european
aluminium association

SUSTAINABILITY OF ALUMINIUM IN BUILDINGS

CONTENTS

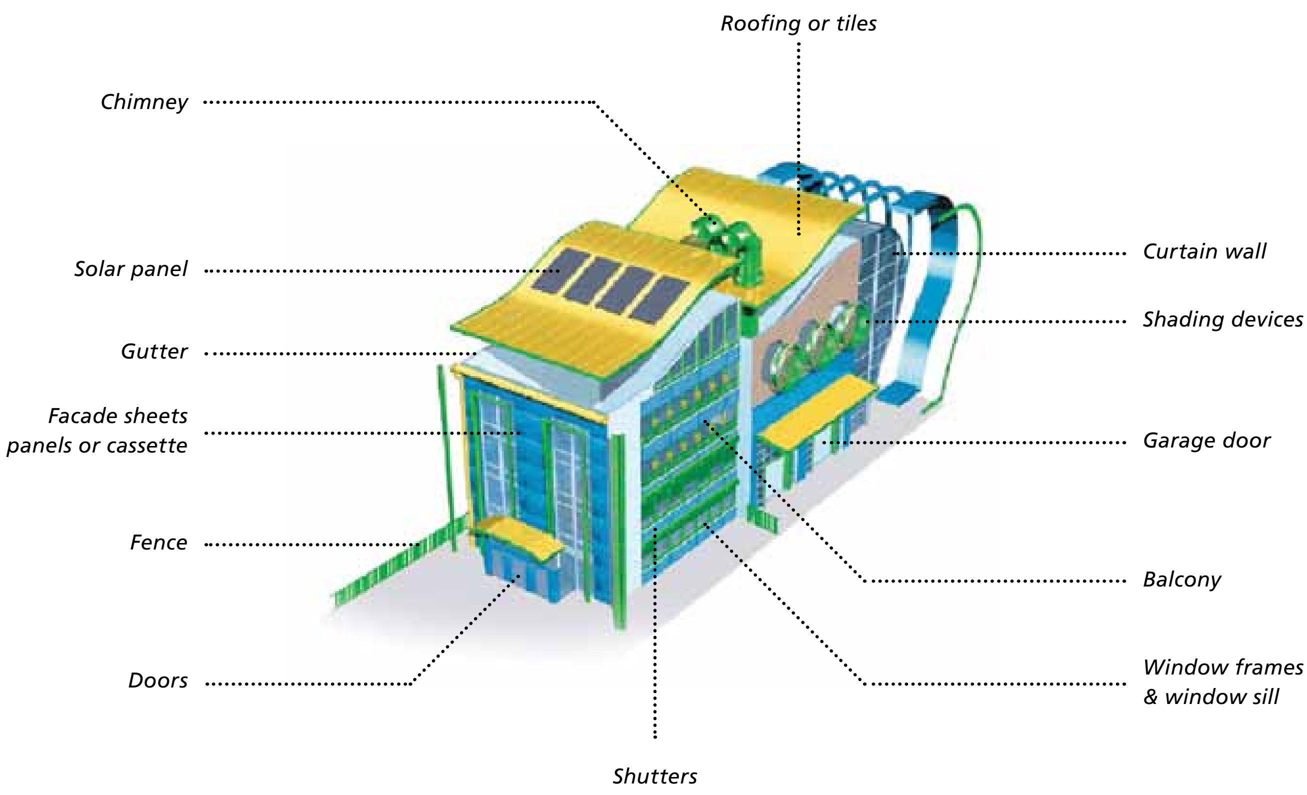
INTRODUCTION

Aluminium is a very young metal, extracted for the first time in 1854. Commercially produced as a precious metal from 1886, its industrial production for civil applications only took off in the 1950's.

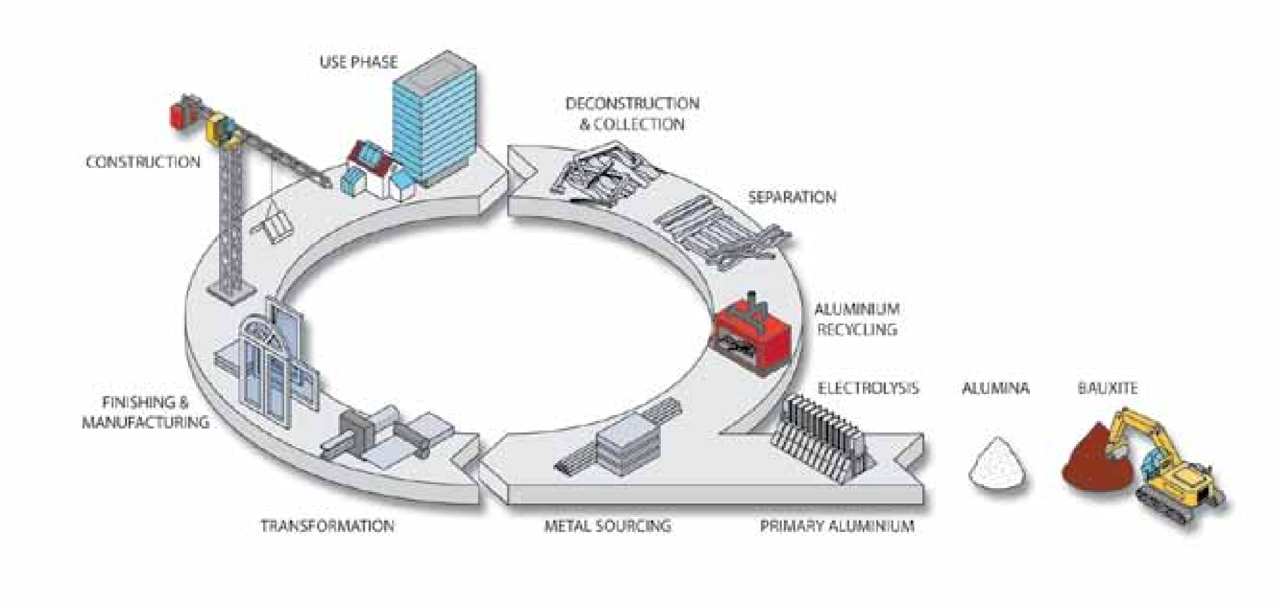
The first well-known application in buildings dates back to 1898, when the dome of San Gioacchino's Church in Rome was clad in aluminium sheets. The stunning Art Deco-inspired Empire State Building in New York was the first building to use anodised aluminium components back in 1931.

