. They are guarantees of overall quality for the entire building. Environmental certification guarantees that the end user will use a building designed to respect the environment and the well-being of the occupants.

Certification is also useful when the building is put into service: without a certification, it can remain unoccupied much longer. The same is true for a company that moves, it will have an easier time convincing its employees to settle in new certified offices.

Some property developers wanting to attract investors sometimes commit to a double or even a triple certification for the same building.

The 4 main environmental certifications are:

LEED

Created in 1998 in USA, LEED label (Leadership in Energy and Environmental Design) takes into account many evaluation criteria :

- Efficiency in water management
- Energy performance of the building
- The low impact on the land and the reduction in pollution
- Energy efficiency: this involves optimizing the use of renewable energies as well as energy performance.
- Use of local, recycled or certified materials
- Limitation of the carbon footprint.

The LEED label uses Life Cycle Assessment (LCA) to certify buildings.

Rating:

CERTIFIED	SILVER	GOLD	PLATINUM
40-49 points	50-59 points	60-79 points	80+ points

Average cost (for 10 000m² building): 6 740 €

Project: ORONA ZERO, Hernani, Guipúzcoa, Spain
Certification : LEED, Gold (BD+C: New Construction), 2015


BREEAM

Created in 1990 in Great Britain by the BRE (Building Research Establishment), its evaluation criteria are as follows:

- Water management
- Energy management
- Improve the well-being of occupants
- Access to sustainable transport
- Waste recovery
- Land use and ecology / biodiversity
- Pollution level of the building
- Innovation

The BREEAM label uses Life Cycle Assessment (LCA) to certify buildings.

Rating:

< 30%	UNCLASSIFIED	☆☆☆☆☆
30% - 45%	PASS	★☆☆☆☆
45% - 55%	GOOD	★★☆☆☆
55% - 70%	VERY GOOD	★★★☆☆
70% - 85%	EXCELLENT	★★★★☆
> 85%	OUSTANDING	★★★★★

Average cost (for 10 000m² building) : 8 780 €

Project: VIEW, Paris, France
Certification: BREEAM, Excellent (New Construction), 2018


HQE

Created in 2004 in France, its evaluation criteria are as follows:

- Respect the environment.
- Energy, water, waste and maintenance management
- Low nuisance (waste, pollution, noise, etc.)
- Improve the well-being of occupants
- Hygrothermal comfort
- Acoustic, visual and olfactory comfort
- Air quality
- Water quality

The design of HQE (High Environmental Quality) buildings requires a Life Cycle Assessment (LCA) in order to minimize the impact on the environment and health.

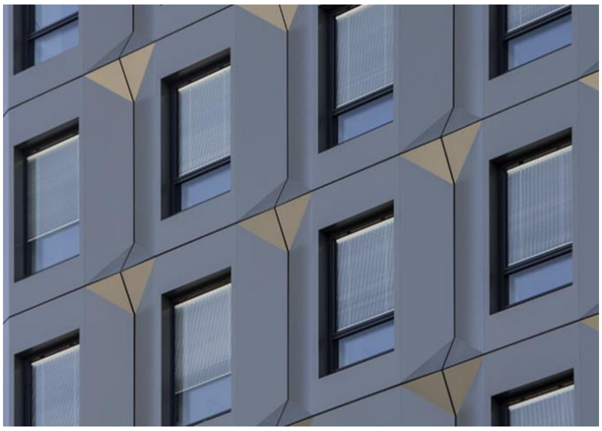
The Program Operator who manages the FDES database with building environmental assessment software is called AFNOR-INIES.

Rating:

HQE GOOD	★ +
HQE VERY GOOD	★★★★★ +
HQE EXCELLENT	★★★★★★★★★ +
HQE EXCEPTIONAL	★★★★★★★★★★★★ +

Average cost (for 10 000m² building): 20 700 €

Project: CHEVALERET, Paris, France
Certification: HQE NF Bâtiment tertiaire, 2016



DGNB

DGNB label is am assessment from the Deutsche Gesellschaft für Nachhaltiges Bauen.

