RM INSIGHT

RENEWABLE MATTER

INTERNATIONAL MAGAZINE
ON THE BIOECONOMY
AND THE CIRCULAR ECONOMY

Supplement issue 45
Septemper 2023
RM Editori

Aluminium

- The global context
- The Italian supply chain
- Aluminium for green and circular transition
- Decarbonizing production
- Urban aluminium mines in Italy
- Separate collection and recycling: methods and technologies

www.renewablematter.eu/en

ISSN 2385-1562

9 772385 156009

RENEWABLE MATTER

Partners

Supporters

Networking Partners

Technical Partners

Printed by Geca Industrie Grafiche using mineral oil free vegetable-based inks. Geca production system does not produce exhaust and all waste of our manufacture is introduced into a process of collection and recycling.
www.gecaonline.it

Contents

RM

INSIGHT
RENEWABLE MATTER

INTERNATIONAL MAGAZINE ON THE BIOECONOMY AND THE CIRCULAR ECONOMY

Supplement issue 45
September 2023
RM Editori

Aluminium

www.renewablematter.eu
ISSN 2385-2240
Reg. Tribunale di Milano n. 351 del 31/10/2014

Editor-in-chief
Emanuele Bompan

Deputy editor
Marco Moro

Managing editor
Giorgia Marino

Aluminium Research
written by Duccio Bianchi

Editing
Jacopo Bertucci

Supervision
Stefano Stellini, Gennaro Galdo

External and Istitutional Relations
Anna Re

Art Direction & Layout
Margherita Gallon

Infographics
Angela Testa

Translations
Gaia Marino

Contacts
redazione@materiarinnovabile.it
t. +39 02 45487277

The magazine is made in *Dejavu Pro* by *Ko Sliggers*

Published and printed in Italy at GECA *Srl*, San Giuliano Milanese (Mi)

A project by RM Editori

Cover
Photo by Alberto Bernasconi

Where not specified, images are by Alberto Bernasconi

Editorial

Valuable renewable matter

@Unsplash, Rui Matayoshi

by **Emanuele Bompan**

Aluminium metal is very rare in native form, and the process to refine it from ores is complex. It comes from alum, a family of double salts, which has been discovered and used since the fifth century BC.
Initially, alum was used as a mordant for dyeing wool, fixing natural dyes, embalming animals and human bodies, and making wood fireproof. Back in his Naturalis historia, Pliny the Elder described in detail various substances called *aluminis* that could be found in nature. The regions of origin were Spain, Egypt, Armenia, Macedonia, and Sardinia. In the Middle Ages it became a commodity of international trade, and its properties amazed scholars and alchemists. In the Renaissance it was believed to be the salt of a new land, matter from a new Jerusalem, special matter of arcane origin, while Chinese alchemists believed it was a magical ingredient to be used in the preparation of elixirs or in the transformation of metals or a dangerous substance capable of diverting from the Quest, as recounted in the 9th-century book *Chen Yuan Miao. Tao Yao Lueh* ("Classified Essentials of the Mysterious. Tao of the True Origin of Things," also known to be the first book to mention gunpowder).

The discovery of aluminium as a metal was announced in 1825 by Danish physicist Hans Christian Ørsted, whose work was extended by German chemist Friedrich Wöhler. Given its potential, the price skyrocketed, even surpassing that of gold, falling again after French chemist Henri Étienne Sainte-Claire Deville began industrial production in 1856.
In the second half of the nineteenth century metallurgists like James Fern Webster produced at most 50 kilograms of aluminium per week in small factories through an unstable chemical process. The revolution came with the "Hall-Héroult process," independently developed by French engineer Paul Héroult and American engineer Charles Martin Hall in 1886.
To date, Hall-Héroult is the only industrial process used to produce primary aluminium, i.e., not derived from recycling: the process involves the dissolution of alumina – derived from bauxite through the Bayer process – in a bath of molten cryolite, resulting in a molten salt that is subjected to electrolysis to obtain aluminium.
It was an immediate success, and with the first large-scale aluminium production plant opening in Pittsburgh in 1888 (later to become the Alcoa company) the material became part of the mass economy. Packaging, construction, aircraft, bicycles-a planetary success. So much so that in 1954 aluminium became the leading non-ferrous metal by production volume, surpassing, with almost 3 million tons made in one year, copper. Not much even compared to the 100 million of aluminium produced in 2019.
The second life of aluminium came in the late 1960s with the industrialization of recycling by remelting the metal, a much less expensive and energy-intensive process than creating new aluminium. Immediately the process is noted for its environmental and economic pluses. The creation of second raw material requires only 5 percent of the energy used to produce new aluminium from raw ore, and today it is seeing increasing shares of the material's use in all fields of application, from construction to transportation, mechanics, electronics, and packaging.

In this *Renewable Matter Insight* issue we put this very recovery process under the magnifying glass, with research by Duccio Bianchi and the work of CIAL, the National Consortium for Aluminium Packaging, trying to analyze the recycled aluminium market, collection and recycling data, industrial processes, innovations and future goals. In the complex arena of ideas and projects about the future of packaging, the lightweight and recyclable aluminic monomaterial pack ad æternum becomes a cornerstone of the circular transition, supported by increasingly efficient virgin aluminium production and higher volumes of recovered material quantitatively and qualitatively globally, as well as by design and process modernization (well recounted in the interview with Assiral). Today because of its inherent characteristics (moisture retention, temperature, light shielding) it poses a direct challenge to recycled plastic packaging and even paper. Its light weight has an impact on tonnage in consumer goods transportation, and there is no shortage of characteristics to excel in various areas.
It may not be a magical material as the Chinese alchemists of the Song Dynasty thought, but aluminium is surely capable of surprising us again and again. ●

Emanuele Bompan is a journalist and geographer, he has written *What Is Circular Economy* (2018), *Atlante geopolitico dell'acqua* (2019) and *Water Grabbing, le guerre nascoste per l'acqua nel XXI secolo* (2018).


Coca-Cola

Numbers that speak for themselves

Interview with Giuseppina Carnimeo

@Giuseppina Carnimeo

by **Emanuele Bompan**

Data does not lie. In line with the principles of the new Action Plan for the Circular Economy of the European Green Deal, the Italian model of managing packaging and waste from aluminium packaging represents excellence on the European scene. An achievement of which Giuseppina Carnimeo, general manager of CIAL – Consorzio Nazionale Imballaggi Alluminio (National Consortium for aluminium Packaging) is particularly proud: in fact, in 2022 the Consortium sent to recycling 73.6 per cent of aluminium packaging placed on the market (or 60,200 tons), a percentage that, including energy recovery, approaches 78 per cent. Important numbers that have avoided greenhouse gas emissions of 423,000 tons of CO_2 and energy savings of more than 185,000 tons of oil equivalent.

Important achievements that position CIAL among the best second raw material supply chains.

Recycling is strategically important for the entire industry because of the enormous savings in raw materials and energy it provides. Suffice it to say that more than 75 per cent of the aluminium that has always been produced, over the last hundred years, is still in circulation. It should also be noted that in Italy 100 per cent of aluminium production is based on recycling, and in terms of quantity, our country is among the first in the world. These

CIAL- Consorzio Nazionale Imballaggi Alluminio https://www.cial.it/en/

results are possible because of the exceptional characteristics and performance of the material, which can be recycled easily, completely and for infinite cycles, providing a durable, permanent material, always ready and available for new and different uses.

What are the reasons for the strength of this packaging supply chain?