Aluminium is now utilised for a host of applications in building and construction and is the material of choice for curtain walling, window frames and other glazed structures. It is extensively used for rolling blinds, doors, exterior cladding and roofing, suspended ceilings, wall panels and partitions, heating and ventilation equipment, solar shading devices, light reflectors and complete prefabricated buildings. Structures like offshore living quarters, helicopter decks, balustrades, scaffolding and ladders, are also commonly made of aluminium.

The reasons for this sustainable success, including aluminium cradle to cradle lifecycle and its contribution to energy efficiency of buildings, are explained in the present brochure.



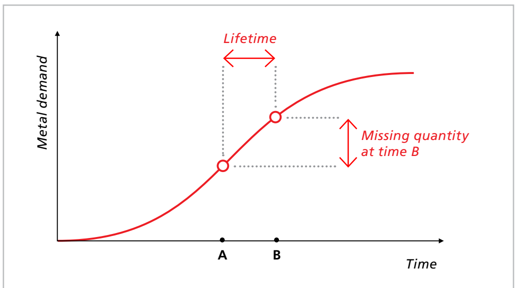
1.FROM CRADLE TO CRADLE, THE ALUMINIUM CYCLE IS INFINITE



1.1. METAL SOURCING

More than half of the aluminium currently produced in the European Union originates from recycled raw materials, and this trend is on the increase. As the energy required to recycle aluminium is about 5% of that needed for primary production, the ecological benefits of recycling are obvious. The way in which aluminium building products are recycled is explained in Section 1.6.

Due to the long lifespan of buildings and transport vehicles, the available quantity of end-of-life aluminium scrap today is limited to what was put on the market many years ago. This volume being much less than current requirements, the missing quantity has to be supplied by the primary aluminium industry.



Bauxite, the ore from which primary aluminium is produced, originates mainly from Australia, Brazil, West Africa and the West Indies, and also from other tropical and sub-tropical regions. Newly mined areas are balanced by the rehabilitation of existing mining areas. 98% of mines have rehabilitation plans, and the area returned to native forests is expected to be higher than the original vegetation before mining*.

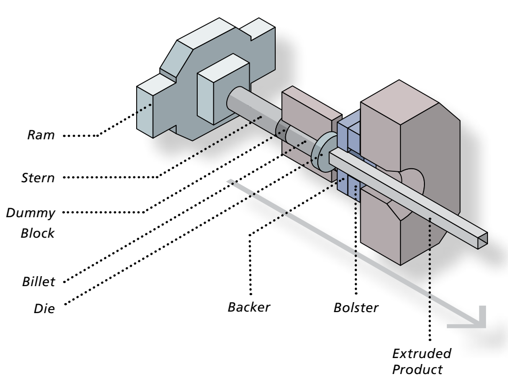
Primary aluminium is obtained by the electrolysis of alumina (aluminium oxide) that is extracted from bauxite.

Total greenhouse gas emissions from European aluminium were reduced by 45% between 1990 and 2005.

*4th Sustainable Bauxite Mining Report International Aluminium Institute - 2008

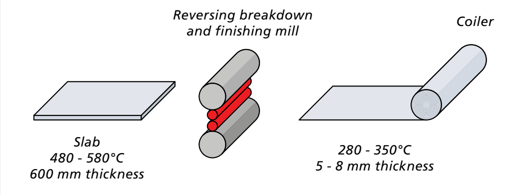
1.2. TRANSFORMATION

EXTRUSION PROCESS



Aluminium profiles are obtained through the extrusion process, which consists of pushing a hot cylindrical billet of aluminium through a shaped die. The ease with which aluminium alloys can be extruded into complex shapes allows the designer to "put metal exactly where it is needed", and also to introduce multi-functional features. Aluminium extrusions are used in commercial and domestic buildings for windows, doors and curtain wall frame systems, prefabricated houses/building structures, and many other applications.

HOT ROLLING PROCESS



Aluminium flat products are obtained through the rolling process, whereby large aluminium slabs are fed into rolling mills that turn aluminium into sheets of various thicknesses. The process normally begins with a hot rolling method, taking the block back and forth through a reducing roller. Final rolling is through a cold roll process, and the sheet can be reduced to a thickness of 0.15 mm. The sheet can be further thinned into foil of a thickness of 0.007 mm. Sheets can be formed for use, e.g. as cladding panels or rolling shutters, while foils are usually applied to other materials (e.g. insulation).