Created in 2007 in Germany, it takes into account the entire life cycle of a building, its economic and ecological aspects, but also at the socio-cultural level. This label is based on 5 categories of criteria:

- Ecology: Impact on the environment
- Economy: Cost of the life cycle and its stability over time
- Technical quality
- Quality of planning, construction and operation processes
- Social quality: health and well-being

The DGNB label uses Life Cycle Assessment (LCA) to certify buildings.

Rating:

	Platinum	Gold	Silver	Bronze*
Total performance index	80% and higher	65% and higher	50% and higher	35% and higher
Minimum performance index	65%	50%	35%	-- %

* This award only applies to certification of existing buildings/the Buildings in Use certificate.

Average cost (for 10 000m² building): 12 600 € (for members: 8 900€)

Project: NORDEXFORUM, Hamburg, Germany

Certification: DGNB Gold (Gebäude/Neubau), 2011

ANNEXES

Environmental impact indicators

The environmental impact indicators of an EPD/FDES are grouped into three categories:

1) Environmental Impact

Global warming potential (GWP)
Unit: kg eq. CO_2
The heat absorbed by any greenhouse gas in the atmosphere leads to global warming. This is called **carbon footprint**. This is the most important impact to consider. ALUCOBOND® panels have a carbon footprint of 23.01 kg eq. CO_2 per m² (source FDES) is lower than HPL2, fiber cement, rock wool, organic stone, terracotta, composite wood, even without taking into account its longer service life (70 years).

Depletion potential of the stratospheric ozone layer (ODP)
Unit: kg eq. CFC-11
The ozone layer protects the Earth from the sun's ultraviolet rays, which can cause human disease, harm plants and marine life, change the climate through the greenhouse effect, and accelerate the deterioration of materials such as plastics and natural fibers. The main source of these substances linked to the building sector and damaging the ozone layer, is attributable to the use of blowing agents used in the manufacture of plastic foam insulation (polyurethane, polystyrene and polyisocyanurate).
Note that the ozone depletion potential for ALUCOBOND® is 0.0 kg eq. CFC-11 per m². It is always 0.0 for cladding materials, so it is not shown in Table 10.

Acidification potential of land and water (AP)
Unit: kg eq. SO2
Some air pollutants emitted contribute, during their fallout, to the acidification of soils. This process can cause deterioration of forests, lakes, rivers and ecosystems.
The building sector contributes to the acidification of the environment through the consumption of fossil fuels for heating (e.g. natural gas) and during the production of materials such as reinforced concrete, gypsum panels and steel tubing.
The acidification potential for ALUCOBOND® is 0.04 kg eq. SO2 per m². It is always less than 1.0 for cladding materials, as this value is not significant, it is not indicated in Table 10.

Eutrophication potential (EP)
Unit: kg eq. (PO4)3
Phenomenon of excessive enrichment of soils and aquatic environments in nutrients, which leads to the excessive growth of certain species (algae for example), and, conversely, the disappearance of other species. Agricultural activity, through excessive use of fertilizers, and wastewater discharges are the main causes.

In the building sector, the production of materials such as reinforced concrete and gypsum panels, as well as their transport and end-of-life management, contributes to eutrophication.
The eutrophication potential for ALUCOBOND® is 0.0 kg eq. (PO4) 3 per m². It is always less than 1.0 for cladding materials, as this value is not significant, it is not indicated in Table 10.

Formation potential of tropospheric ozone photochemical oxidants (POCP)
Unit: kg eq. ethene
Ground-level ozone (low altitude) is an air pollutant dangerous to health, to plants, and has corrosive effects on materials. It is formed by chemical reactions activated by solar radiation, from volatile organic compounds (VOCs) and nitrogen oxides (NOx).
The ground-level ozone formation potential for ALUCOBOND® is 0.0 kg eq. Ethene per m². It is always less than 1.0 for cladding materials, as this value is not significant, it is not indicated in Table 10.