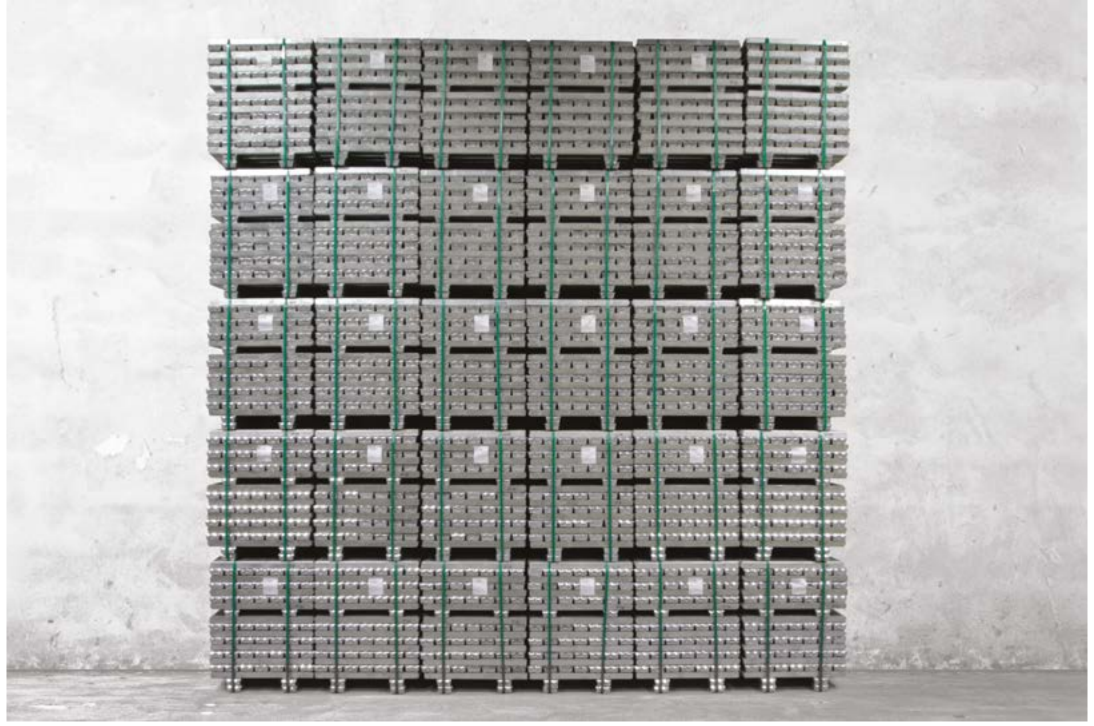
The choice of management criteria for the aluminium packaging supply chain guarantees a cost-effectiveness among the most efficient in Europe, realizing an excellent model of social, economic and environmental sustainability alongside an extremely constructive relationship with the territory, thanks to the combined action of institutions, companies, operators, citizens and municipalities.

The Italian system is characterized by a strong industrial symbiosis supported by a great technological evolution of the national plant network. We have state-of-the-art and extremely efficient plants that enable aluminium recovery at every stage of waste treatment. We are able to maximize recovery and minimize the waste that is necessarily created during waste treatment. Various plants throughout Italy are equipping themselves with additional technologies to go into the so-called sub-sieve, that is, the smaller fractions of the material sorting stage that are often lost. Only through this model can we contain as much as possible the environmental contribution paid by companies, which – it should be remembered – today is the lowest in Europe.

At the national level, collection and recycling figures are already above EU targets: you are at 73.6 per cent while EU recycling targets to 2025 are 50 per cent and 2030 targets are 60 per cent. So what are the next challenges for CIAL?

The new challenge today is qualitative rather than quantitative and concerns the need to have a new and innovative attitude and approach, also from a cultural point of view, to facilitate the transition from linear to circular economy. Focusing further on supporting separate collection and the development of new and integrative ways of recovery for constant and continuous growth in recycling is the main objective of the strategies and initiatives that the Consortium is planning for the next three years. In particular, we will work in those areas of the country that are still lagging behind. We are also aware that the development process is now irreversible and that, albeit patchy, the main regions of southern Italy show interesting and growing performance capable of reducing the gap with the most advanced areas in a relatively short time.

Moreover, CIAL's commitment has for many years



now included personalized support, throughout the country. This support is not limited to the simple disbursement of economic considerations against the material collected and conferred but, rather, to ensure the identification of the best possible options for maximizing the recovery of aluminium in the different territorial contexts. Through continuous analysis and monitoring, we also evaluate possible rewarding and incentivising forms according to increasing levels of quantity and quality collected per capita; we offer support in the adoption of new technologies and integrative solutions of the separate collection itself to ensure the capture of material fractions mistakenly conferred in the undifferentiated waste; we strengthen the recovery of the aluminium fraction from the sub-sorting plants of waste from separate collection to minimize waste disposal and thus maximize the recovery of this component, not forgetting the recovery of aluminium from the treatment of post-combustion slag after the waste-to-energy process.

The circular strategies of the European Green Deal require not only that all packaging be recyclable by 2030, but also that it be designed for this purpose, seeking to prevent waste formation.
I would emphasize how aluminium is the ideal material for the production of packaging (beverage cans, food cans, aerosol cans, tubes, trays, thin foil in rolls and for wraps, caps, closures and coffee capsules) because it is light, malleable, impact and corrosion resistant, and provides a barrier effect that protects against light, air, moisture and bacteria. In line, therefore, with the very high standards required in the food and beverage sectors for long and safe storage, protecting human health and making an indispensable contribution to the prevention of organic waste formation and the reduction of food waste and scraps.

How is aluminium packaging design changing?
Lightening is a key strategy for reducing material consumption. Thanks to research and technological development, the weight of a 33 cl beverage can has decreased over the past 20 years from 14 grams to the current 12.2 grams, a drop of 12 per cent, that of cans has been reduced by 13.2 per cent, while the average thickness of thin aluminium foil has been reduced by 27.5 per cent and that of trays by 15 per cent. For environmental protection, these are “heavyweight” grams that, when multiplied by the billions of pieces made each year, translate into tons saved in production. If we add up the results obtained for the different types of aluminium packaging, we arrive at a total saving of about 107,000 tons, with 5350 tons saved on average each year. Of course, all of this affects not only the supply of aluminium, whether from raw material or scrap, but, cascading into so many production costs and energy savings. Taking a numerical example, the average annual aluminium savings had over the past 20 years is equivalent to over 51,000 car bodies, while the total savings of 107,000 tons of aluminium translates into lost greenhouse emissions of 936,000 tons of CO_2 equivalent. ●

The circular challenge of aluminium refineries

Interview with Roberta Niboli

by **Emanuele Bompan**

@Roberta Niboli

For an energy-consuming material like aluminium, circularity is an economic as well as an environmental opportunity. From this point of view, aluminium refineries do a very important job by recovering waste materials derived from industrial processing. There are many issues affecting aluminium: from energy efficiency to electric cars to the effects of the Carbon Border Adjustment Mechanism on European refineries. To frame the sector’s present and future challenges, we met Roberta Niboli, president of Assiral, the Italian Association of aluminium Refiners.

How far has the evolution of aluminium refining evolved from a circular perspective?
On so many issues such as environment, safety and production efficiency we are seeing continuous improvement due to the evolution of available technologies. What has increased most of all has been the efficiency, which consequently has reduced energy consumption and environmental impact in the production phase. Also thanks to the European Green Deal, another growing trend is to maximize the recycling percentage of the semifinished products we make. There has been a lot of investment in the refining sector so that all types of scrap can be recovered, even those with a higher percentage of organic material. This makes it possible to go and optimize processes from a circular perspective.

What technological innovations and strategies have been brought to the ground to cope with the expensive energy that has hit the most energy-consuming sectors like yours?
We have done a lot of work on reducing consumption: from increased insulation of furnaces to efficient combustion processes that limit heat loss. New energy carriers such as hydrogen, which are much talked about but not yet used industrially, are also being studied. Let's say that from an energy point of view, a ready-made solution is to take advantage of photovoltaic panels to generate clean energy directly.

If we are to look at performance instead, what are the types of products that can be achieved?
Maximizing circularity is now a requirement. In the past two years, even companies that were not using scrap as a secondary raw material are trying to focus on recycling. This trend to maximize the recycling component in all types of materials will grow, partly due to the push of European legislation.
In addition to energy efficiency, the main innovations will be related to the major transformation of the automotive sector. With the shift from the endothermic engine to the electric motor, the key will be to be able to make products with a low carbon footprint, a high recycling rate, and the use of green energy.