Aluminium is one of the few metals that can be cast in all metal casting processes. The most common methods include die casting, permanent mould casting and sand casting. Castings can also be made to virtually any size and, for the architect, this offers a flexible material with which to work, offering few restrictions in design.

1.3. FINISHING

Aluminium is one of only a handful of metals that can be left in their natural state without finishing. Aluminium will naturally oxidise when exposed to air, and this thin film of oxide then fully protects the aluminium from further oxidation.

Anodising is an electrochemical process whereby to reinforce the natural oxide film on the aluminium surface, increasing hardness, corrosion and abrasion resistance. Anodising gives a very decorative silver matt surface finish, and coloured surfaces can also be obtained by sealing metallic dyes into the anodised layer. Full anodizing usually corresponds to an anodized layer of about 15-20µm, while pre-anodizing is limited to about 5-10µm.

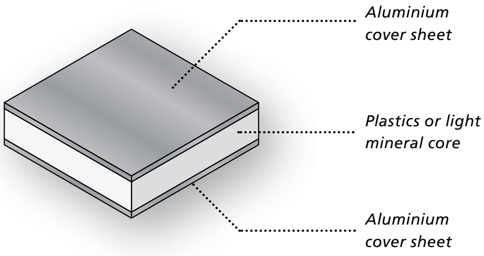
The two coatings described hereafter can be applied with or without pre-anodizing.

Powder coating is mostly used for profiles, but can also be used for rolled products.

It is a type of paint that is applied as dry powder. The coating is typically applied electro-statically and is then cured under heat to allow it to flow and form a "skin". The powder may be a thermoplastic or a thermoset polymer. A wide range of colours and gloss levels can be achieved.

Continuous wet coil coating is the most common process for rolled aluminium products.

The aluminium substrate is delivered in coil form from the rolling mills. The coil is positioned at the beginning of the line, and then unwound at a constant speed, passing through pre-treatment, coating baths and curing furnaces before being recoiled.



Composite panels constitute an important application of coil-coated sheets, i.e. a sandwich of two aluminium sheets bonded to a polyethylene core. Easy to curve and bend, these products can be used for cladding, roofing, corporate identity and display applications.

1.4. USE PHASE

Aluminium is highly appreciated in the building sector for its very long in-service life, low maintenance and its contribution to the energy performance of buildings. These assets are explained in detail in Chapters 2, 3 & 4

1.5. DECONSTRUCTION AND COLLECTION

A study by Delft University of Technology revealed aluminium's considerable end-of-life recovery rate in the building sector. Aluminium collection rates taken from a large sample of commercial and residential buildings in 6 European countries were found to be in excess of 92% (on average 96%), demonstrating the value and preservation of the material at the end of the aluminium product life cycle.

Collected aluminium products are subsequently reused or recycled.

1.6. RECYCLING

The high intrinsic value of aluminium is a major economic incentive for its recycling. Indeed, aluminium scrap can be repeatedly recycled without any loss of value or properties. Furthermore, the energy required is a mere fraction of that needed for primary production, often as little as 5%, yielding obvious ecological benefits.

In many instances, aluminium is combined with other materials such as steel or plastics, which are most frequently mechanically separated from aluminium before being molten: shredding followed by eddy current and sink-float separation.

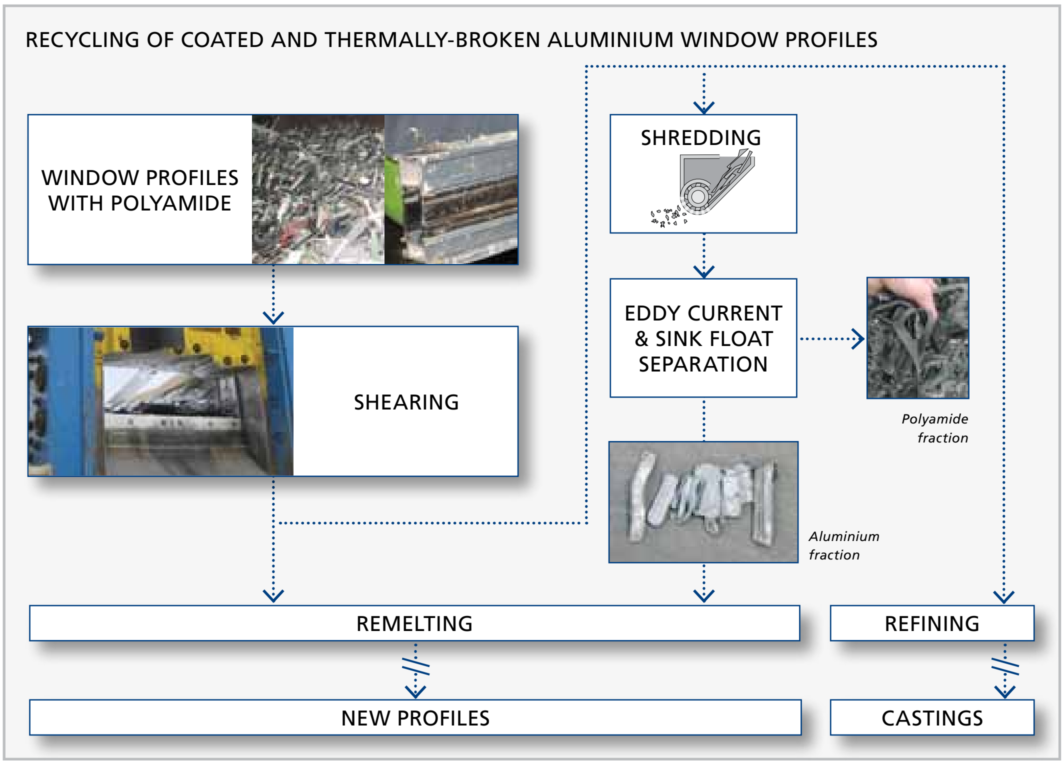
Aluminium can then be melted either by remelters or refiners.

