Aluminum lightens the world

Aluminum manufacturer LCA-UACJ's environment-related insights

UACJ at the core of aluminum circularity.

We have reached a turning point where we need to seriously re-think the way we use resources to create a carbon neutral society as part of efforts to address the pressing issue of climate change.

While aluminum is just one of many resources that are available to us, its lightweight, strength, and corrosion resistant characteristics mean aluminum is used extensively all around us, enriching our lives in all manner of ways. Despite this, aluminum has earned the odd title of "congealed electricity" because its production (smelting*) requires vast amounts of electricity, a factor that has long been of significant environmental concern.

Yet aluminum has the intrinsic property of being able to be recycled indefinitely. Aluminum is a material with the potential to significantly cut back environmental impact and GHG* emissions by using renewable energy* sources for production and developing associated recycling systems and technology. There have been increasing moves in recent years to focus on methods of reducing the impact that aluminum itself has on the environment. Aluminum has characteristics like being light in weight and good thermal conductivity, making it a material that can lower the environmental impact of products while they are actually being used.

Here, aluminum manufacturer UACJ will showcase how it can help develop a sustainable recycling-oriented society and less environmentally damaging world using aluminum.

See P18 for an explanation of terms marked with *.

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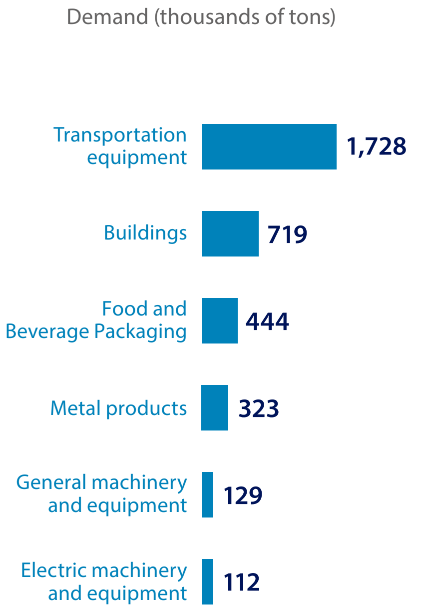
Vision of the future with sustainable aluminum

Vision of the future with sustainable aluminum

01 The benefits of aluminum to society

Aluminum is used throughout a broad range of applications—vehicles, buildings, beverage cans, and much more. The weight savings and recycling characteristics of aluminum will be harnessed moving forward in order to meet the environmental needs of the future.



Source: Japan Aluminium Association (2019)

Diverse applications of aluminum

Aluminum has a relatively brief history with only around 130 years of industrial use, but quickly gained widespread popularity for its light weight, strength, and corrosion resistance. It is estimated that more than 75% of aluminum is still in use by recycling ever since.

Lightweight properties are essential for transportation equipment, and it is for this reason that aluminum is used extensively throughout vehicles, railroads, aircraft, and ships. Aluminum is also widely used as an external cladding material for buildings due to its excellent corrosion resistance, design aspects and processability. And in the food and beverage packaging sector, aluminum is used for beverage cans due to its lighter weight and superior heat conductivity, as well as a range of other packaging and containers for its ease of adhesion with other materials and being harmless to the human body.

Aluminum—a material full of potential

The weight savings and recycling characteristics of aluminum will also be harnessed in order to meet the environmental needs of the future. The properties of aluminum make it ideally suited to recycling, as it can be recycled indefinitely. It is corrosive-resistant and has a low melting point, which means after use, products can be melted down for recycling. The development of cutting-edge technologies mean aluminum can increasingly be used in brand new sectors and applications, with weight savings anticipated in a broad range of products.

02 Aluminum alloys developed for diverse characteristics

The addition of alloying elements to form aluminum alloys gives aluminum a range of excellent characteristics as a material. When aluminum products are recirculated for use, mixtures of different types of scrap make it difficult to develop alloys with superior characteristics. In light of this, the methods used for recycling need to be re-examined based on our knowledge of alloys.

Aluminum Alloy Series	Main Alloying Elements	Features	Main Applications
1000 series	–	Low strength, but excellent processability, electrical conductivity and corrosion resistance	Aluminum foil, household appliances, electrical equipment
2000 series	Copper, magnesium	High strength and used as construction material, but less corrosion resistance	Cutting parts, aircraft material, etc.
3000 series	Manganese, magnesium	Good balance between strength and formability	Aluminum cans, piping material, construction material, etc.
4000 series	Silicon	Excellent wear resistance	Pistons, etc.
5000 series	Magnesium	Excellent strength	Construction material, rail stock, ships, etc.
6000 series	Magnesium, silicon	Most common construction material with superb strength and corrosion resistance	Aluminum sashes, transportation equipment, etc.
7000 series	Zinc, copper, magnesium	Highest strength of all aluminum alloys, but poor corrosion resistance	Welded construction material, aircraft material, sporting products, etc.

Characteristics of aluminum alloys

The addition of alloying elements to form aluminum alloys gives aluminum features like strength, electrical conductivity, processability, and corrosion resistance. These variations in alloys have made aluminum suitable for numerous requirements throughout society, and thus have been used for an extensive range of applications.

An example that highlights this is the high-strength aluminum alloy used as aircraft construction material. Commonly referred to as a type of "duralumin," it is a series 2000 aluminum alloy made by adding copper and magnesium to an aluminum base. Various other aluminum alloys can also be made through different combinations of alloying elements, resulting in alloys that are excellent at cutting, or those that provide superior balance between strength and corrosion resistance.