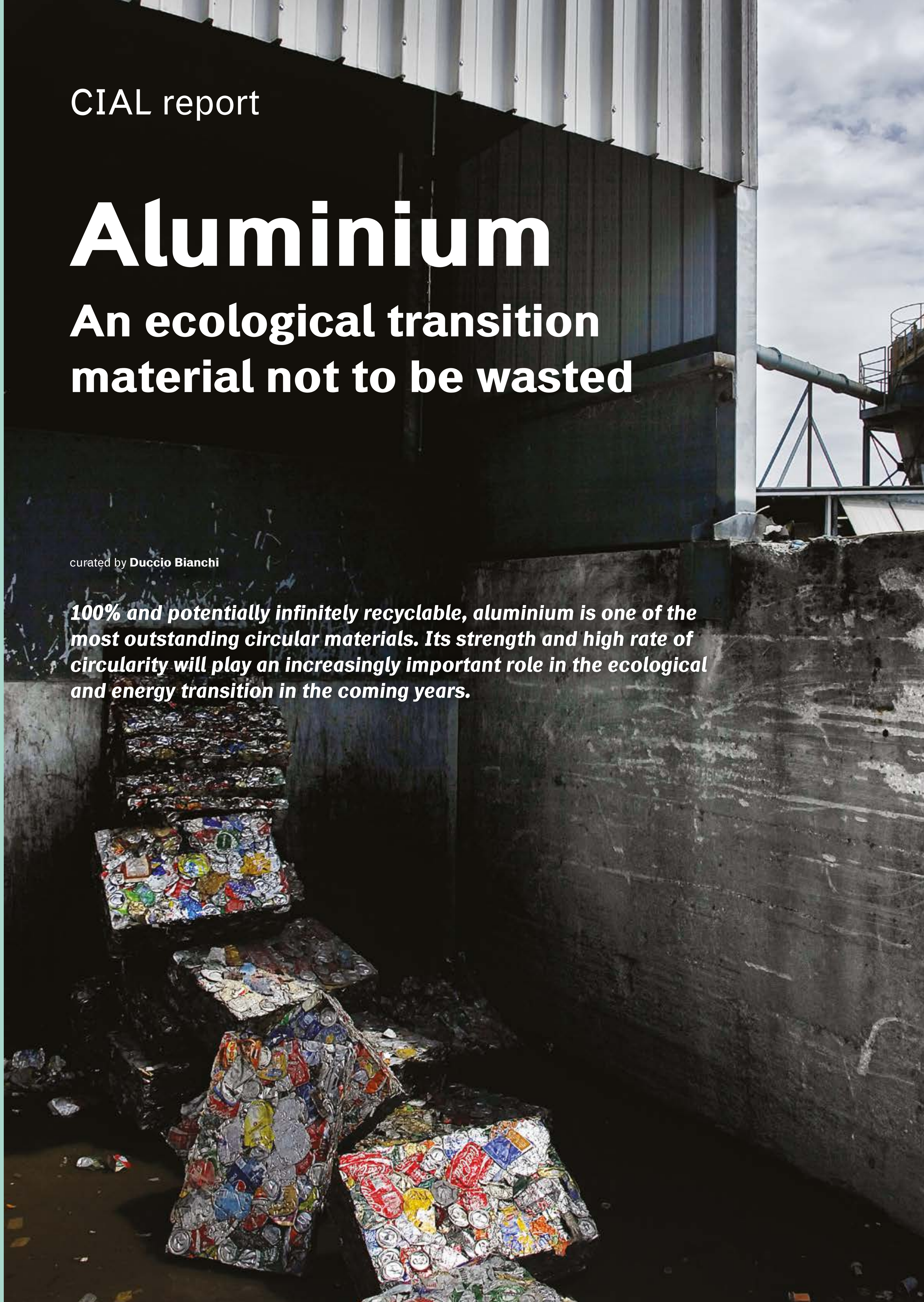
When it comes to digitization, what roles can these technologies play in production processes?
Undoubtedly, digitization will involve all processes in companies: from production and sales to administrative processes. To respond to a dynamic market, it is essential to invest in digitization, the evolution of which is very rapid. Especially in automotive, a sector undergoing a major transformation.

CBAM - European Commission
https://shorturl.at/fhoV8

What kind of scenario is in store for the transition to electric?
It is difficult to get an accurate picture at the moment. Growth volumes were expected in 2018, but these were still modest shares. The updated estimates show that in many countries, especially those in the North, the growth rate will be very high. We will have to figure out what new types of aluminium components will be present, what types of alloys will be used to produce them, and then, upstream, how to meet these needs through the recycling process.

Among the carbon-intensive products included in the Carbon Border Adjustment Mechanism (CBAM) is aluminium. Will it serve to prevent emissions leakage (carbon leakage) out of Europe?
It will now simply be a study and data collection phase. However, if the purpose of the CBAM mechanism is to protect the European industry, there is a risk that Europe, having still a high dependence for primary aluminium on non-European countries, will find itself paying additional costs on importing material that we need anyway. It will be important both to increase the recycling rate, but also to have availability of primary aluminium in Europe.

Are there other critical issues that Assiral is fighting for?
Every year Europe exports millions of tons of scrap, which essentially translates into electricity exports. Because when we export scrap, we lose a raw material that can be recovered and reused with 95 percent less energy than producing aluminium from ore. The percentage of aluminium in electric cars will increase in various forms, and there will definitely be a need to make sure that the available aluminium is used for European production. If it is exported, however, there is a need to make sure that those who recover it have environmental standards similar to those in Europe. ●



CIAL report

Aluminium

An ecological transition material not to be wasted

curated by **Duccio Bianchi**

100% and potentially infinitely recyclable, aluminium is one of the most outstanding circular materials. Its strength and high rate of circularity will play an increasingly important role in the ecological and energy transition in the coming years.

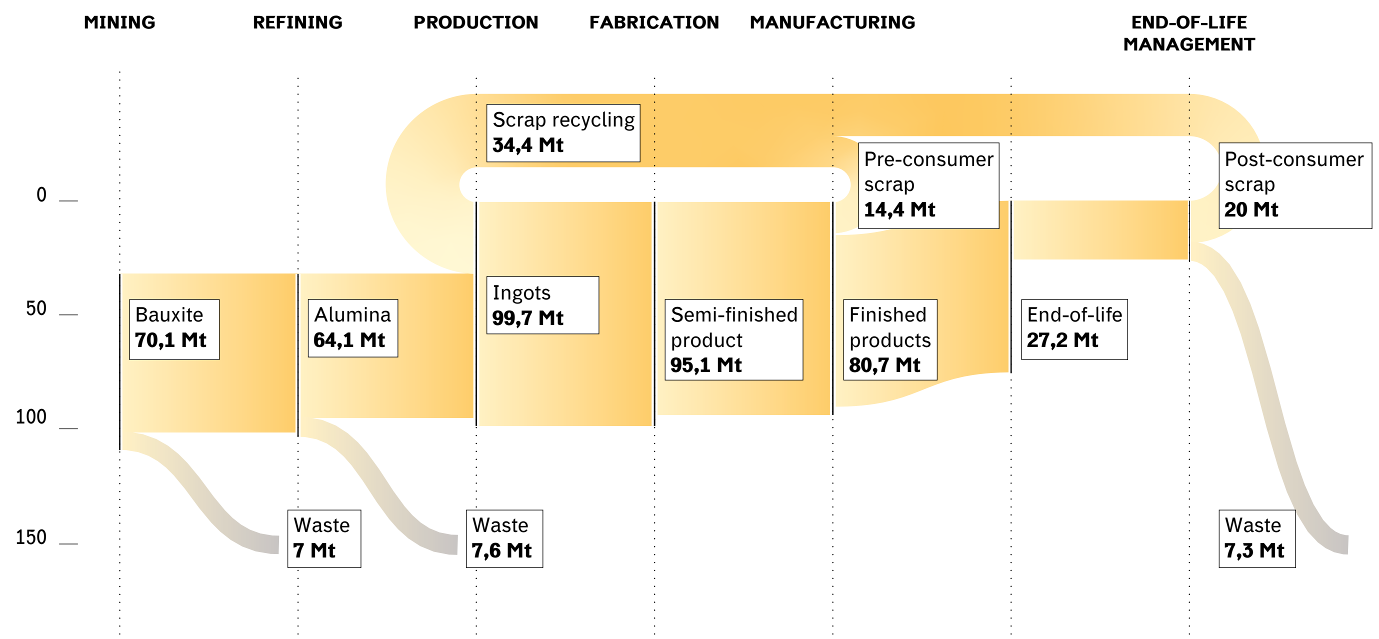
The global context

The global flows of aluminium

Aluminium is one of the most "circular" materials, with almost complete and infinite recyclability, and a long stay in the system: 75 per cent of primary aluminium produced in the past 125 years is still in use, either as an original or recycled product. Aluminium currently in use (2019) is 1098 million tons.

