

# Aluminum in Green Buildings

A Guide to Green Building Development  
and Certification with Aluminum Products

**Marshall Jinlong Wang**



The Aluminum Association  
1400 Crystal Drive, Suite 430  
Arlington, VA 22202  
USA

Main Line: 703-358-2960  
Bookstore: 480-779-6259  
info@aluminum.org

[www.aluminum.org](http://www.aluminum.org)



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## Introduction

### Goal of this Guide

The objective of this guide is to assist aluminum users (e.g., architects, designers, engineers, building owners) in accurately identifying, accessing, using, and interpreting reliable and up-to-date data and information regarding the life cycle characteristics and environmental performance of aluminum products.

Life cycle and environmental performance data is often necessary for green building development and certifications as well as compliance with green construction codes. By sharing this guide, the aluminum industry is contributing to sustainable building development by providing transparent and robust industry information needed to make informed choices when selecting materials for specific building and construction applications.

The intended use of this guide is to support users in understanding how aluminum contributes to current commonly adopted green building certification systems and green construction codes, including:

- Leadership in Energy and Environmental Design (LEED®)
- Green Globes®
- International Green Construction Code (IgCC)

**Disclaimer:** The material presented in this publication has been prepared for the general information of the reader and should not be used or relied on for specific applications without first securing competent advice. The Aluminum Association can help refer users to appropriate experts. Contact information is enclosed in the final section of this guide.

### About The Aluminum Association

The Aluminum Association represents U.S. and foreign-based companies and their suppliers throughout the value chain, from primary production to value added products to recycling. The Association is the industry's leading voice, providing global standards, business intelligence, sustainability research and industry expertise to member companies, policymakers and the general public. The aluminum industry helps manufacturers produce sustainable and innovative products, including more fuel efficient vehicles, recyclable packaging, greener buildings and modern electronics. In the U.S., the aluminum industry creates \$152 billion in economic activity.

For more information visit [www.Aluminum.org](http://www.Aluminum.org), on Twitter @AluminumNews or at Facebook.com/AluminumAssociation.

# Aluminum Properties

Aluminum's unique properties make it an important material in building and construction.

Aluminum is:

- **Lightweight and strong:** Aluminum's high strength-to-weight ratio makes it especially useful as a structural material, weighing up to 65% less than steel.
- **Corrosion resistant and long-lasting:** Aluminum naturally generates a protective oxide coating that resists corrosion. Different types of surface treatment can further improve this property.
- **Flexible:** Aluminum can be made into any form, shape, size, and gauge without compromising material integrity and performance.
- **Reflective:** Aluminum is a good reflector of visible light and heat. That, together with its low weight, makes it an ideal material for reflecting sunlight and saving energy.
- **Recyclable:** Aluminum can be recycled again and again without loss of quality. The re-melting of aluminum saves up to 92% of the energy required for primary aluminum production.
- **Safe:** Aluminum building products and their surface treatments do not present a hazard to occupants or the surrounding environment during use.

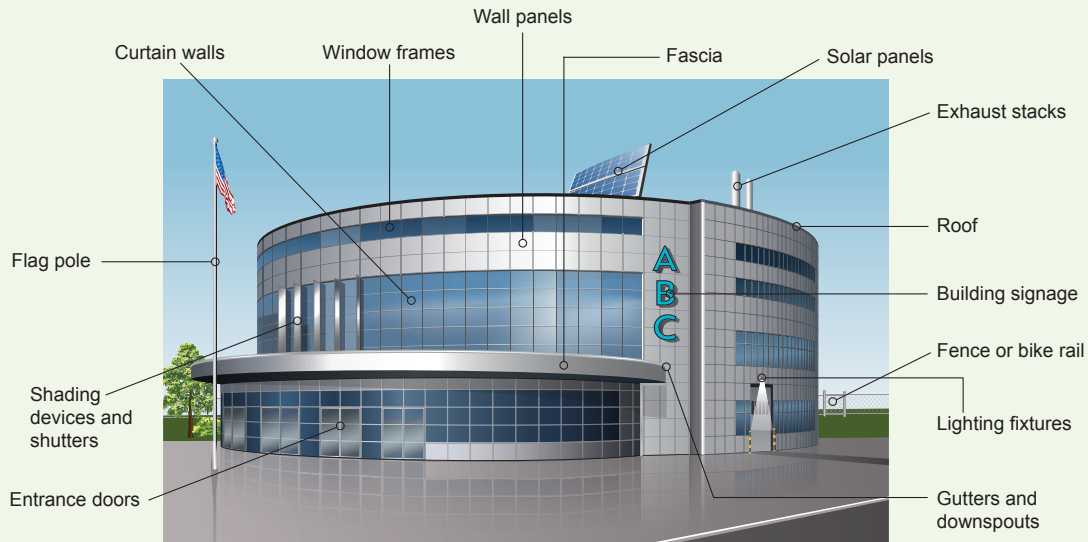
Smart utilization of part or all of these properties will enable aluminum products to not only perform their designated functions but also give people better, brighter, healthy spaces to live, work, and play.