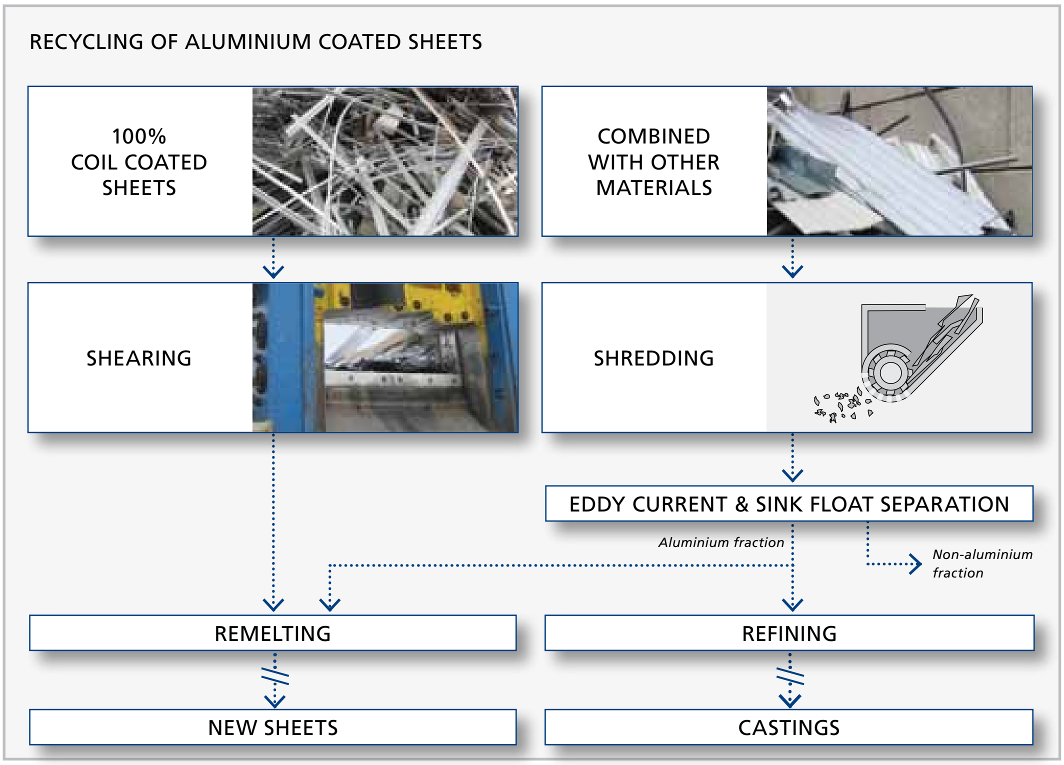
- Remelters mainly process sorted wrought alloy scrap in dry hearth furnaces to produce extrusion billets or rolling slabs.
- Refiners melt all kinds of scrap, including mixed alloys and soiled scrap in rotary furnaces, which melt and refine aluminium scrap under a salt layer. Refiners mainly produce casting alloys for foundries.

As technology evolves, a growing number of remelters are now able to process coated and polymer-containing scraps with no or limited preparation processes. They use a two-chamber furnace. Finishes to the aluminium (e.g. coating) are burnt away in the first chamber, and gas emissions are collected in efficient fume capture equipment. Aluminium heating mainly takes place in the second chamber.

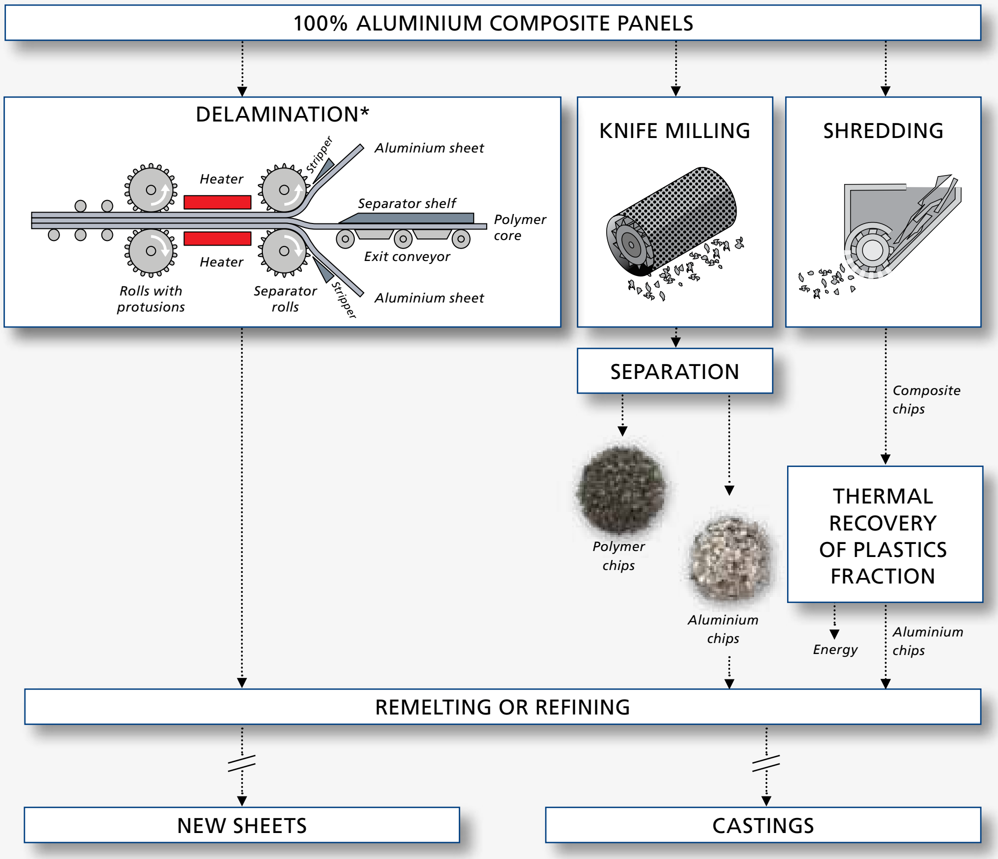
Liquid aluminium can then be transported directly to foundries or cast into ingots, extrusion billets or rolling slabs, ready to start a new life. Consequently, the life cycle of an aluminium product is not the traditional “cradle-to-grave” sequence, but rather “cradle-to-cradle”.