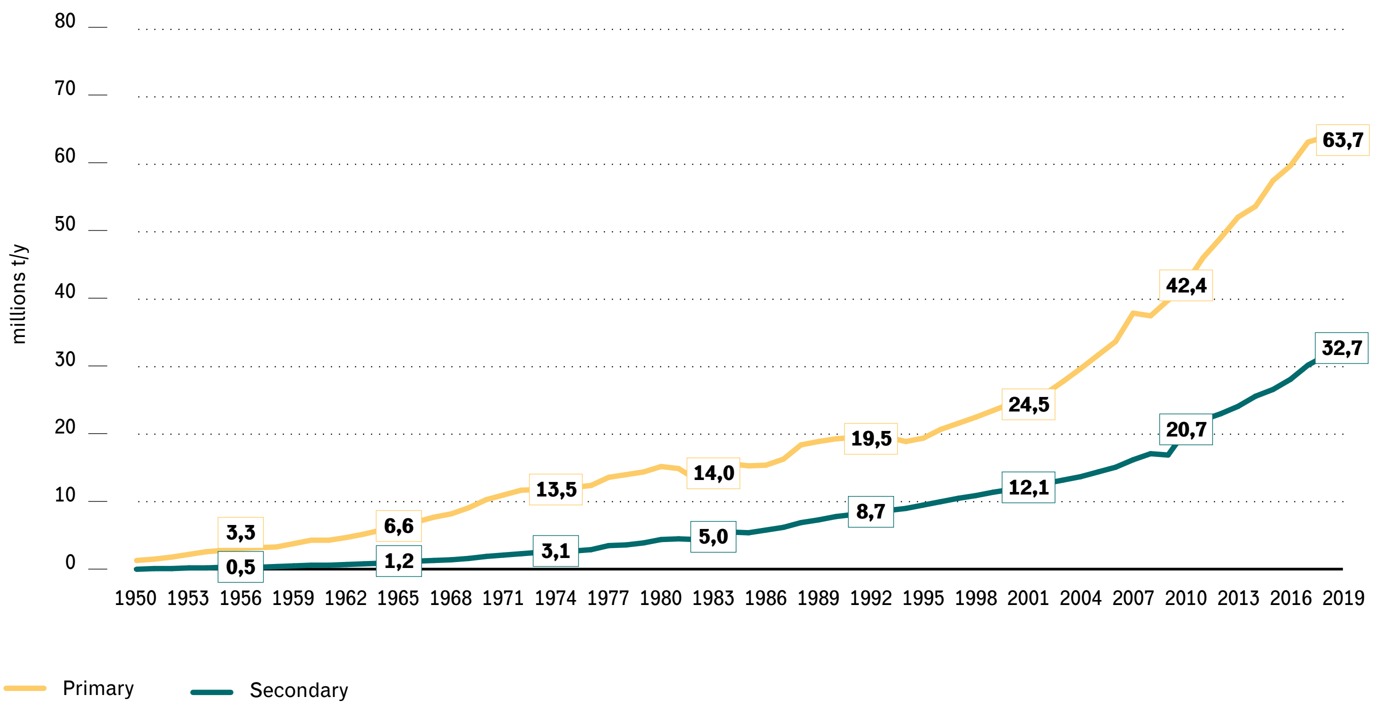
In 2019, world aluminium production was just under 100 million tons, from which about 81 million tons of finished products were obtained. About 40 per cent of these were replacement products, and 60 per cent (48 Mt) were additional products to the stock in use.
End-of-life products totalled about 27.2 million tons (Mt), of which 20 Mt were recycled in the same production process.

Aluminum Global Flow



Mt = million tons

Primary e Secondary Aluminium World Production (millions t/y)



@Envato Elements

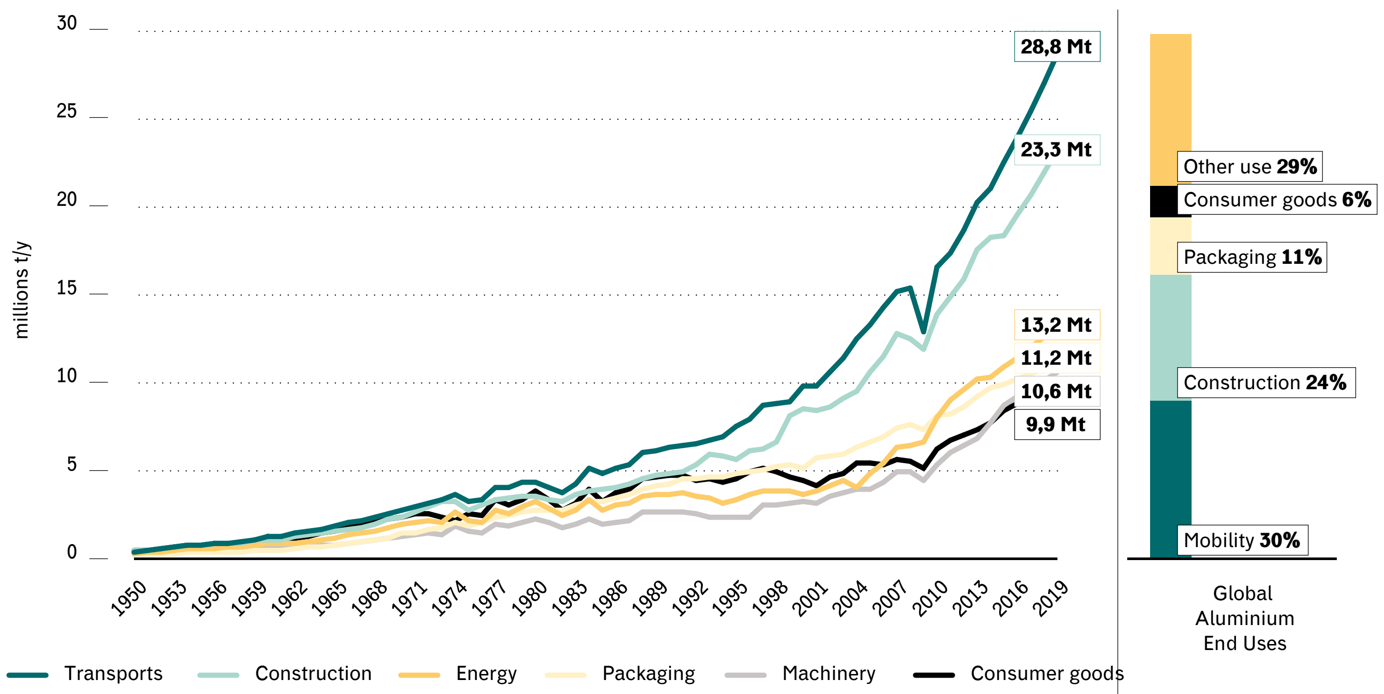
Data, here and below unless otherwise specified, is derived from the public database in https://alucycle.international-aluminium.org/ Data has been made available since 1962 and is separated by various world regions (e.g., Europe, North America, etc.).

Global aluminium production comes from both primary (66 per cent in 2019) and secondary (34 per cent) processes, i.e., recycling.
Primary processes are based on the extraction of alumina from bauxite and subsequent electrolysis to obtain metallic aluminium. To produce 63.7 Mt of primary aluminium, more than 70 Mt of bauxite was extracted in 2019.
On a global scale, secondary processes, from which 32.7 Mt of aluminium is derived, were fed by 34.4 Mt of process waste and pre- and post-consumer scrap (42 per cent and 58 per cent of the scrap used, respectively, but in Italy, the breakdown is different). About 73 per cent of post-consumer aluminium waste is directly recycled.
Primary aluminium production, based on the electrolytic process, has nearly tripled in the past twenty years to about 64 Mt in 2019. Over the past twenty years, primary production has declined in Europe and North America (from a cumulative 10.7 Mt in 2000 to 7.6 Mt in 2019), while it has grown tremendously in China (from 2.8 Mt to 36 Mt between 2000 and 2019), where 56 per cent of world production is now concentrated.
Secondary aluminium production (both from domestic and pre-consumer scrap and from post-consumer scrap) was about 33 Mt in 2019 (34 per cent of total production) and has tripled over the past two decades, although the ratio of primary to secondary has remained essentially stable.
In Europe and North America (as well as Japan), secondary production has become predominant over primary production: it was 37 per cent in 2000 became 58 per cent in 2019. China accounts for 35 per cent of the world's secondary aluminium production.
Recycled post-consumer comes mainly from demolition of motor vehicles and transport equipment, construction, and packaging collection.