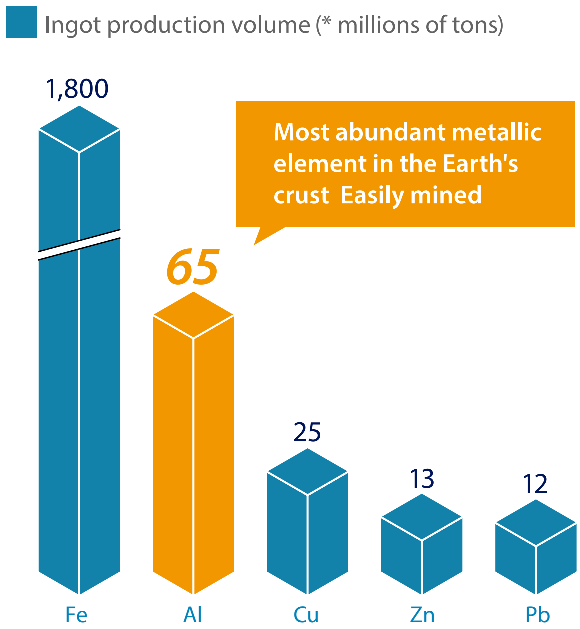
Recirculation of aluminum alloys and its restrictions

When aluminum products are recirculated for use, the combination of different series of aluminum alloy results in aluminum scrap containing various alloying elements mixed together. This often makes it difficult to reproduce or refine the material to meet required characteristics. For this reason, recycling is based on recirculation of each type of application, such as turning scrap aluminum cans into aluminum beverage cans.

03 Sustainability of aluminum resources

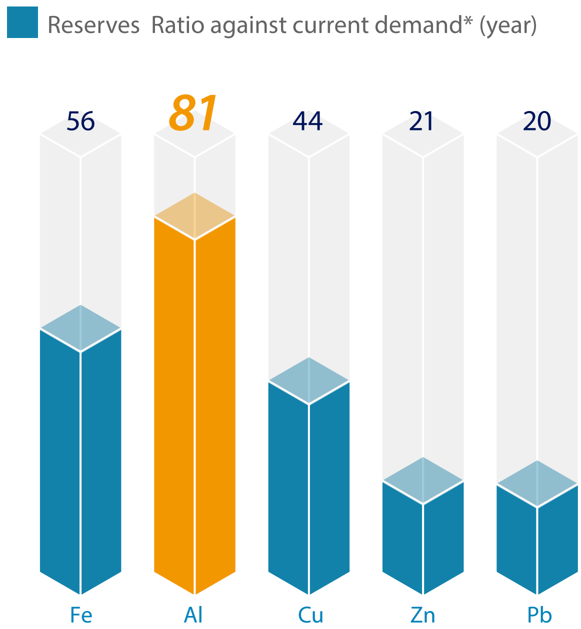
There are vast reserves of aluminum available and mining them is easy, making it a base metal* with one of the highest production volumes. In fact, aluminum has ample reserves to meet demand, which means it is a material suited to sustainable societies.

Production volume of base metal ingots



Source: USGS2021, JGMEC2020 *Figures from 2020

Sustainability of base metals



Source: USGS2021 *Amount of ore production in 2020

Aluminum—a type of base metal

Between 55 to 75 billion tons of bauxite, the main source of aluminum, is said to be available globally—the second highest figure of all metal ores. Of this figure, there are reserves (amount of resources that meet minimum physical and chemical levels, and that are economically viable to extract) of around 30 billion tons, also the second highest figure of metal ores. Aluminum is the third most abundant element (8%) in the Earth's crust (Clarke number) after oxygen (50%) and silicon (26%), and is easily mined because it is almost always found near the surface of the terrain.

As a base metal, large volumes of aluminum ingots are produced and used for a broad range of applications.

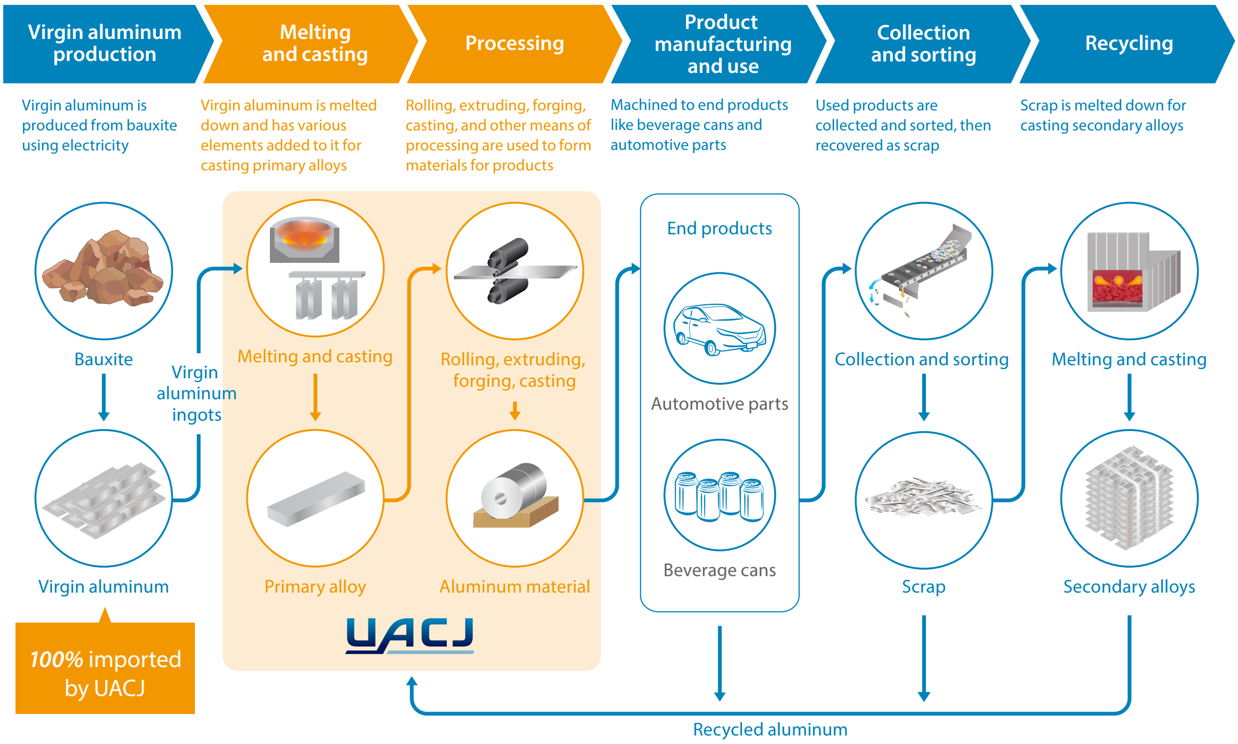
Aluminum resources have excellent sustainability

As a base metal, aluminum has the second largest amount of resources after iron, but it has the highest volume of reserves in relation to demand. Other metals are lacking in sufficient reserves to meet the amount of future demand, but there are sufficient known reserves of bauxite to meet demand through to 2050. While efforts need to be made to reduce large-scale consumption of resources and shift to recirculation-based models over the long term given the resource constraints, it is important to ensure ample time to develop the systems required to achieve this. Aluminum is considered superior in this regard, and is a material with excellent sustainability.