Abiotic depletion potential for non-fossil resources (ADPE)
Unit: kg eq. Sb
Consumption of non-renewable fossil resources, thereby reducing their availability for future generations, such as rare earths (does not apply to oil, gas, or coal).
The ADPE potential for ALUCOBOND® is 0.0 kg eq. Sb per m². It is always 0.0 for cladding materials, so it is not shown in Table 10.

Abiotic depletion potential for fossil resources (ADPF)
Unit: MJ
Consumption of non-renewable fossil resources, thereby reducing their availability for future generations, for example oil, gas, or coal.
ALUCOBOND® panels have an ADPF potential of 274.70 MJ per m², which is lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood cladding, even without taking into account its service life. most important (70 years). See table 10.

Air pollution (AirP)
Unit: m³
Concentration of harmful pollutants in a given volume of air. Most air pollution comes from energy production and transportation. This category only exists in the FDES (French EPD), not in the EPD.
ALUCOBOND® panels generate air pollution of 1022.66 m³ per m², which is much lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood cladding, even without taking into account his most important service life (70 years). See table 10.

Water pollution (WaterP)
Unit: m³
Amount of water polluted during production. This water is then purified but there often remains polluted sludge or sediment. This category only exists in the FDES (French EPD), not in the EPD.

ALUCOBOND® panels generate water pollution of 30.62 m^3 per m^2, which is a little more than HPL, fiber cement, rock wool, mineral resin, terracotta or Douglas wood siding, but much less than wood composite, without taking into account its longer service life (70 years). See table 10.

2) Ressource use

Renewable primary energy as energy carrier (PERE)
Unit: MJ
It is the amount of renewable energy used to run the systems, equipment and processes required during the life cycle of a product.
The PERE for ALUCOBOND® is 29.89 MJ per m^2. It is lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood or Douglas wood cladding, even without taking into account its longer service life (70 years). See table 10.

Renewable primary energy resources as material utilization (PERM)
Unit: MJ
This is the amount of renewable energy available in the form of raw materials (eg: energy content of wood).
The PERM for ALUCOBOND® is 0.0 MJ per m^2. HPL cladding, fiber cement, organic stone, terracotta, composite wood or Douglas wood, have a much higher value. See table 10.

Total use of renewable primary energy resources (PERT)
Unit: MJ
It is the sum of the two previous values.
ALUCOBOND® panels have a total use of renewable primary energy resources of 29.89 MJ per m^2, which is much lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood or Douglas wood cladding, even without taking into account his longer service life (70 years). See table 10.

Non-renewable primary energy as energy carrier (PENRE)
Unit: MJ
It is the amount of non-renewable energy used to operate the systems, equipment and processes required during the life cycle of products (eg natural gas burned in a boiler).
The PENRE for ALUCOBOND® is 248.46 MJ per m^2. It is lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood cladding, even without taking into account its longer service life (70 years). See table 10.

Non-renewable primary energy as material utilization (PENRN)
Unit: MJ
This is the amount of non-renewable energy available in the form of raw materials (eg: energy content of plastics).

The PENRN for ALUCOBOND® is 13.30 MJ per m². It is lower than HPL, rock wool, organic stone cladding, even without taking into account its longer service life (70 years). See table 10.

Total use of nonrenewable primary energy resources (PENRT)
Unit: MJ
It is the sum of the two previous values.
ALUCOBOND® panels have a total use of non-renewable primary energy resources of 261.46 MJ per m², this is much lower than HPL, fiber cement, rock wool, organic stone, terracotta, composite wood cladding, even without taking into account his longer service life (70 years). See table 10.

Use of secondary material (SM)
Unit: MJ
This is the amount of material recovered after first use or from waste, replacing primary materials.
The secondary material usage for ALUCOBOND® is 0.99 MJ per m². It is always less than 5.0 for cladding materials, as this value is not significant, it is not indicated in Table 10.