Final uses of aluminium

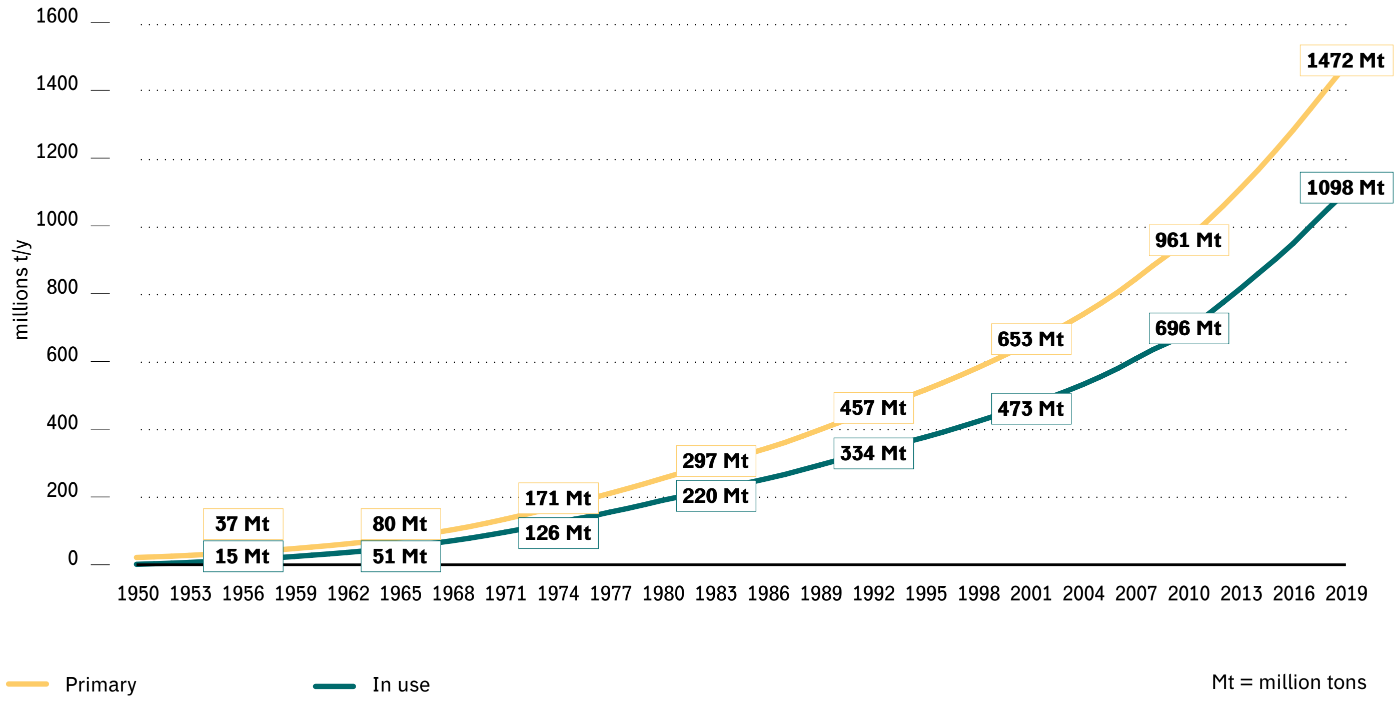
Aluminium finds use in a plurality of applications. On a global scale, the predominant uses are in the production of transportation equipment (mainly motor vehicles and trains) and in construction, accounting for 30 per cent and 24 per cent, respectively. In Europe and Italy, uses in the mobility sector are predominant (42 per cent of the total).
Other important fields of employment include the electrical sector (mainly cables), packaging production, mechanical production, and the production of consumer durables (from cookware to furniture products).
All employment sectors have experienced strong quantitative growth, albeit with regional differences. In China, construction and machinery jobs grew considerably, while in Europe, jobs in the transportation sector grew a lot.

Global Production and End Use of Aluminium Goods (millions t/y)



Mt = million tons

Cumulative Production of Primary Aluminium and Aluminium in use (millions t/y)



The permanence of aluminium

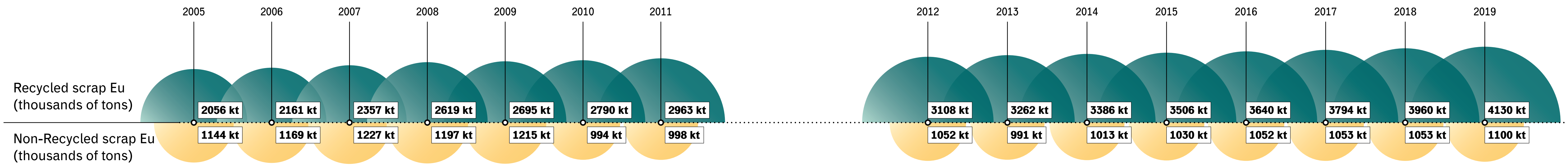
Aluminium is a “permanent” material, meaning that once produced and placed on the market it remains there for a very long time, both because of the long service life of the main products and because of the high recycling rate and minimal losses it is subject to during recycling.
Of the total primary aluminium historically produced – an estimated 1,471,000 tons, more than half of which was released in the past twenty years – about 75 per cent is still in use, either as an original product or as a product resulting from recycling (elaboration on IAI - Alucycle data).
The original aluminium products still in use correspond to about 65 percent of the aluminium historically placed on the market.
The average lifespan of aluminium products is very high, exceeding 25 years. In the construction sector, the average lifetime is about 50 years, and in the mobility sector it ranges from about 15–20 years for cars to more than 40 in aeronautics or trains. In consumer durables, the average life span is also estimated to be about 12 years. Packaging, which obviously has an annual lifespan, weighs in at only 11 per cent of products placed on a global scale.

@Envato Elements

Recycling and disposal of aluminium

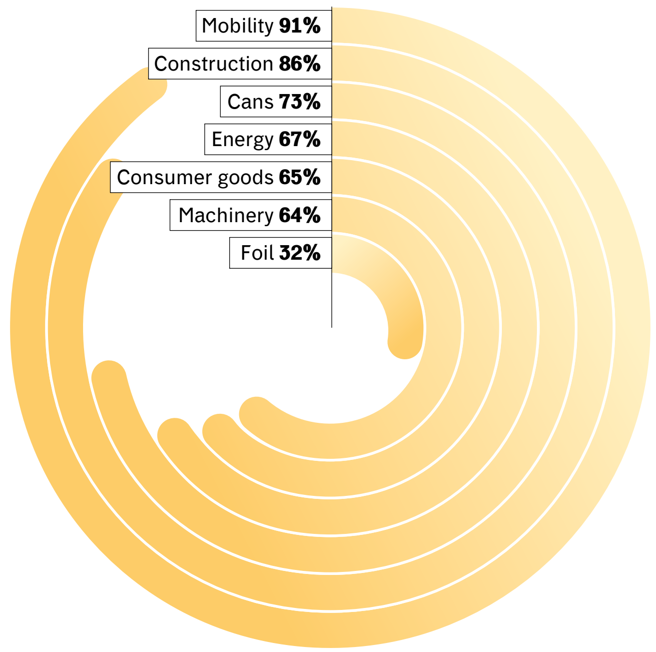
Despite aluminium’s high value and recyclability, a significant portion of it is still being disposed of. On a global scale, IAI estimates that unrecovered post-consumer aluminium waste is worth cumulatively (from 1950 to the present) about 46 per cent of the total waste generated. On post-consumer waste generated today, however, the recycling rate is much higher, about 70 per cent on a global scale and 79 per cent in Europe.
The product types for which a lower recycling rate is estimated (70 per cent to 33 per cent) are machinery components, consumer durables electrical uses and foil packaging.
In Europe, the recycling rate (or rather, domestic collection, since Europe is an exporter of aluminium scrap) has significantly increased in recent years, from 65 per cent in 2005 to 79 per cent in 2019, with a doubling of scrap recovered for recycling, from 2.06 to 4.13 million tons.
High amounts of scrap are also generated in the industrial processes of aluminium production and semifinished products. This pre-consumer scrap, at present, has almost total recovery, primarily in remelting processes.
In addition, a significant portion of the scrap generated in production processes and recycled within the same processes does not statistically emerge because it is recycled within the plant or within the property itself.