*Figure 1: The curtain walls and ventilation ducting shown in this image take advantage of aluminum's inherent properties: lightweight, strong, flexible, and long-lasting.*

# Aluminum in Buildings

Applications of aluminum products in buildings include both structural and non-structural uses. Typical applications are shown in Figure 2:



**Figure 2: Aluminum applications in buildings**

Aluminum metals are generally in alloy forms whereby aluminum is the predominant metal that is intimately mixed with other elements such as copper, magnesium, manganese, silicon, tin and zinc. Aluminum alloys can be processed into different forms depending on the method of processing. Like most other metals, the

processing methods involve rolling, casting, forging, drawing, tubing, extrusion, etc. As a result, aluminum products can be categorized into the following types: sheet and plate, foil, extruded products, forged products, wire and cable, casting/foundry products, and paste and powder.

Major applications of aluminum products in building and construction include:

<i>Semi-Fabricated Aluminum Products</i>	<i>Applications</i>
<b>Sheet and plate</b>	Roofs, sidings and claddings, signs and wall decorations, blinds and screens, HVAC channels, gutters and downspouts, electric armors
<b>Foil</b>	HVAC systems, daylight collecting systems, solar devices
<b>Extruded products</b>	Windows and doors, skylights, curtain walls and facades, green houses and sun rooms, shades and screens, sports stadium structures and canopies, furniture and decorations, pipes and tubes, renewable energy devices (PV panels and integrated PV devices, micro wind turbines, solar heating devices, etc.)
<b>Forged products</b>	Components of windows, doors, facades, curtain walls and other structural systems; furniture and decoration
<b>Wire and cable</b>	Electric systems, lighting systems
<b>Casting/foundry products:</b>	Components of windows, doors, facades, curtain walls and other structural systems; furniture and decoration
<b>Paste and powder</b>	Coatings, pastes for electric and electronic devices

## Contributions of Aluminum Products to LEED® v4

### Energy & Atmosphere

Aluminum contributes optimized and systemic solutions for a building's energy efficiency by enabling controlled and balanced functioning among heating, cooling, lighting, and ventilation systems. This optimization is achieved through balancing the competing needs of occupants in terms of optimal indoor temperature, maximum daylight and view, and maximum fresh air.

#### ***Building envelope***

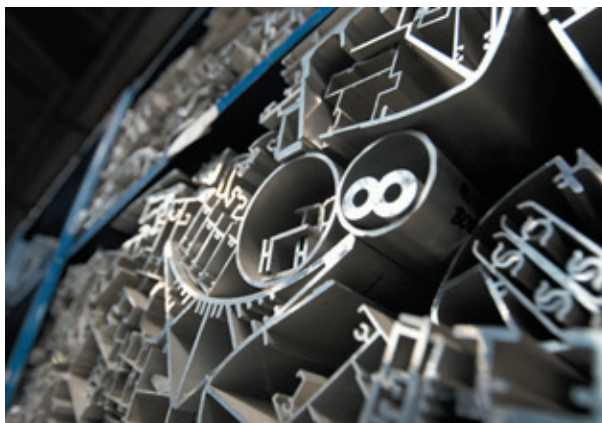
Curtain walls, façades, windows, doors, and skylights, together with assisting aluminum products such as sunshades, light shelves, screens, curtains, and indoor-outdoor air exchange devices, can provide optimized energy efficiency performance in all seasons and weather conditions. For instance, complex aluminum extrusion shapes are designed to make exceptionally insulated building fenestration systems through unique manufacturing technologies. These technologies integrate individual components such as internal and external sashes and frames, thermal barriers, and double or triple pane insulating glass. In addition, with the use of warm edge glass spacers, these fenestration systems provide excellent condensation resistance. By adding to or combining with other components and/or technological solutions, aluminum fenestration systems can be made to strike an ideal balance among U-factor, Solar Heat Gain Coefficient (SHGC), and Air Leakage, suitable for all seasons and climate zones.