See P18 for an explanation of terms marked with *.

04 The aluminum lifecycle

With its advanced casting and processing technology, UACJ plays a crucial role in taking imported virgin aluminum ingots and scrap or recycled secondary alloys (alloys mainly used for casting) and machining them into sheets and other cast products.



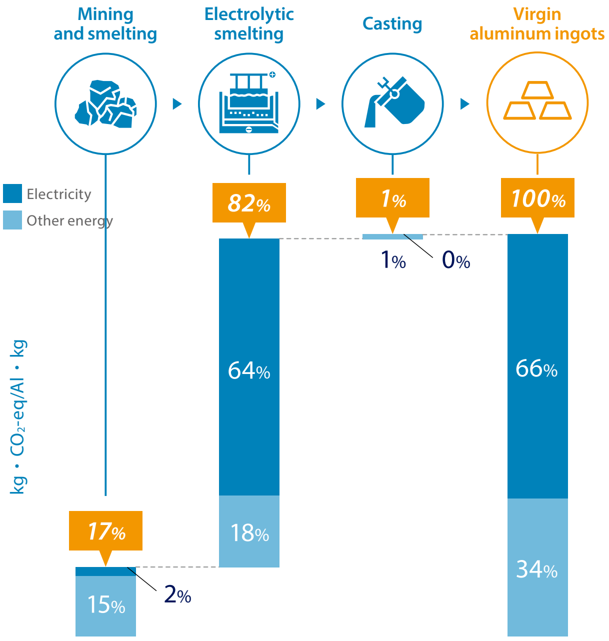
Steps for recycling aluminum

Various processes are required in order to use aluminum as products. The first step is to process the principle ore bauxite into alumina (aluminum oxide) and then extract the pure aluminum, before smelting it into virgin aluminum. Bauxite is mainly mined in countries like Australia and China. Alumina is dissolved using a process called electrolytic smelting, which requires an immense amount of electricity—this process is not performed in Japan where electricity costs are too high. In light of this, 100% of virgin aluminum is imported. Alloying elements are added to the pure virgin aluminum to produce primary alloys (mainly used for expanded material), and it is here that UACJ's expertise and technologies for producing aluminum material play a role in processing these materials. Magnesium and other alloying elements are added to molten virgin aluminum ingots and then cast to primary alloys (mainly used for expanded material). These alloys are then processed using a broad range of methods like rolling, extruding, forging, and casting, to produce sheets and various other shapes of materials and parts. These aluminum materials and parts are then supplied to automotive manufacturers and food and packaging manufacturers, where they are converted to end products like the automotive parts and beverage cans available throughout the market. End of life products are collected and sorted, then recovered as scrap. This is then melted and cast into secondary alloys (mainly used for casting), for use in another aluminum product. Production of secondary alloys does not require electrolytic smelting, and thus intense efforts are made toward recycling, even in Japan. In some cases, offcuts left over when producing end products and some types of community scrap are recycled directly to aluminum material without being turned into a secondary alloy.

05 Energy consumption and environmental impact of the aluminum industry

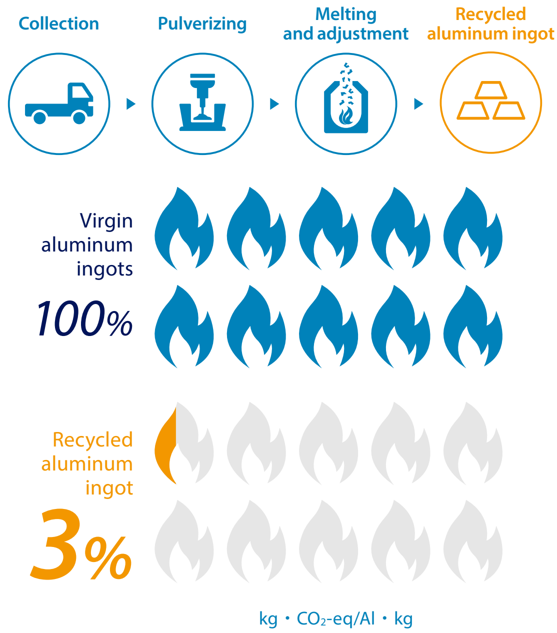
While virgin aluminum ingot generates relatively high GHG emissions, the majority of this is generated during the electrolytic smelting process, which means the environmental impact can be reduced through the use of renewable energy. In contrast, recycled aluminum ingots do not require smelting, and thus have a much lower environmental impact.

Amount of GHG emissions by production process of virgin aluminum ingots



Source: International Aluminum Institute

Recycled aluminum ingot production process and amount of GHG emissions



Source: Japan Aluminium Association

Virgin aluminum ingot major environmental impact is electricity

The environmental impact that aluminum poses differs to that of other resources.
The electrolytic smelting process requires immense amounts of electricity, and as a result virgin aluminum ingots have a relatively high environmental impact. The amount of GHG emissions generated from electricity used during the production of virgin aluminum ingots accounts for around 70% of the total process for the production of aluminum as a metal. It is because of this that aluminum is often referred to as "congealed electricity," but as electricity generated by renewable energy sources are the amount of GHG emissions can be reduced significantly.