In the following pages, charts illustrate how today’s aluminium building products are recycled.


RECYCLING OF COATED AND THERMALLY-BROKEN ALUMINIUM WINDOW PROFILES
WINDOW PROFILES WITH POLYAMIDE
SHEARING
SHREDDING
EDDY CURRENT & SINK FLOAT SEPARATION
Polyamide fraction
Aluminium fraction
REMELTING
REFINING
NEW PROFILES
CASTINGS


RECYCLING OF ALUMINIUM COATED SHEETS
100% COIL COATED SHEETS
COMBINED WITH OTHER MATERIALS
SHEARING
SHREDDING
EDDY CURRENT & SINK FLOAT SEPARATION
Aluminium fraction
Non-aluminium fraction
REMELTING
REFINING
NEW SHEETS
CASTINGS

RECYCLING OF ALUMINIUM COMPOSITE PANELS



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

1.7. LIFE CYCLE ASSESSMENT AND ENVIRONMENTAL PRODUCT DECLARATIONS

Recognising an increasing demand, the European Aluminium Association is developing Environmental Product Declarations (EPDs) for aluminium building products in line with international ISO standards.

An EPD is the most comprehensive and transparent type of environmental labelling, destined for business-to-business communication. It takes into account the entire product life cycle and computes a vast quantity of environmental information into a set of internationally recognised indicators, such as “use of primary energy”, “water consumption”, “greenhouse gas emissions”, etc. in well known units as CO_2-equivalents. It is, moreover, verified by an independent third party.

Manufacturers’ software generating EPDs is available for aluminium windows and aluminium coil coated sheets, and shortly also for aluminium composite panels.

2. ALUMINIUM COMBINES MANY ADVANTAGES

2.1. WIDE CHOICE OF ALLOYS

Aluminium in its pure form is a very soft metal, and hence not suited for building applications. Thanks to the addition of alloying elements such as copper, manganese, magnesium, zinc, etc… and thanks to suitable production processes, the physical and mechanical properties can be varied in a wide range to satisfy the requirements of a large number of different applications.

2.2. DESIGN FLEXIBILITY

The extrusion process offers an almost infinite range of forms and sections, allowing designers to integrate numerous functions into one profile. Coated sheets and composite panels may be manufactured flat, curved, shaped into cassettes, or sandwiched with other materials.

In addition, aluminium can be sawed, drilled, riveted, screwed, bent, welded and soldered in the workshop or on the building site.

2.3. LONG SERVICE LIFE

Aluminium building products are made from alloys that are weatherproof, corrosion-resistant and immune to the harmful effects of UV rays, ensuring optimal performance over a very long period of time.

In 1898, the dome of San Gioacchino's Church in Rome was clad in aluminium sheets, which are still in pristine condition today, more than 100 years later.

2.4. LOW MAINTENANCE

Apart from routine cleaning for aesthetic reasons, neither bare nor painted aluminium requires any maintenance, which translates into a major cost and ecological advantage over the lifetime of a product.

2.5. HUNDREDS OF SURFACE FINISHES

Aluminium can be anodised or painted in any colour, to any optical effect, using any number of surface touches, in order to meet a designer's decorative needs. Such processes also serve to enhance the material's durability and corrosion resistance, as well as providing an easy-to-clean surface.

2.6. HIGH STRENGTH-TO-WEIGHT RATIO

This unique property allows architects to meet required performance specifications, while minimising the dead load on a building's supporting structure. This is a key advantage for cladding and roofing applications.

Furthermore, thanks to the metal's inherent strength and stiffness, aluminium window and curtain wall frames can be very narrow, maximising glazed surface and solar gains for given outer dimensions.

Moreover, the material's light weight makes it easier to transport and handle on-site, reducing the risk of work-related injury.

2.7. HIGH REFLECTIVITY

This characteristic feature makes aluminium a very efficient material for light management. Aluminium solar collectors and light channels can be installed to lower energy consumption for artificial lighting and heating in winter. Aluminium shading devices can be used to reduce the need for air conditioning in summer.