#### ***Renewable energy systems***

Photovoltaic (PV), solar thermal devices, and micro wind turbines are usually made of aluminum frames and/or structures due to their strength, ease of maintenance, and light weight. These systems generate energy that can be used by the system owner (i.e., in an adjacent building) or integrated back into the power grid to achieve energy reduction or energy neutrality goals. For instance, state-of-the-art photovoltaic systems can be integrated into aluminum framed

façades. These are called aluminum-glass-PV facades and they can be made as ventilated or non-ventilated facades. Similarly, solar thermal devices and photovoltaic modules can also be integrated into other aluminum building components to accommodate architectural requirements for shape, structure, color, aesthetics, and to perform the dual functions both as part of the building envelope and as renewable energy generators. The integration of renewable energy devices into building envelopes in densely populated urban environments is a critical solution for buildings to achieve a “Net Zero” energy status. Aluminum's unique formability makes it possible to do so with ease and low cost.

Aluminum is also an important part of the manufacturing process of solar cells within PV systems. A thick layer of aluminum paste covers most of the silicon cell to provide a passivating layer on the back surface field (BSF), and increase the overall efficiency of the cell.



***Figure 3: Complex aluminum extrusion shapes are designed to make exceptionally insulated building fenestration systems.***

### **Cool roofs**

A cool roof is one that has been designed to reflect more sunlight and absorb less heat than a standard roof. Cool roofs can be made of a highly reflective type of paint, or highly reflective materials. Aluminum contributes to cool roofs both as a coating and as a roofing material. Aluminum coatings form a highly reflective surface on traditional built-up roofing (BUR) systems that reduce roof surface temperatures and protect the underlying roof membrane from UV degradation, thereby helping to prolong its life. Installing a durable metal roof is an alternative to a traditional BUR. An aluminum metal roof can achieve cool roof status by being painted a lighter color to increase its solar reflectance and thermal emittance.



**Figure 4: Frontier Project, Rancho Cucamonga, California.** Energy efficiency and thermal performance were key considerations in the design of this LEED® Platinum certified building. A north-facing glass wall provides daylight while the double-paned glass with a low-E coating, supported by high-strength, low-weight aluminum frames, reduces radiant heat transfer.

### **How aluminum contributes to LEED® v4 certification**

#### **EA Credit: Optimize Energy Performance**

**Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impact associated with excessive energy use.**

**Framing Systems, Curtain Walls and Windows** - Aluminum framing systems and curtain walls accommodate double pane and triple pane insulating glass to maximize thermal performance.

**Light Shelves** - Light shelves installed on the building interior direct available natural light to interior spaces and reduce requirements for artificial perimeter lighting, thereby conserving electrical energy costs.

**Sun Shades** - Sunshades installed on the building exterior shade interiors and optimize energy performance by reducing solar heat gain and demand on the HVAC.

#### **EA Credit: Renewable Energy Production**

**Reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.**

**Frames and Structures** - Renewable energy systems such as photovoltaic (PV), solar thermal devices and micro wind turbines are usually made of aluminum frames and/or structures. These systems can ideally be integrated into the building envelope itself to perform dual functions.

**Solar Cells** - Aluminum paste is also an important part of the manufacturing process of the solar cells that go into PV systems.



### Indoor Environmental Quality

Fresh air, natural daylight, and view are critical elements for the health and comfort of a building's occupants. A high-quality indoor environment also enhances productivity, decreases absenteeism, improves the building's value, and reduces liability for building designers and owners.

Aluminum contributes to a wide range of design strategies and environmental factors that influence the way people learn, work, and live. These include: air quality, lighting quality, acoustic design, aesthetic benefits, and control over one's surroundings.