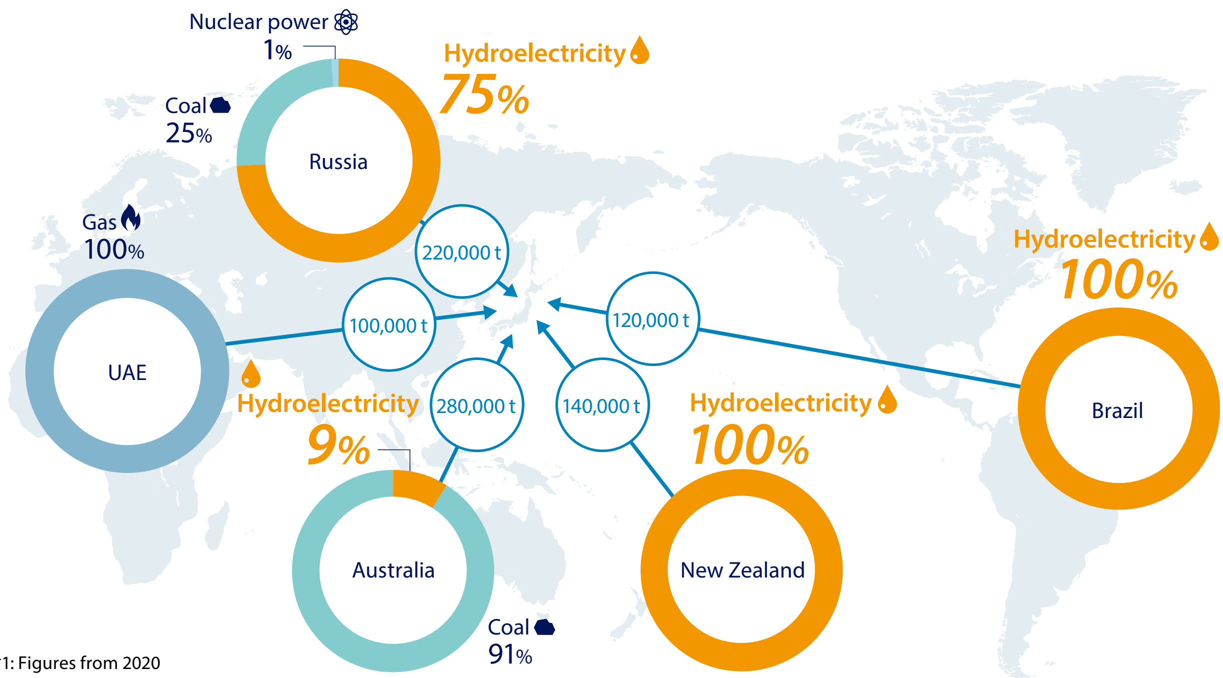
Recycled aluminum ingots have a low environmental impact

In fact, the electrolytic smelting process is not required for the production of recycled aluminum ingots (aluminum material made from used products or re-melting processing waste). Aluminum has a low melting point, and as such melting during the recycling process only requires a small amount of energy. The amount of GHG emissions required for recycled aluminum ingots is just 3% of that of virgin aluminum ingots.
In essence, aluminum is an excellent material in that once it has been smelted, only a small amount of energy is required to turn them into ingots, even if it has already been made into products. By increasing the amount of recycled aluminum ingot we use, the amount of GHG emissions throughout the entire aluminum industry can be reduced.

06 Environmental impact of virgin aluminum ingots

Not all "virgin aluminum ingots" have the same environmental impact—this differs depending on the power source used during production. UACJ procures materials from sources globally in environmentally conscious manner to suit customer requirements.

Major exporters to Japan*[1] and ingot smelting power source makeup by country*[2]



*1: Figures from 2020

*2: Estimated based on figures from 2010

Source: Created by UACJ from Japan Aluminium Association and Ministry of Finance trade statistics

Environmental impact differs with source

Aluminum is not smelted using electrolysis processes in Japan, and as such Japan imports 100% of its virgin aluminum ingots. The major exporters to Japan include Australia, New Zealand, Brazil, and the United Arab Emirates (UAE).

Virgin aluminum ingots do have a relatively high environmental impact, but as outlined earlier, the majority of that is attributed to electricity. The actual environmental impact of virgin aluminum ingots depends on just how much electricity is suppled from renewable energy sources during electrolysis processes. This essentially means that despite the same type of virgin aluminum ingots being imported, their environmental impact differs widely depending on which country and which smelter the ingots were imported from.

More specifically, virgin aluminum ingots imported from Australia and the United Arab Emirates have a high environmental impact as electrolytic smelting in those countries use coal-fired or gas-fired thermal power. Virgin aluminum ingots from New Zealand and Brazil, in contrast, have a lower environmental impact as hydroelectricity is mainly used there.

Procurement factoring in environmental impact

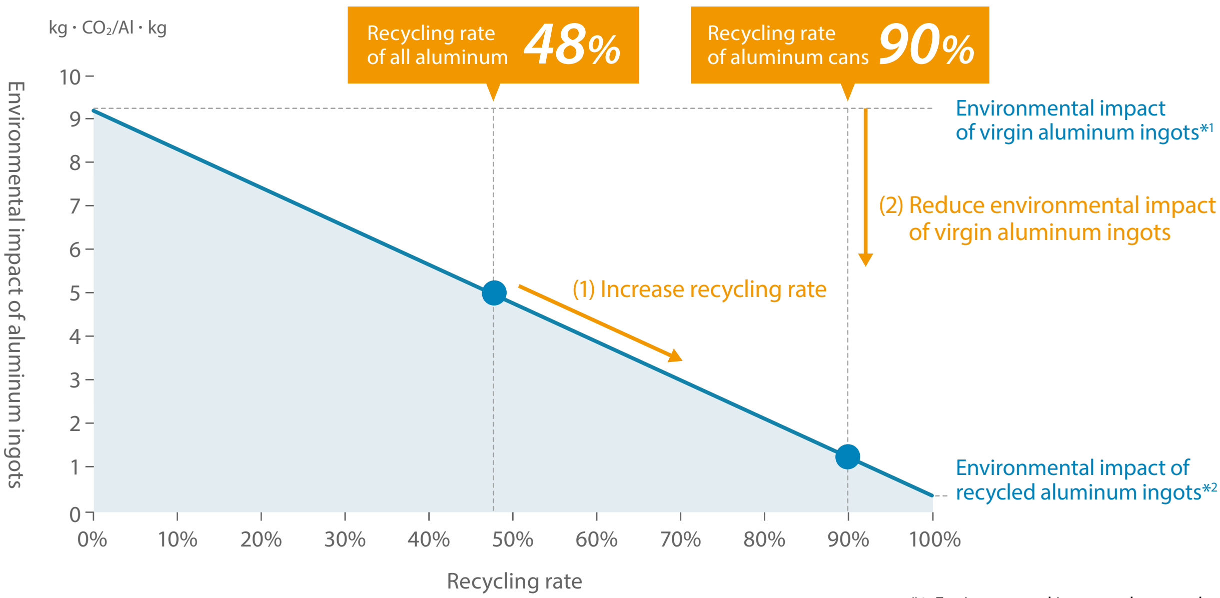
With this in mind, procurement of virgin aluminum ingots needs to factor in aspects other than cost alone.