Use of renewable secondary fuels (RSF)
Unit: MJ
It is the amount of energy from renewable fuels recovered after first use or from waste, which replace primary fuels (e.g. wood from the demolition of a building used as fuel in a system during the product life, used vegetable oil).
The use of renewable secondary fuels for ALUCOBOND® is 0.0 MJ per m². It is always 0.0 for cladding materials, as this value is not significant and is not shown in Table 10.

Use of non-renewable secondary fuels (NRSF)
Unit: MJ
It is the amount of energy from renewable fuels recovered after first use or from waste, which replace primary fuels (e.g. wood from the deconstruction of a building used as fuel in a system during the product life, used vegetable oil).
The use of non-renewable secondary fuels for ALUCOBOND® is 0.0 MJ per m². It is always 0.0 except for HPL type 1 (25.56 MJ / m²) and rock wool (21.24 MJ / m²) panels.

Use of net fresh water (FW)
Unit: m³
It is the amount of fresh water (of natural origin) used during the life cycle of products.
ALUCOBOND® panels have a net fresh water use of 0.13 m³ per m², it is always less than 5.0 for cladding materials, this value is not significant, it is not indicated in the table 10.

3) Output flows and waste categories

Hazardous waste disposed (HWD)
Unit: kg
Waste classified as "hazardous" produced during production and disposed of.
The hazardous waste eliminated for ALUCOBOND® is 0.0 kg per m². It is always close to 0.0 except for organic stone panels (5.12 kg/m²). This value is not shown in Table 10.

Non-hazardous waste disposed (NHWD)
Unit: kg
It includes the deposit of waste in a permanent storage location, for example, landfill and disposal by incineration.
The non-hazardous waste eliminated for ALUCOBOND® is 2.07 kg per m². This is much lower than HPL type 1, fiber cement, rock wool, organic stone, terracotta, composite wood or Douglas wood cladding, even without taking into account its longer service life (70 years). This value is not indicated in table 10 because it is considered to have no relevant environmental impact.

Radioactive waste disposed (RWD)
Unit: kg
Waste classified as "radioactive" produced during production and disposed of. They mainly result from the share of the consumption of electricity of nuclear origin used.
The radioactive waste eliminated for ALUCOBOND® is 0.0 kg per m². They are always close to 0.0 for cladding materials, so they are not shown in Table 10.

Components for re-use (CRU)
Unit: kg
Re-use is any operation whereby products or components that are not waste, are reused for their initial function or are used for other functions without undergoing reprocessing.
The components intended for re-use for ALUCOBOND® are 0.0 kg per m². They are always 0.0 for cladding materials, so they are not shown in Table 10.

Materials for recycling (MFR)
Unit: kg
Recovery operation by which waste is reprocessed into products, materials or substances, for their original function or for other functions. Recycling operations include:

- recycling of organic substances
- metal recycling
- recycling of other inorganic materials

The components for recycling for ALUCOBOND® are 1.55 kg per m². This value is not shown in table 10, because it depends on the weight of the cladding per m², a light panel tends to have less recyclable mass than a heavy panel.

Materials for energy recovery (MER)
Unit: kg
It is the operation of treating waste with the aim of replacing other resources or aiming to prepare the waste for energy recovery.
The components for energy recovery for ALUCOBOND® are 4.14 kg per m^2. This value is not shown in Table 10 because it depends on the path chosen between material recycling, re-use or energy recovery. For ALUCOBOND®, the binder in the core becomes energy, used to melt aluminum sheets.

Exported energy (EEE-EET-EEP)
Unit: MJ
It is the surplus energy production that takes place on the building site, which is supplied externally in the form of electricity, heat or gas (only in the FDES).
The different energies supplied to the exterior for ALUCOBOND® are 0.0 MJ per m^2. This value is not shown in table 10, as it does not depend on the material itself but on the equipment at the factory.

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