#### ***Operable fenestration systems***

Operable fenestration systems provide immediate fresh air to indoor spaces and allow for air and temperature exchanges through controlled operation. These fenestration systems

rely on aluminum's unique properties that allow it to be formed (through extrusion and other processing and joining techniques) into intricate shapes that are strongly bound, structurally supportive, air and water tight, thermally insulated, and yet can be automatically or manually operable. No other alternative materials, e.g. steel, wood, and vinyl, can serve such functions alone without the assistance of aluminum products. Even today's high performance wood framed windows are often combined with an exterior aluminum cladding to achieve durability from exterior elements.

#### ***Maximizing views***

Modern aluminum alloys can easily support the weight of heavy glass spans, thus maximizing the building's capability for using natural sunlight and providing the broadest possible view.



***Figure 5: Gates Hall, Cornell University, Ithaca, New York. To meet the needs of the students and faculty, it was vital for the building to feature copious amounts of natural light and open spaces. The building was designed to incorporate a 35,000 square foot aluminum curtain wall, offering sprawling views of the picturesque campus.***

**Reflective devices**

Tubular daylighting devices (TDD) and other reflective devices can deliver daylight into the inner core of a building (i.e., where daylight is blocked) creating optimal natural lighting for stadiums, classrooms, shopping malls, factories, etc.

**HVAC channeling systems**

Aluminum is a great material to build HVAC channeling systems that can be easily installed and maintained without rusting or corrosion.

**Low maintenance**

Apart from routine cleaning for aesthetic reasons, neither bare, anodized nor painted aluminum requires any maintenance. This lack of maintenance translates into a major cost and ecological advantage over the lifetime of a product. Cleaning and maintenance of aluminum products in buildings usually does not involve chemicals or toxic agents.

**Fire safety**

In the event of a fire, aluminum alloys will not burn. Rather, aluminum melts at around 650°C. To develop information on the combustibility and flammability of aluminum alloys, the Aluminum Association commissioned testing in accordance with the ASTM E 136-11 “Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C” on common alloys 3003, 5052, 5083 and 6061. The testing indicated that all four alloys met the performance criteria presented in ASTM E 136-11.

**How aluminum contributes to LEED® v4 certification**

**EQ Credit: Thermal Comfort**

*To promote occupants’ productivity, comfort, and well-being by providing quality thermal comfort.*

**Operable Windows** - Operable architectural grade aluminum windows provide controllable natural ventilation to increase thermal comfort.

**EQ Credit: Daylight**

*Provide building occupants with a connection to the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.*

**Framing Systems and Windows** - Aluminum framing systems and windows offer strong and versatile solutions that maximize daylight autonomy and sunlight exposure.

**EQ Credit: Quality Views**

*Provide building occupants a connection to the natural outdoor environment by providing quality views.*

**Framing Systems and Windows** - Aluminum framing systems and windows offer strong and versatile solutions that maximize occupants’ views.

**EQ Credit: Acoustic Performance**

*Provide workspaces and classrooms that promote occupants’ wellbeing, productivity, and communications through effective acoustic design.*

**Framing Systems and Curtain Walls** - Aluminum framing systems and curtain walls accommodate double and triple pane insulating glass to maximize thermal performance and reduce acoustic transmission.

## Materials & Resources

Life cycle thinking is the fundamental strategy that the aluminum industry takes to address sustainability issues. A significant component of this strategy is to adopt Life Cycle Assessment (LCA) as a tool to measure performance and promote resource efficiency.

Aluminum’s contribution to green buildings covers all phases of the building’s life cycle – from design, to construction and use, to demolition and end-of-life management.

### **Raw material made with renewable energy**

Primary aluminum production demands an extensive amount of electricity. Yet the overall energy intensity can be reduced by using cleaner electricity such as hydro power. In North America, the majority of primary aluminum consumption is increasingly met by using hydro power as an energy supply. In 2010, the smelting electricity mix of primary aluminum produced for consumption in the United States and Canada was:

- 75% hydro power
- 24% coal power
- Less than 1% other sources such as gas and nuclear

This trend of increasing the share of hydro power used for aluminum smelting in North America continues, and it is expected that the share of hydro power production will grow to above 85% and the share of coal power production will decrease to less than 15% in the next few years.