07 Options for reducing environmental impact of aluminum

When examining how to reduce the environmental impact of aluminum overall, reducing the impact that virgin aluminum ingot production has is not the only option available—another effective method is increasing the recycling rate.

Aluminum recycling rate and average environmental impact*

* (environmental impact of virgin aluminum ingots) x (1 - (recycling rate)) + (environmental impact of recycled aluminum ingots) x (recycling rate)



Source: Created by UACJ from Japan Aluminium Association "Aluminium VISION 2050"

*1: Environmental impact when producing virgin aluminum ingots
*2: Environmental impact when producing recycled aluminum ingots

Limited amount of virgin aluminum ingots produced with renewable energy

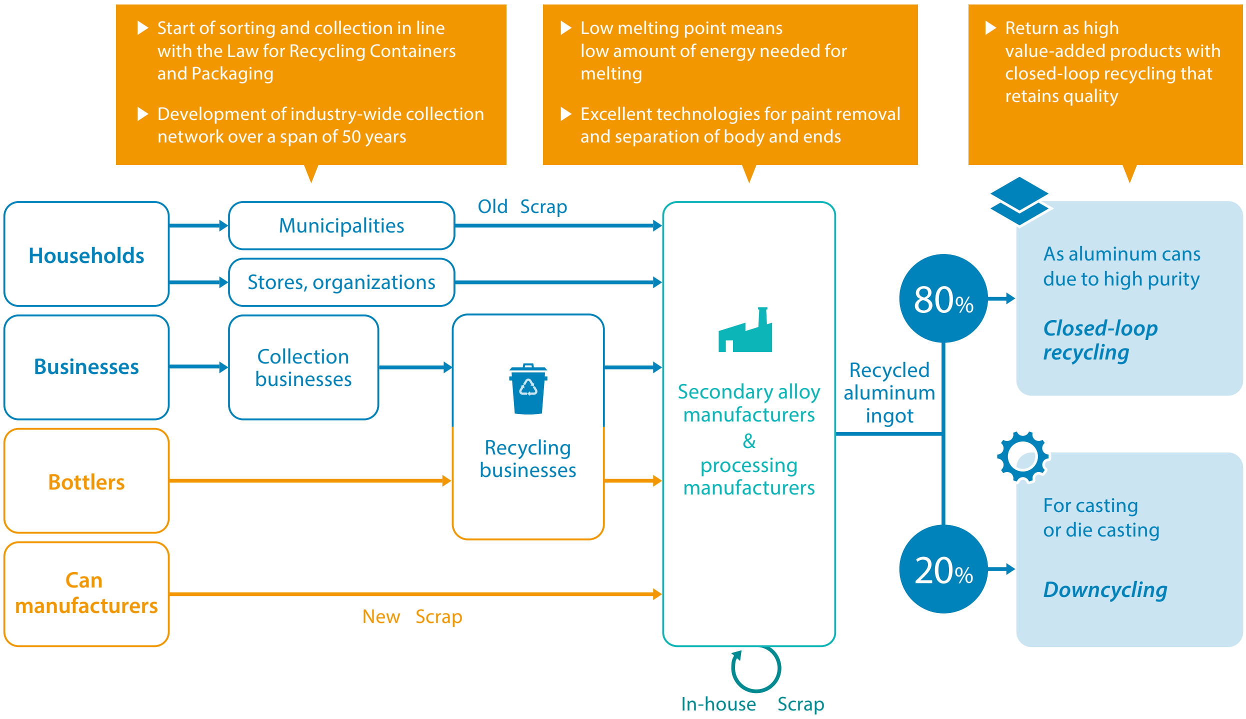
As outlined above, virgin aluminum ingots have a high environmental impact due to the immense electricity consumption required for electrolytic smelting. Yet ingots with a lower environmental impact can also be selected, like more advanced aluminum produced using hydroelectricity. Unfortunately, virgin aluminum ingots produced with clean energy sources like these only account for around 30% of global production volume, and does not cover all the required demand

Reducing environmental impact with recycling

The key to overcoming this challenge will be the use of recycled aluminum ingots with low environmental impact—or in other words, increasing the recycling rate. The environmental impact of recycled aluminum ingots is about 3% of that of virgin aluminum ingots, and using more recycled aluminum ingots can help to reduce the average environmental impact when considering the overall amount of aluminum.
Around 48% of the total amount is already being recycled, meaning the average environmental impact is around half that of using just virgin aluminum ingots. The recycling rate of aluminum cans is already at 90%, meaning almost all cans are being turned into recycled aluminum ingots with an extremely low environmental impact.
The key challenge that lies ahead will be to further increase the overall recycling rate of aluminum, and in turn reduce the amount of virgin aluminum ingots used to achieve a lower average environmental impact.

08 Aluminum recycling framework

Systems are already in place throughout society for collecting aluminum, and as only a small amount of energy is required to melt down aluminum, high-quality recycling is possible at a low cost—this boosts the value of scrap. This is what drives the recirculation of aluminum throughout society.