Recycled and Non-Recycled Scrap in Europe



kt = thousands of tons

Global Recycling Rate, per sector (2019)

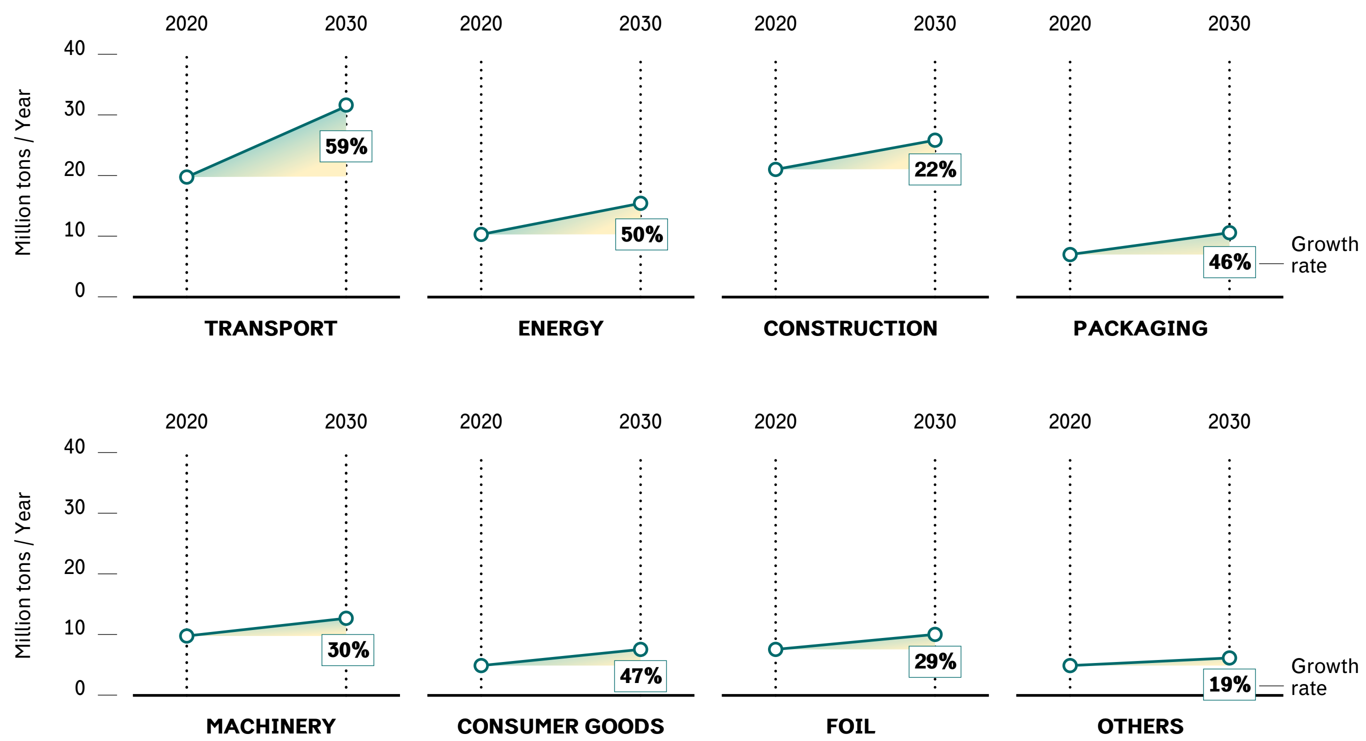


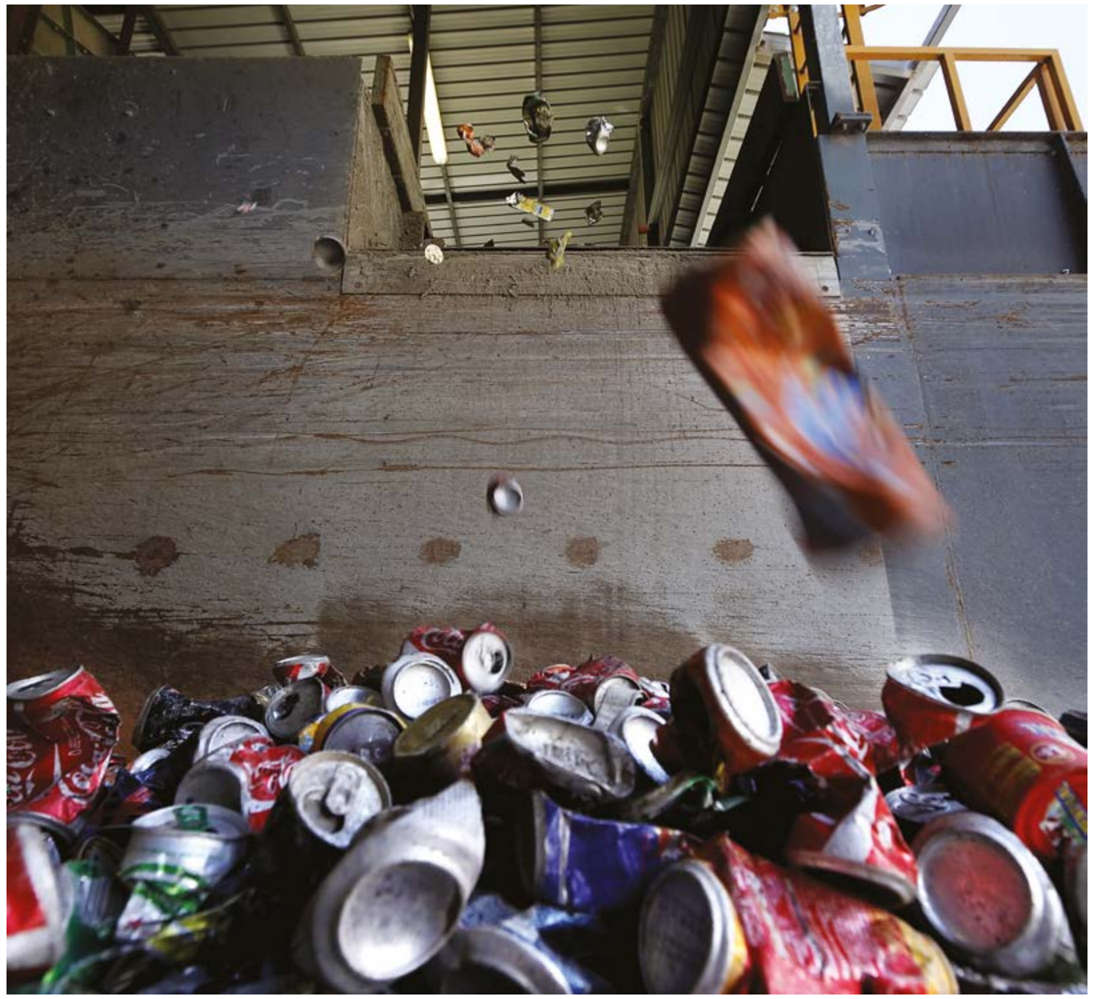
@Envato Elements

The development prospects for production and consumption

Strong growth in demand for aluminium is expected in the coming years and decades. CRU International's study for the International Aluminium Institute, *Opportunities For Aluminium In A Post-Covid Economy* (2022), details demand forecasts in key industrial sectors and regions in a post-Covid economy. Transportation, construction, packaging, and the electrical sector are the four key sectors that will drive demand, accounting for 75 per cent of the total metal demand.
Overall, global demand for aluminium is expected to increase by nearly 40 per cent by 2030, and the aluminium sector will need to produce an additional 33.3 Mt to meet demand growth in all industries, rising from 86.2 Mt in 2020 to 119.5 Mt in 2030.
Nearly two-thirds of this growth will come from China and the rest of Asia (20.9 Mt), while Europe's increased demand will be in the range of 4.8 Mt.
In almost all aluminium end-use sectors, the demand driver is related to environmental sustainability and in particular to reducing energy consumption and climate-changing emissions.
The greatest growth in absolute demand will come from the Transportation sector, which, driven by electrification, will grow from a consumption of 19.9 Mt of aluminium in 2020 to 31.7 Mt in 2030. Most of this growth will come from China (33 per cent), North America (22 per cent), and Europe (19 per cent).
In the electricity sector, the transition to green energy sources will strengthen demand for aluminium, which will reach 15.6 Mt in 2030 from 10.4 Mt in 2020. Even greater growth could occur in the 2030-2050 timeframe, particularly where all countries move to Net Zero policies.
The electricity sector represents one of the most substantial opportunities for the aluminium industry in the coming years. The transition to renewable energy will result in greater demand for aluminium because renewable sources have a higher intensity of use (per MW of power) than fossil or nuclear sources. Solar power requires over four times more aluminium per installed megawatt than wind power and about 25 times more than coal. In addition, this increase in consumption from renewable sources, against a background of increasing electrification of