### **Significant use of recycled raw material**

A typical aluminum building product made in North America today very likely contains less than 50% of primary metal and more than 50% recycled metal. The recycled portion is often a combination of post-consumer scrap (e.g., recycled auto parts, window frames, beverage cans) and

pre-consumer (i.e., post-industrial) scrap. Generic aluminum products’ material composition can be found in the Aluminum Association’s Environmental Product Declaration (EPD) documents.

### **Pre-fabricated**

Most aluminum building products or components are normally pre-fabricated and often assembled in factories before reaching the construction site. This means that the scrap materials are centrally generated and recycled, minimizing excess waste on the construction site. At the same time, pre-fabricated aluminum building products can also help to reduce the work load of construction and speed up the construction process, saving significantly on construction costs.

For example, pre-fabricated aluminum walkways, ramps and stairs can be put together quickly. While concrete and wood stairs are low in material cost, these take more time to build and install than prefabricated metal stairs. Both concrete and wood have to be sealed regularly to protect them over time – this ongoing routine maintenance adds cost over the long term. It’s also difficult to remove and relocate concrete and wood stairs when the structure they are attached to needs to be moved.

### **Share of Hydro and Coal Power in Primary Aluminum Smelting Process**

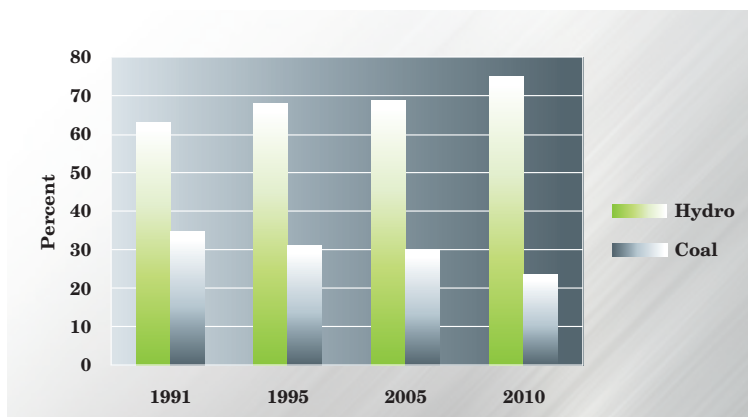


Figure 6: The share of hydro power in primary aluminum smelting is increasing over time.

***Durable and low-maintenance***

Through the evolution of product development, modern aluminum building products are made to be highly durable and maintenance-free in most cases. Thanks to the characteristics of aluminum alloys in terms of strength, integrity, and resistance to the influence of natural environment and extreme weather, aluminum products both inside and outside the building envelope neither rust, decay, crack, lose shape,

nor are susceptible to pests. Its strength and durability have led to the development of products which are both hurricane- and blast-resistant.

Aluminum used in buildings usually has a designated service life of multiple decades. In fact, most aluminum products coexist with the building's entire lifespan.



***Figure 7: An American cultural icon, the Empire State Building, constructed in 1930-1932, was the first building to make major use of aluminum components and fabricated structures.***

### **Environmental Product Declarations (EPDs)**

The Aluminum Association strongly supports the role of EPDs in helping customers and consumers understand the environmental impacts of products and make informed decisions.

The Aluminum Association has developed EPDs for generic aluminum products. These include the following:

- **Hot-Rolled Aluminum:** Aluminum sheet and plate rolled at a high temperature. Plate and thicker-gauge sheet may be used for structural applications including aircraft and aerospace.
- **Cold-Rolled Aluminum:** Previously hot-rolled sheet subsequently rolled at or near room temperature to make the metal thinner and stronger. Cold-rolled aluminum is often used to make building roofs and wall plates, sheet for transportation applications and packaging material.
- **Extruded Aluminum:** Aluminum that is fed through a die using a hydraulic press to make a particular shape. The infinite shape flexibility of extruded aluminum enables use in windows, doors, curtain walls, automotive parts, as well as various consumer durable products.
- **Primary Ingot:** Raw material produced directly from bauxite ore and used to make cast, rolled or extruded aluminum.
- **Secondary Ingot:** Raw material produced from recycled aluminum and used to make cast, rolled or extruded aluminum



**Figure 8: Aluminum Association EPDs. Available for download at: <http://www.aluminum.org/sustainability/environmental-product-declarations>**

### **How aluminum contributes to LEED® v4 certification**

#### **MR Credit: Building Product Disclosure and Optimization - Material Ingredients**

*To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.*

#### **Cradle to Cradle Certification -**

A number of aluminum products are Cradle to Cradle Certified. Please contact your supplier.