2.8. HEAT CONDUCTIVITY

Aluminium is a good conductor of heat, which makes it an excellent material for heat exchangers used in energy efficient ventilation systems or in solar thermal heat collectors.

While it may be a disadvantage in window and façade applications, this property is overcome by an appropriate profile design and the use of thermal breaks made of low conductivity materials.

2.9. FIRE SAFETY

Aluminium does not burn, and is therefore classified as a non-combustible construction material (European Fire Class A1). Aluminium alloys will nevertheless melt at around 650°C, but without releasing harmful gases. Industrial roofs and external walls are increasingly being made of thin aluminium cladding panels, intended to melt during a major fire, allowing heat and smoke to escape and thereby minimising damage.

2.10. NO RELEASE OF DANGEROUS SUBSTANCES

Several studies have proved that aluminium building products do not present a hazard to occupants or the surrounding environment. On both sides, today's studies prove that the alloys used, their surface treatments (either coating or anodising) and the materials used are all neutral. Aluminium building products have no negative impact, either on indoor air quality or on soil, surface and groundwater.

2.11. OPTIMAL SECURITY

Where high security is required, specially designed, strengthened aluminium frames can be used. While the glass for such applications may well be heavy, the overall weight of the structure remains manageable thanks to the light weight of the aluminium frame.

3. ALUMINIUM BUILDING PRODUCTS ARE HIGHLY ENGINEERED

3.1. DESIGN, TESTING AND MANUFACTURING

Aluminium building products are not limited to aluminium profiles or sheets: based on these semi-products, complete solutions are offered to satisfy market needs.

For windows and curtain walls for example, a sector where manufacturers are mostly SME's employing between 2 and 12 people, aluminium system companies design and test complete window and curtain wall solutions in accordance with European and International Standards.

Manufacturers can buy these systems, cut them to the required size and assemble them following guidance from aluminium system companies in order to obtain finished products fulfilling all the necessary requirements to be put on the European market.

The same goes for coated aluminium sheets and composite panels used for cladding. These are designed and tested to meet the required European Fire Safety Class, and dedicated fixing kits are developed to simplify their installation in buildings.

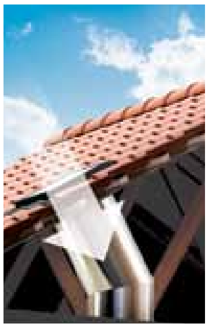
3.2. AFFORDABLE CE-MARKING FOR SMES

Small- and medium-sized enterprises can benefit from the "cascading" principle, i.e. using reports on expensive and time-consuming tests performed by a system company, with whom they cooperate and receive training and manufacturing guidelines. Using that principle, manufacturers can affordably affix the CE-mark and declare the performance of their products.

4. ALUMINIUM IMPROVES THE ENERGY PERFORMANCE OF BUILDINGS

4.1. NATURAL LIGHTING

Design flexibility, strength, durability and dimensional stability are remarkable attributes of aluminium profiles. It is not surprising, therefore, that aluminium profiles constitute the natural structural components for large glazing surfaces like verandas, skylights, curtain walls and large sliding windows.



Aluminium profiles and glass provide the perfect combination to ensure a high level of natural lighting inside buildings. As an example, for the same window dimension, slender thermally broken aluminium profiles can increase transparent areas by up to 20% compared to windows equipped with frames made of other materials. As illustrated in Section 2.7, the upper part of aluminium solar protection can be used to deflect part of the sun rays towards the ceiling. For rooms or halls without windows, aluminium light channels can bring natural light from the roof down to the darkest locations. Increasing natural lighting is unquestionably beneficial for the occupants' comfort and well-being, while it also reduces the need for artificial lighting, contributing significantly to the building's sustainability.

4.2. ENERGY SAVINGS DURING THE HEATING SEASON

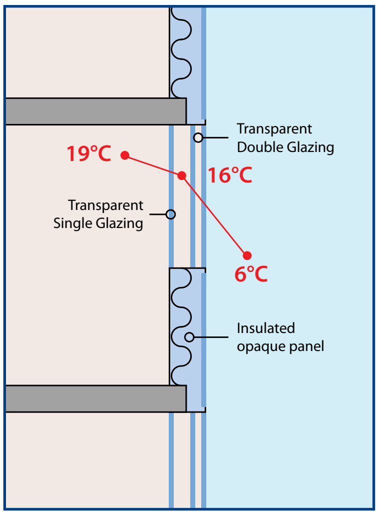
In cold periods, heat losses need to be reduced, while solar gains have to be maximised. In this case, a large insulated glazing surface with a high solar gain will be used in the shiniest position, in the same way as it is frequently used in passive and energy-efficient buildings. Maximising the transparent areas of windows through the use of slender frames can also help to optimise such solar gains. The use of aluminium shutters in cold periods will also limit heat losses at night.

Buffer zone concepts such as double skin glazed facades further reduce energy losses.

Aluminium foils also protect insulation materials from the inner side, offering an impermeable barrier to moisture, gas and light. In addition, aluminium foil reflects infrared heat into the building, thereby improving insulation performance.

Aluminium ventilated cladding systems protect the outer side of insulation materials against rain, which would cause their heat-saving properties to deteriorate. Furthermore, the air gap serves as an additional retainer of warmth. Ventilated facade systems make it possible to prevent considerable loss of energy.