Increasing global aluminium consumption. Projections 2020-2030 in Mt per year (CRU 2022)



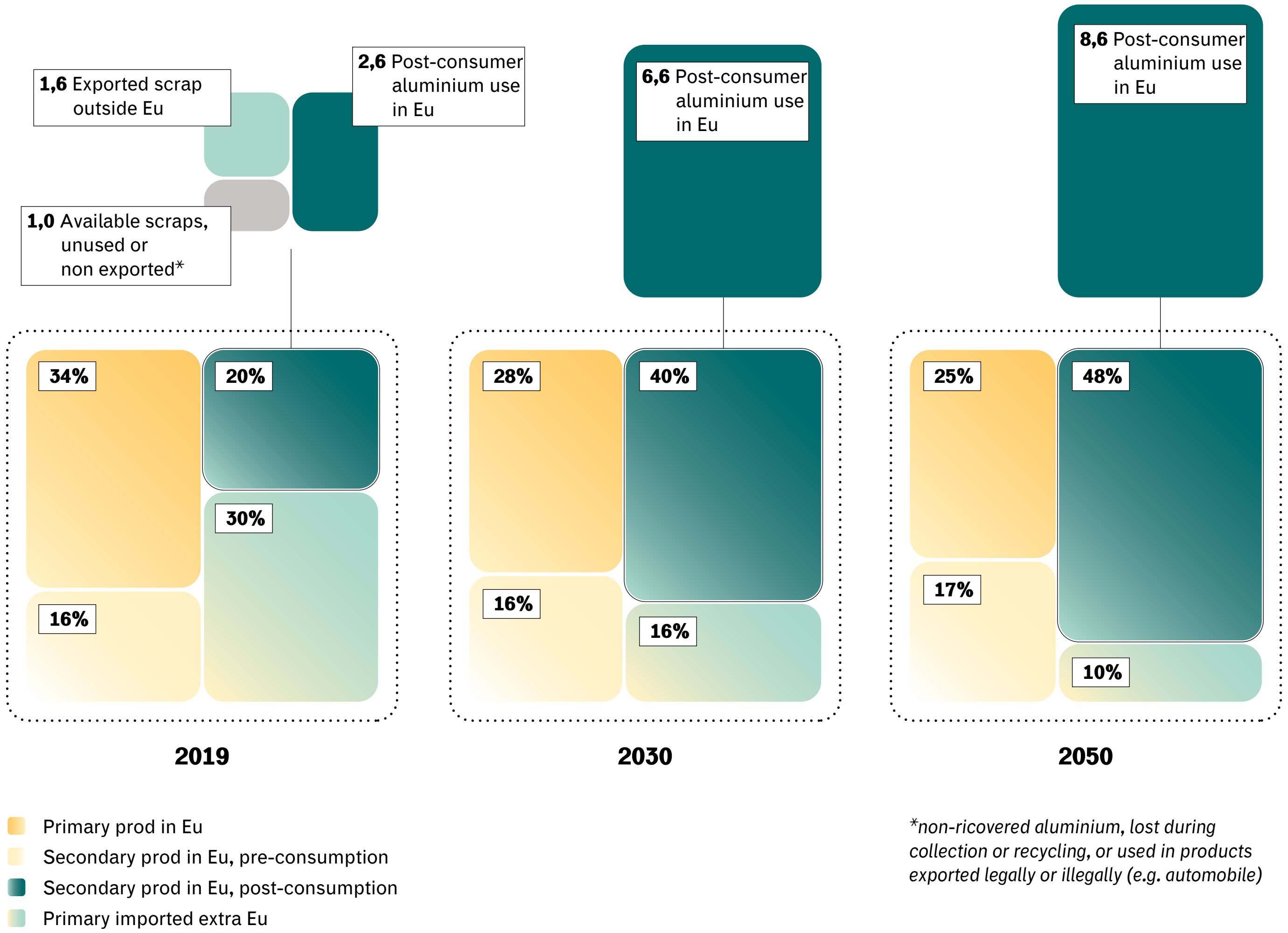


energy consumption, will lead to an increase in the need for conductive cables for power and its distribution. Although conductor cables are traditionally made of copper, the switch to aluminium is a viable alternative in terms of both cost and physical space.
Construction is expected to show relatively little growth over the next decade with consumption increasing from 21.2 Mt in 2020 to 25.8 Mt in 2030, mainly driven by infrastructure and new urbanization rather than the use of aluminium for more energy-efficient housing and buildings. Where environmental building renovations are encouraged, or specific building standards are applied, demand could increase significantly.
Finally, aluminium consumption from the packaging sector will increase from 7.2 Mt in 2020 to 10.5 Mt in 2030, driven mainly by the rise in popularity of canned beverages in North America, Europe, and China. The surge in demand for canned beverages in recent years and the consequent demand for aluminium from the packaging sector is expected to be driven by the emergence of new products and increased competitiveness, including for reasons of environmental perception, against plastic packaging.

The increase in demand for secondary aluminium

The expected increase in aluminium production on a global scale could never be met by secondary aluminium production, for the simple reason that the end-of-life products that will be generated will be far less than the new products required.
Nonetheless, even with a reduction in direct and indirect emissions from primary aluminium production, a strong enhancement of secondary aluminium production by reducing all leakage and improving the quality of collection (e.g., by segregating aluminium from re-melting and refining) will become essential to meet climate goals. Added to these reasons are also those related to the strategic importance of aluminium – one of the critical materials, despite the availability of bauxite reserves – especially at a time of geopolitical and market tensions.
On a global scale, therefore, a strong push toward production from secondary aluminium is expected, for environmental and energy reasons and because of the strategic value of the material, which may also lead to criticality in secondary material supplies.
In Europe, where the share of secondary is already high, there is an opportunity to meet the increased needs for aluminium products through increased secondary production. According to data from European Aluminium (Circular Aluminium Action Plan, 2020) at present, the use of post-consumer aluminium from domestic collection in Europe is about 2.6 Mt (the value obviously does not include pre-consumer industrial scrap or non-European scrap imports). But an almost equivalent value is generated without being used within the borders of the European Union: about 1 Mt of post-consumer scrap is, in fact, exported outside Europe, and about 1.6 Mt of aluminium scrap is not recovered or is exported (legally or illegally) in scrap vehicles and WEEE.
By stopping exports and optimizing post-consumer scrap recovery, assuming an increase in aluminium consumption, the post-consumer waste generated could be 6.6 Mt in 2030 and 8.6 Mt in 2050, an increase of 25 percent and 65 percent, respectively, over 2019. This increase could translate into 2.5 to 3.3 times the amount of post-consumer scrap used in secondary aluminium production in Europe today.
The recovery of this important fraction could allow for an increase in secondary production, reducing both the share of primary production in Europe (from 34 per cent to 25 per cent in 2050 of total production) and especially reducing the absolute share and amount of primary aluminium imports from non-European countries. ●

Potential for development of the use of post-consumer aluminum and reduction of primary aluminum imports with the increase in the use of secondary material in Europe