#### **Health Product Declaration -**

HPDs are available for a number of aluminum products. Please contact your supplier.

#### **MR Credit: Construction and Demolition Waste Management**

*Reduce the construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.*

**Pre-Fabrication** - Most aluminum building products or components are pre-fabricated and often assembled in factories before reaching the construction site. This means that the scrap materials are centrally generated and recycled, minimizing excess waste on the construction site.

**Recycling** - Both pre- and post-consumer aluminum can be recycled into the metal waste stream. Due to aluminum's high scrap value and ease of recycling, almost all aluminum used in construction is recycled.

***Aluminum recycling at end-of-life***

Aluminum components can usually be recycled in a single process using up to 92% less energy than the primary production process and with 92% less GHG. Due to aluminum's high scrap value, its well-developed scrap market, and its ease of recycling, almost all aluminum used in construction is recycled, and recycled infinitely without loss of its fundamental properties. Aluminum could therefore be thought of as a permanent material, and a critical technical nutrient within a Circular Economy framework. The sustainability benefit of aluminum recycling

is that the considerable initial amount of energy and resource invested in the production of primary aluminum can be passed on to future generations.

Aluminum recycling infrastructure extends to almost every North American community through municipal solid waste recycling and other well-developed aluminum scrap recycling systems. As such, the recycling process can be efficiently and effectively operated through existing material flow systems, leaving little burden to builders.



***Figure 9: Aluminum is one of the only materials in the consumer and industrial waste stream that more than pays for its own recycling.***

## Innovation

As problem solvers, architects, designers, and engineers are always seeking novel approaches to improve the environmental and energy footprint of a building.

Aluminum is light, strong, durable, flexible and easy to recycle. No wonder aluminum inspires architects, designers, engineers, artists and

many more to see innovative possibilities. An increasing number of industries are becoming aware of how aluminum can solve challenges and benefit different applications, and new areas of uses are still being discovered.

In other words, aluminum is a material of today – and tomorrow.

## Innovation Case Study

**Architect:** Travis Price Architects

**Location:** Washington DC

**Project:** 24-occupant housing project built from upcycled shipping containers

Travis Price Architects, alongside Brookland Equity Group, designed and built SeaUA, Washington D.C.'s first residential project to utilize sea shipping containers, a growing trend in eco-building.

Instead of following traditional LEED® Certification targets, the architects sought to address deeper ecological, design, and affordable housing issues in the city's up-and-coming Brookland neighborhood.

The new-build project features a unique pairing of repurposed shipping containers, modern glass elements, and aluminum architectural systems that outfit the new residential building.

CRL-U.S. Aluminum provided key fenestration solutions that align with the project's functional demands for energy efficiency and aesthetic demands for modernity: high performance thermal sliding doors provide units with exceptional thermal performance, and a mix of fixed and operable aluminum window units further mitigate energy loss and optimize efficiency.



*SeaUA is an apartment building made of retired shipping containers. Aluminum fenestration solutions align the project's functional and aesthetic demands.*