Source: Created by UACJ from Japan Aluminium Association "Aluminium Can Recycling"

Aluminum recycling framework

The key benefits of recycling aluminum is that scrap retains a high value, and that frameworks are in place to ensure it is recirculated instead of going to waste.

Society already has collection systems developed for aluminum, and combined with the low melting point and superb removal and separation technologies that are available, this makes high-quality recycling achievable for a low cost. This results in a positive cycle, where scrap retains a high value and people tend to collect it as second nature.

Look at aluminum cans to illustrate this in action. Highly effective collection systems have been developed by municipalities, and technologies for removing paint and various sorting methods mean high-quality recycled material can be produced for a low cost.

Types of scrap

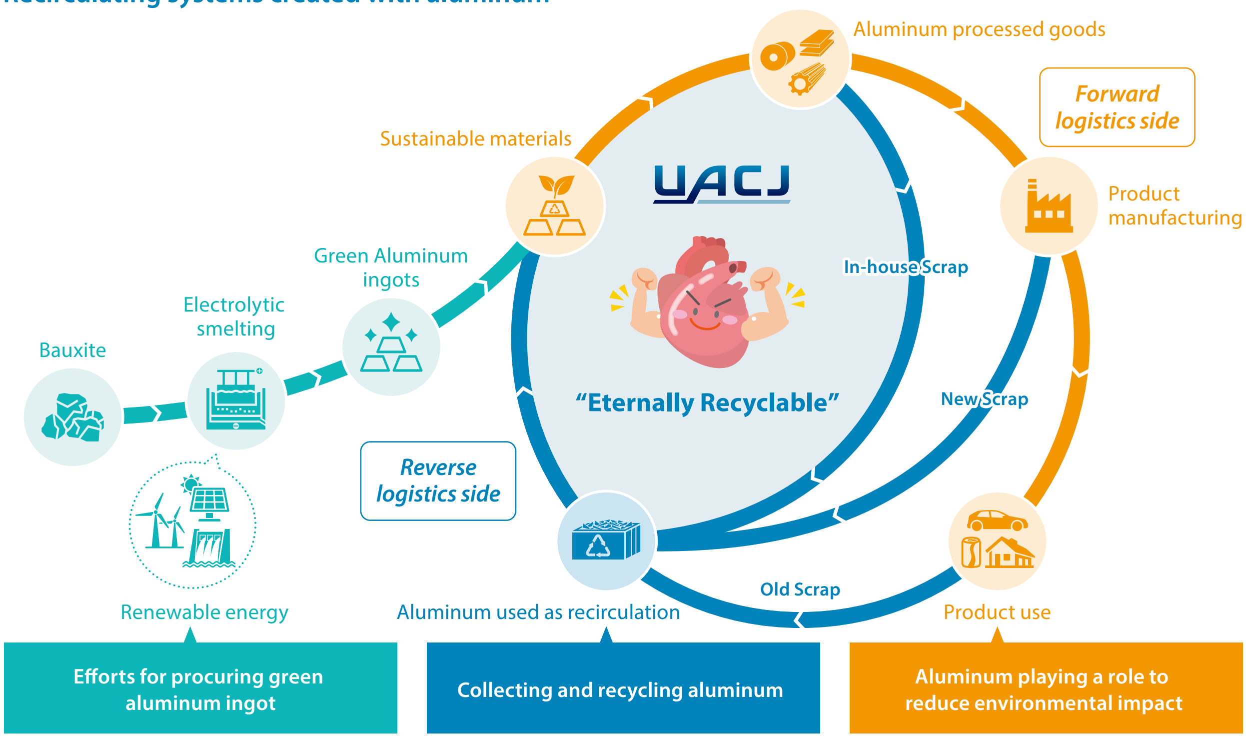
There are three main types of scrap available: In-house Scrap generated by manufacturers during the production of alloy and machining; New Scrap generated by product manufacturers during the production process; and Old Scrap arising from products disposed of by consumers.

Of these, Old Scrap is the most difficult to recycle due to the broad range of types available and the large variations in quality. Beverage cans are one sector of the aluminum industry that has achieved a very high recycling rate. Applying models of success like these to other sectors will help to boost the value of scrap and further increase the use of recycled aluminum ingots.

09 The future of the aluminum industry

UACJ is not only focusing on creating value for society through materials by reducing their environmental impact, but also plans to take on a central role for expanding aluminum recycling.
In essence, UACJ will help achieve a sustainable society and deliver environmental value through aluminum with recirculating supply chains built upon forward and reverse material flows.

Recirculating systems created with aluminum



Aluminum production with renewable energy

Electrolytic smelting and aluminum production using renewable energy is one key area of the upstream sector. Choosing aluminum made using carbon-free renewable energy sources like hydroelectricity represents significant value in terms of reducing the environmental impact from a materials perspective. Looking ahead, catering to societal demand will be needed by expanding availability of eco-virgin aluminum ingots to suit various applications and the way aluminum products are used.

Reduce environmental impact through the use of aluminum

A key factor with forward logistics is the way aluminum contributes to the environment. An example of this is reducing the amount of CO_2 emissions by making vehicles lighter in weight. In fact, there are many areas where the characteristics of aluminum contribute directly to reducing environmental impact when products are used. The development and supply of new optimal materials in sectors where aluminum does not yet play a role will also lead to a proportional increase in reduced environmental impact.