DOUBLE SKIN FACADE TEMPERATURE PROFILE IN WINTER MODE



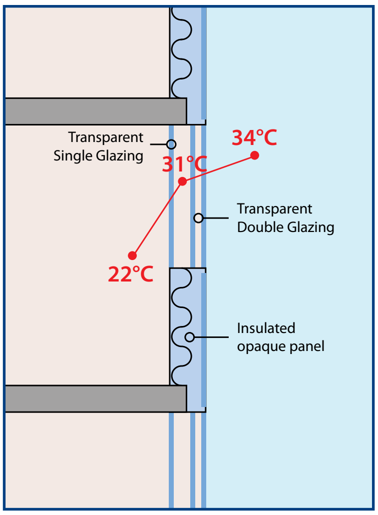
4.3. ENERGY SAVINGS DURING THE COOLING SEASON

In hot seasons, solar gains need to be minimised in order to optimise the occupants' thermal comfort and to reduce air conditioning needs. As a result, in warm regions, low solar gain glass should be used with associated shading devices like solar blades or shutters. In regions where winter and summer temperatures vary significantly, it is then crucial to design shading devices capable of optimising the window's solar gains according to the seasons.

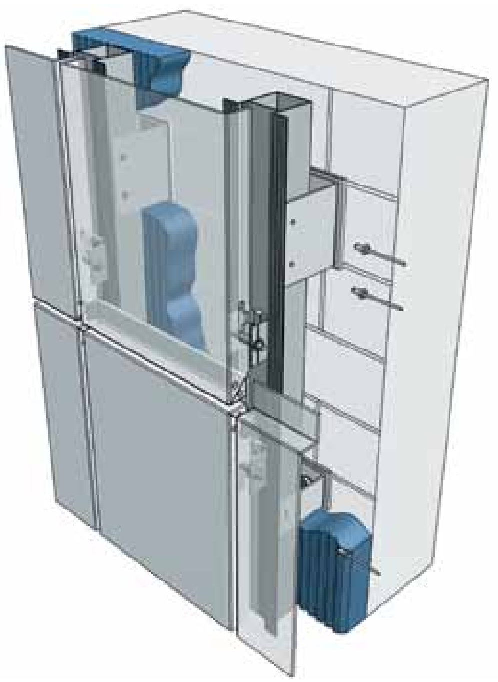
A double skin facade can also be designed to reduce solar gains, using its external layer and/or shading devices installed in the cavity.

Ventilated aluminium claddings partially reflect solar radiation and ensure natural ventilation, which reduces the amount of heat that buildings absorb in hot weather.

DOUBLE SKIN FACADE TEMPERATURE PROFILE IN SUMMER MODE



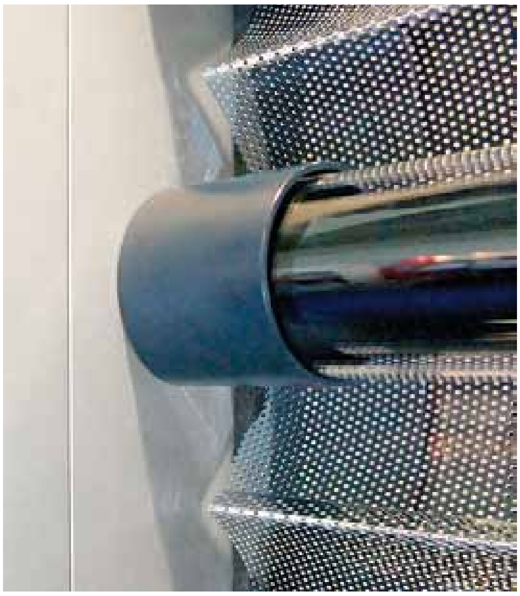
VENTILATED ALUMINIUM CLADDING



4.4. AIRTIGHTNESS

International Standards, European and National building regulations are becoming tougher by the day, with the aim of increasing the airtightness of buildings, and thereby minimising heat losses. Aluminium products are ideal, as they are not porous and their mechanical stability secures the highest performance throughout the years.

4.5. SOLAR HEATING AND PHOTOVOLTAICS



Solar tube with aluminium reflector

Harnessing solar energy is obviously a natural way of positively balancing the energy performance of the building envelope. As an example, the use of solar thermal energy panels and tubes is an extremely effective way of providing hot water for domestic and commercial applications. Thanks to its heat conductivity and durability, anodised aluminium, possibly combined with aluminium reflectors to concentrate the sun’s rays, seems to be the material of choice to capture solar radiation.

Taking advantage of the material’s durability and lightness, aluminium profiles are largely used in photovoltaic systems, and are especially installed on building roofs, where weight needs to be reduced as much as possible. Photovoltaic cells may also be directly built into large glazing areas such as verandas, as well as aluminium shading devices. Aluminium profiles are specifically designed to allow for the easy and durable electrification of the whole photovoltaic system.

Hence, aluminium is a key material supporting the development of solar-based energy supply systems, which are making a significant contribution to the sustainability dimension of buildings.

4.6. ALUMINIUM ALLOWS FOR EFFICIENT RENOVATION

Aluminium enables "energy monsters" to be transformed into energy-efficient buildings.

For example, the Torenflat (high-rise apartment block) contains 484 apartments on central corridors on 19 residential levels. One of the important objectives of this renovation, which was carried out entirely whilst people were living in the building, was to eliminate all the thermal bridges of the complex. This was achieved by enclosing the entire building in a 'warm jacket', a light thermal skin comprised of fully prefabricated aluminium façade units that could be fixed onto the existing structure. Each apartment was given a new skin in one working day. By enclosing the building in this way, the thermal performance of the building was dramatically improved: the energy performance of the building has been improved by three categories according to the Dutch energy labelling system. This project combined minimal investment with the maximum social economic impact.