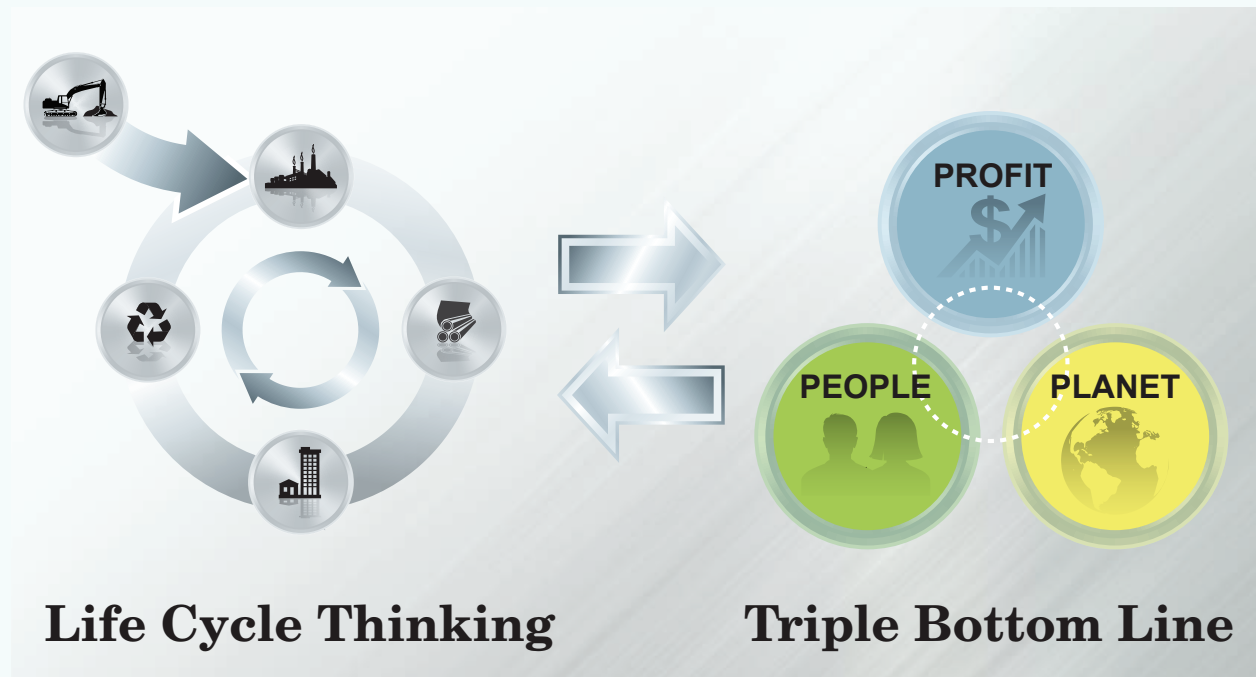
## A Responsible Industry

### Industry Sustainability Strategies and Metrics

Throughout the decades, the aluminum industry has taken a holistic approach to address sustainable development issues. The Aluminum Association’s strategy is to integrate Life Cycle Thinking into the Triple-Bottom-Line principles initiated by the United Nations (see Figure 10). The industry sees a need to **enhance both product and corporate stewardship** under this strategy.

On product stewardship, the Aluminum Association promotes a comprehensive evaluation of aluminum as a material from the entire life cycle perspective, focusing on both the “costs” and “benefits” – from production to use to the fate at end-of-life. **The goal is to minimize the “costs” and maximize the “benefits”.**

On corporate stewardship, the Aluminum Association emphasizes the Triple-Bottom-Line principles, **encouraging corporations to conduct their businesses by addressing comprehensive environmental, social and governance issues.**



*Figure 10: Aluminum industry sustainability strategies – integrating Life Cycle Thinking into the Triple Bottom Line principles*

Under the product stewardship strategy, the industry has developed reporting metrics to monitor its performance by concentrating on selected environmental indicators – energy and carbon footprint – and examining them through the following distinctive life cycle stages:

- Production efficiency improvement and footprint reduction
- Benefits of products brought to society during use
- Savings and offsets through recycling



### Increasing Production Efficiency and Reducing Carbon Footprint

Over the examined two decades (1991-2010), the North American aluminum industry has achieved tremendous progress in increasing production efficiency and reducing its carbon footprint. In terms of per ton material manufactured, the energy and carbon footprint have consistently decreased (see Figure 11).