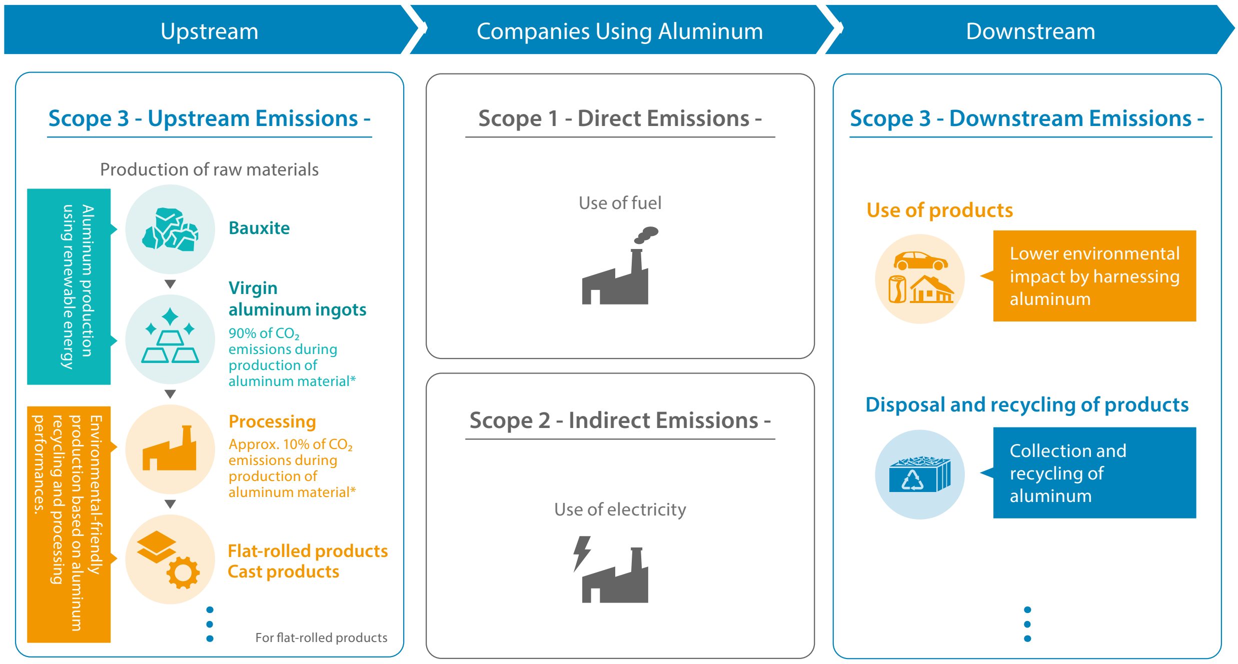
Collecting and recycling all aluminum

The most crucial area is reverse logistics and the recycling of aluminum scrap. Collecting, sorting and recycling scrap into recycled aluminum ingots with a low environmental impact helps to feed back into the recycling loop. Aluminum retains its characteristics even after it is recycled. Working with this property and using smelted aluminum over and over helps to reduce the environmental impact of aluminum.

10 Aluminum industry helping to reduce GHG emissions

Achieving the future goals of the aluminum industry is directly related to reducing Scope 3 emissions and improving LCI from the perspective of companies using aluminum.

Areas where the aluminum industry contributes to supply chain emissions (Scope 3) of companies using aluminum



Source: Created by UACJ from Ministry of the Environment "Approach to Calculating Emissions Throughout the Supply Chain"

Helping reduce environmental impact of the entire supply chain

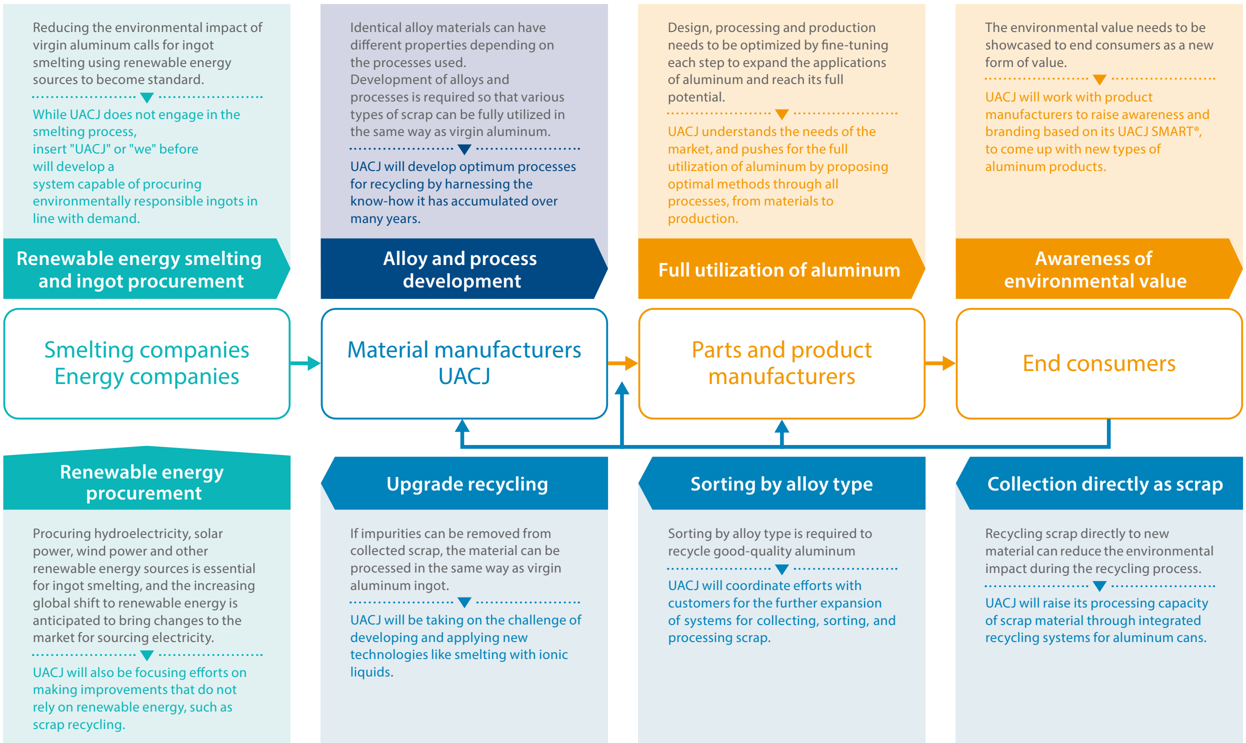
Achieving the future goals of the aluminum industry set out above also has a significant implication for companies using aluminum.