4.7. INTELLIGENT BUILDING ENVELOPES

Intelligent facades incorporating aluminium systems can decrease energy consumption in buildings by up to 50%. The key feature of these intelligent buildings is their optimized interaction with the exterior, markedly reducing heating, cooling, ventilation and lighting energy demands throughout the seasons. This is achieved through numerous techniques and processes, including photovoltaics, optimised ventilation mechanisms, and appropriate light and shade management.

CONCLUSION

Aluminium plays a key role for the sustainability of new buildings and the renovation of existing ones. Thanks to its performance properties, aluminium largely contributes to the energy performance, safety and comfort of new buildings. Aluminium's versatility also allows for an easy upgrade of existing buildings, including historic ones. Aluminium plays an important role in the production of renewable energy from solar sources. Finally, at the end of its very long lifespan, the high intrinsic value of aluminium is a major economic incentive for its recycling, through several processes adapted to the nature of building scraps, securing its cradle-to-cradle life cycle and associated environmental benefits.

The recycling of aluminium building products is therefore not a potential, it is today's reality.

FURTHER INFO / REFERENCES

European and global links

European Aluminium Association	www.aluminium.org
European Aluminium Association, Building Group	www.alu-build.eu
Federation of European Aluminium Windows & Curtain Wall Manufacturers' Associations	www.faecf.org
European Aluminium Award	www.aluminium-award.eu
European Commission portal for energy efficiency in buildings	www.buildup.eu
Organisation of European Aluminium Recycling Industry	www.oea-alurecycling.org
European Aluminium Foil Association	www.alufoil.org
International Aluminium Institute	www.world-aluminium.org
International Aluminium Institute, Green Building Website	http://greenbuilding.world-aluminium.org

National aluminium associations

Austria	Fachverband NE-Metall - Wirtschaftskammer Österreich	www.nemetall.at
	Aluminium Fenster Institut	www.alufenster.at
	Arbeitsgemeinschaft der Hersteller von Metall-Fenster/Türen/Tore/Fassaden	www.amft.at
Belgium	Aluminium Center	www.aluminiumcenter.be
Denmark	Aluminium Danmark	www.alu.dk
France	Association Française de l'Aluminium	www.aluminium-info.com
	Association Aluminium Architecture	www.aluminiumarchitecture.com
	Syndicat National de la construction des fenêtres, façades et activités associées	www.snfa.fr
Germany	Gesamtverband der Aluminiumindustrie	www.aluinfo.de
	Verwertungsgesellschaft Aluminium-Altfenster	www.a-u-f.com
Greece	Aluminium Association of Greece	www.aluminium.org.gr
	Greek Association of Aluminium Manufacturers	www.seka.org.gr
Italy	Centro Italiano Alluminio	www.assomet.it
	Unione Nazionale Costruttori Serramenti Alluminio Acciaio e Leghe	www.uncsaal.it
Spain	Asociación Nacional de Extruidores de Perfiles de Aluminio	www.anexpa.org
Switzerland	Association Suisse de l'Aluminium / Aluminium-Verband Schweiz	www.alu.ch
The Netherlands	Vereniging Nederlandse Metallurgische Industrie	www.vnmi.nl
	Aluminium Centrum	www.aluminiumcentrum.nl
	Vereniging Metalen Ramen en Gevelbranche	www.vmrg.nl
Sweden	Aluminiumriket Sverige	www.aluminiumriket.com
United Kingdom	Aluminium Federation	www.alfed.org.uk
	Council for Aluminium in Buildings	www.c-a-b.org.uk

SPONSORS (BRANDS)

Alcoa Architectural Products (Kawneer, Reynobond, Reynolux)	www.alcoa.com
Alumil	www.alumil.com
Hydro Building Systems (Wicona, Technal, Alumafel/Domal) and Hydro Rolled Products	www.hydro.com
Metra	www.metraarchitettura.it
Novelis	www.novelis-painted.com
Reynaers Aluminium	www.reynaers.com
Sapa Building System & Sapa Profiles	www.sapagroup.com
Schüco	www.schueco.com
Elval Colour (Etem and Etalbond)	www.elval-colour.com
3A Composites (Alucobond)	www.3acomposites.com

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4.5	Top: solar tube collectors with aluminium reflector, Ritter Energie & Umwelttechnik
4.5	Bottom: aluminium curtain wall with built-in photovoltaïc cells, O.L.V. Ziekenhuis, Aalst, BE, VK STUDIO Architects, Sapa Building System
4.6	Energy efficiency upgrade of "Torenflat", Zeist, NL, Frowijn de Roos Architects, Kremers Aluminium
4.7	Intelligent building facade, ift Rosenheim, DE
Conclusion	Office complex, Athens, GR, L. Giannousi Architect, Etem & Etalbond

ALUMINIUM AND SUSTAINABILITY

Aluminium is a sustainable material:

- → 100% recyclable, without any loss of quality
- → Cradle-to-cradle life cycle
- → High durability

Aluminium contributes to sustainable buildings:

- → Natural lighting
- → Energy saving systems
- → Air tightness
- → Solar heating and photovoltaics

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Aluminium for Future Generations