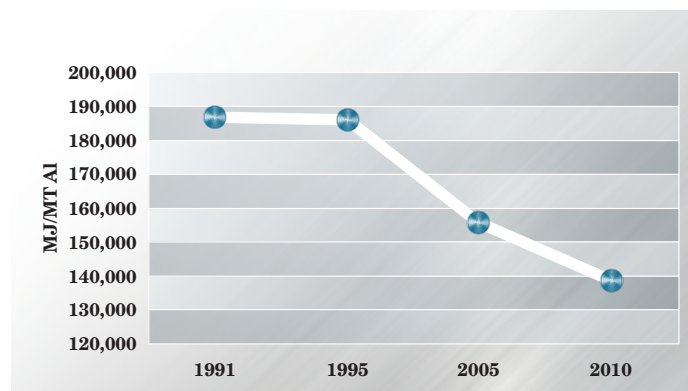
### Looking Ahead

Looking forward, there are challenges that will require aluminum producers as well as consumer action to advance sustainability objectives. For producers, the challenge is to continue to make improvements in energy efficiency and environmental releases associated with their upstream operations. Together with end users of aluminum – both product manufacturers and consumers – the industry must work to increase recycling rates at the end of products’ useful life. These efforts will require coordination among the industry, policy makers, manufacturers and the general public.

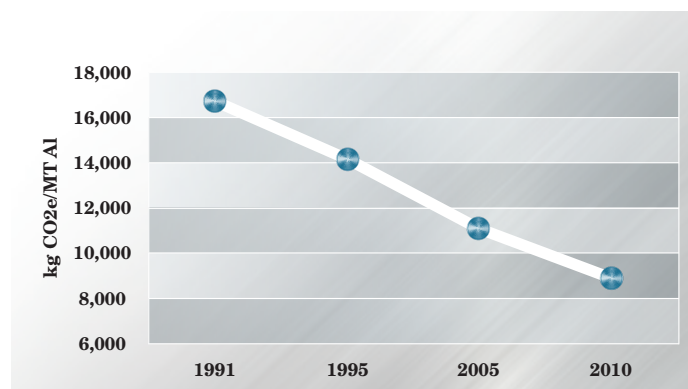
In addition, the aluminum industry will continue to disseminate its best knowledge and understanding of its metal and products to encourage society to use the material for more extensive and expanded sustainable solutions – to lower the weight of transportation equipment, construct greener buildings, protect food and beverage from nutrition loss and spoilage, and develop more sustainable sources of energy such as solar and wind power.

For detailed information regarding the sustainability of the North American aluminum industry, please refer to: [www.aluminum.org/Sustainability/Sustainability-Reports](http://www.aluminum.org/Sustainability/Sustainability-Reports).

*Primary Energy Demand for Primary Aluminum Production*



*Global Warming Potential for Primary Aluminum Production*



*Figure 11: These graphs show the reduction of energy and carbon footprint intensities over time. As a result, the industry’s overall footprints are estimated to have been reduced in 2010 by 37 million barrels of oil equivalent and 25 million tons of CO<sub>2</sub> equivalent.*

## Contact Us

For detailed information regarding the sustainability of the North America aluminum industry, please refer to: [www.aluminum.org/Sustainability/Sustainability-Reports](http://www.aluminum.org/Sustainability/Sustainability-Reports).

Any informational requests regarding these guidelines should be directed to the following:

**For general information regarding sustainability, production process, environmental performance and life cycle:**

Marshall Jinlong Wang  
Senior Sustainability Specialist  
The Aluminum Association  
Phone: + 1-703-358-2971  
Email: [jwang@aluminum.org](mailto:jwang@aluminum.org)

**For the Building & Construction Committee:**

Charles D. Johnson  
VP, Policy  
The Aluminum Association  
Phone: + 1-703-358-2981  
Email: [cjohnson@aluminum.org](mailto:cjohnson@aluminum.org)

**For aluminum application and technology information:**

John Weritz  
VP, Standards and Technology  
The Aluminum Association  
Phone: + 1-703-358-2988  
Email: [jweritz@aluminum.org](mailto:jweritz@aluminum.org)

**For statistical information:**

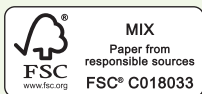
Ryan Olsen  
VP, Business Information & Statistics  
The Aluminum Association  
Phone: + 1-703-358-2984  
Email: [rolsen@aluminum.org](mailto:rolsen@aluminum.org)

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Member companies of the Building & Construction Committee of the Aluminum Association also reviewed and commented on draft versions of this document.



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The Aluminum Association  
1400 Crystal Drive, Suite 430  
Arlington, VA 22202  
USA

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