With growing demand to slash GHG emissions in recent years, there is an increasing need to find ways to reduce GHG emissions throughout the entire supply chain, in addition to focusing on in-house emissions. Companies need to have a thorough understanding of the amount of emissions throughout their entire supply chain—from direct emissions under Scope 1, indirect emissions arising from the use of electricity, heat and steam supplied by other companies under Scope 2, and emissions from other companies related to society and business activities under Scope 3—and make an effort to reduce these.

Achieving the future goals of the aluminum industry outlined above is directly related to more advanced supply chain management and reducing Scope 3 emissions at companies using aluminum. Helping to reduce the environmental impact of the entire supply chain by recirculating green aluminum is exactly the type of future the aluminum industry is setting out to achieve.

11 Future challenges and UACJ's environmental capabilities

To achieve this future goal, UACJ is aiming to become the “core of circulation” by incorporating its expertise with alloy and process development capabilities into the recycling system, as well as working with companies throughout the value chain to address various latent issues.



“The core of circulation” by harnessing alloy and process development capabilities

There are a multitude of issues remaining throughout the value chain (VC) when it comes to achieving the aforementioned future goal. One of these that UACJ is focusing on is the development of alloys and related processes.

Recycling is one of the most important factors for this future vision, and impurities (Fe, Si) end up being introduced each time aluminum is recycled. Expanding the scope of recirculation and recycling calls for the production of high-standard materials, even if there is a greater amount of impurities like these. Alloy and process development is the key to overcoming this challenge.

One example that highlights this is that different processes can increase the strength of an aluminum alloy almost 10-fold, even if identical elements are used for alloying. UACJ has long fine-tuned its development of alloys and processes through its 125-year history of rolling aluminum. While it is easy to imitate alloying elements, know-how is required for the associated processes, and this is one field that UACJ excels at. Applying this expertise with alloy and process development capabilities into the recycling system will allow UACJ to transform various types of scrap into value—in essence becoming the very core of recycling.

Working with partner companies to address challenges

Yet by itself, UACJ is unable to address the difficult challenges that are present in areas outside its alloy and process development capabilities. In those such areas, UACJ will work with parts manufacturers, product manufacturers and other customers, and upstream players such as smelting companies to focus on resolving the underlying challenges.

A lighter society co-created with aluminum

UACJ is aiming to work with a diverse range of companies to overcome challenges by recirculating aluminum throughout society and creating a more environmentally conscious future.

While aluminum is used in a broad range of sectors today, countless challenges need to be overcome in order to extract the full potential that aluminum promises. To achieve eternally recyclable aluminum, efforts need to be coordinated with all facets of society and companies using aluminum to focus on collecting all forms of scrap without any waste.

Procurement of environmentally friendly virgin aluminum also requires coordination with smelting companies and energy companies to develop a framework for properly assessing and purchasing aluminum produced using renewable energy.

Challenges that UACJ alone is unable to address will be overcome by coordinating efforts with an extensive range of companies and partners. Aluminum will be updated as an "eco-material" through co-creation with partner companies to help achieve a lighter society by using aluminum.

Editor's postscript

Thank you for reading through this booklet. The editing team has taken great pleasure in presenting the future potential of aluminum through the initiatives outlined here.

Studies have revealed that the level of CO_2 in the Earth's atmosphere first began rising in the late 18th century. This matches the timing when humans began to rapidly expand their activities following the Industrial Revolution. Today, the impact that human activities have on climate change is being scientifically proven. As we increased our understanding of this mechanism, the international framework Kyoto Protocol was developed in 1997 and culminated with the Paris Agreement in 2015, where both developed countries and developing countries alike declared their intentions to tackle climate change. And now we may have reached a turning point that will change the very structure of industry.

Let us take a moment to reflect on the materials used by industry. The quality and performance standards of materials are finalized and assured from the moment those materials are shipped from a factory. There was value in supplying higher quality material in greater quantities at a lower cost. Yet taking a closer look at materials from the perspective of sustainable growth, the performance of those materials (which we refer to as the quality, performance and all intrinsic value) cannot be guaranteed unless all aspects are taken into account—processes from when it is mined from the Earth's surface to production of material, production methods, use as an industrial material and industrial product, and how it is handled afterwards. It is these changes in industry that have an impact on materials. Aluminum is no exception—its widespread applications and eternally recyclable properties mean aluminum has inherent complexity equal to or greater than that of other materials.

This booklet represents the first step we are trying to take with our stakeholders to address such complex challenges like these. During the editing stage we were grateful to receive assistance from Nomura Research Institute, and we feel that this gave us the opportunity to view aluminum from a completely fresh perspective. Examining how materials are used and what happens to them afterwards is, in a way, the same as taking a closer look at an uncertain future. Aluminum is used, collected, and turned into new products again. With this, we are confident that this recycling system is a key factor for supporting a sustainable society. It goes without saying that we still do not have a complete understanding of everything. Yet we embraced honesty and foresight for gaining an understanding and showcasing the current state and potential of this material.

Finding a solution to one problem only leads to numerous new problems arising. After reading this, you too may have come up with questions or requests related to aluminum. If so, raise the matter—any matter—with UACJ staff.

We live by the UACJ corporate philosophy of "Contribute to society by using raw materials to manufacture products that enhance prosperity and sustainability." We believe it is worth addressing these challenges together with all our customers and stakeholders.

Editors: Kenji Nose, Ph. D., Shingo Iwamura, Ph. D.

Glossary

Smelting

Extracting metals from the ores. Aluminum uses electricity for electrolytic smelting.

GHG

Abbreviation of greenhouse gases.

Base metal

Name of metals with large amounts of reserves and production.

Renewable energy

An energy source that can be used repeatedly without exhausting any resources, unlike fossil fuels with finite quantities.

LCA (Life Cycle Assessment)

A method for quantifying the environmental impact of each stage of a product or service's life (from extracting resources to manufacturing, use and disposal of products). The amount of resources and energy consumed during each process of a product or service's lifecycle (manufacturing, use and disposal), CO_2 emissions, and other environmental impacts quantified using LCA methods are called the Life Cycle Inventory (LCI).

Aluminum lightens the world

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