@Nicolas Teodori

The Italian supply chain

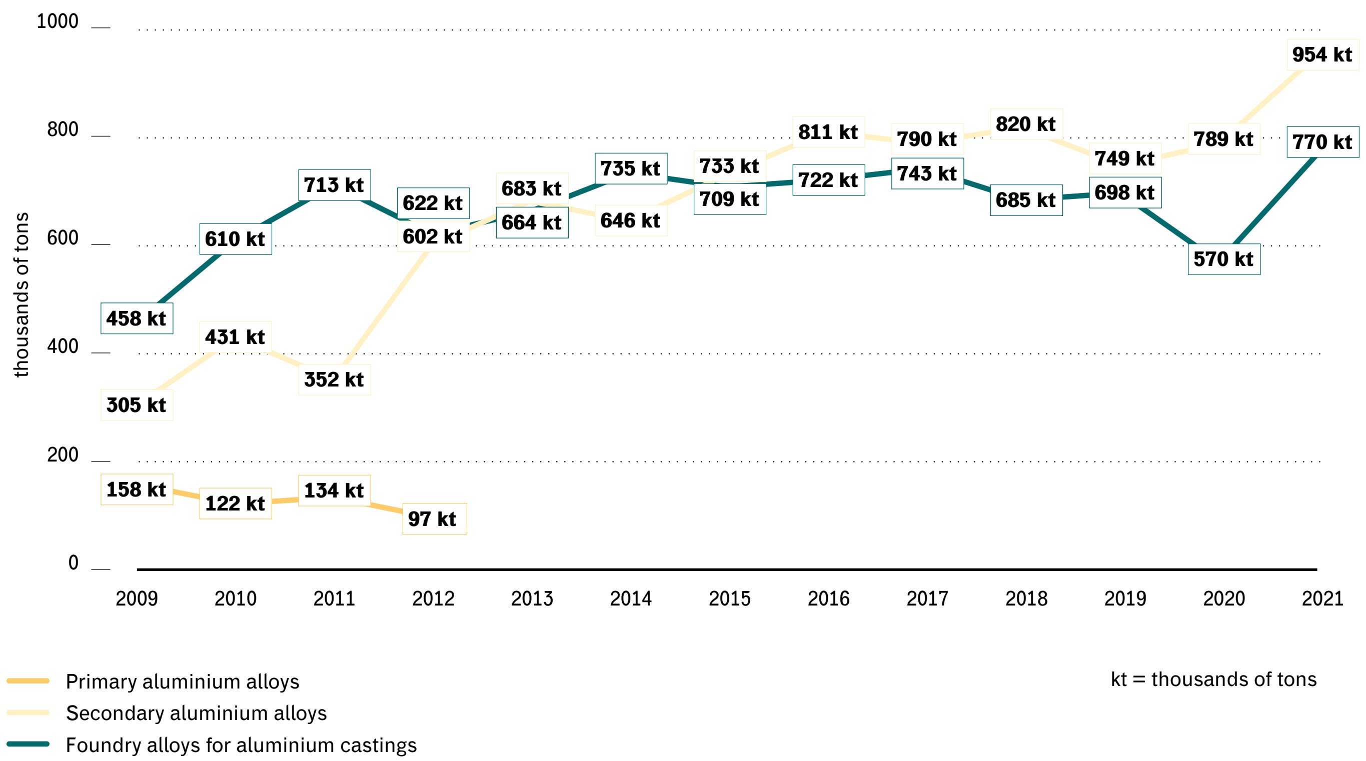
Unless otherwise indicated, data is based on Assomet's annual statistical reports.

Aluminium flows in Italy

Italy is Europe's second-largest producer and processor, after Germany, of raw and alloyed aluminium and semifinished aluminium products, but as of 2021, it ranks first by value of foundry castings.
In terms of recycled aluminium production, on the other hand, Italy ranks first in Europe, both in terms of the amount of aluminium alloys formed and the amount of scrap used.
Italian production has historically been scrap-based (similar to the Italian steel industry), but with primary production (from bauxite imports) still relevant in the first decade of the 2000s (averaging 190,000 t/y, just under 25 per cent of total production), until the final closure of production plants in 2012.
In 2021, production of secondary aluminium alloys in sizes reached an all-time high of 954,000 tons . In addition, the production of melt-bundle alloys is largely based on secondary aluminium, reaching 770,000 tons in 2021, the highest value in recent years.

Secondary aluminium production, i.e., from recycling, is derived from both internal recoveries (scrap from rolling and extrusion processes integrated with remelting plants) and pre-consumer scrap (from industrial processes) and post-consumer scrap (decommissioning of transport vehicles, construction demolition, consumer goods waste, and packaging). A significant share of scrap is imported. Overall, aluminium production is fed by more than 1.7 million tons of domestic waste and scrap, 1.3 million of which is marketed.
The most significant uses of aluminium production are in automotive and transportation (mainly from foundry castings), construction (mainly extrusions), sheet and packaging production (from rolled products), household and office products, and mechanical and electro-mechanical engineering.
Most, though not all, semifinished and finished aluminium products are derived from secondary aluminium alloys, the only domestic aluminium production.

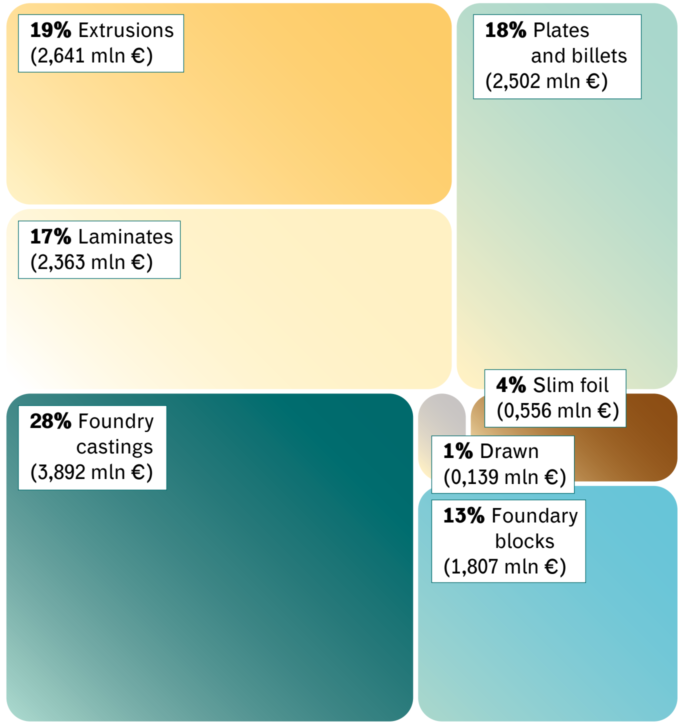
Primary and Secondary Aluminium Production



The economic dimension of the Italian aluminium industry

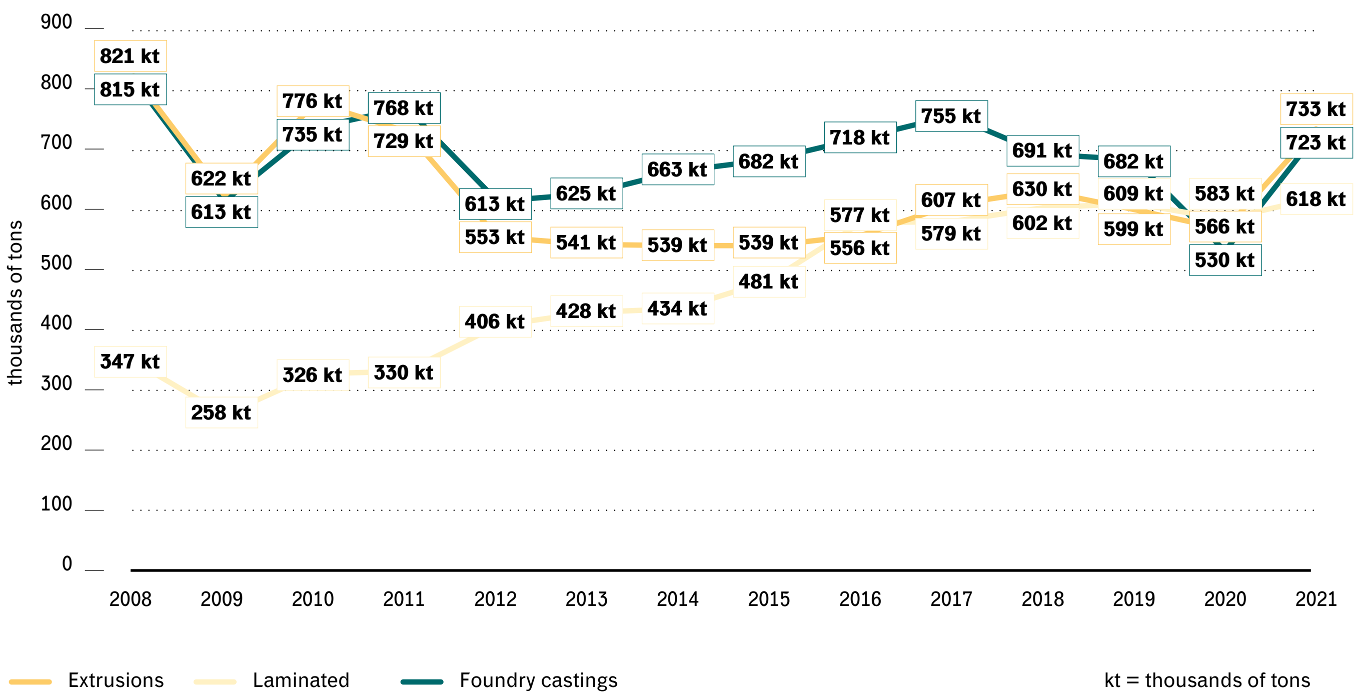
In 2019, the Italian aluminium production industry, based on Eurostat data, was worth 12 per cent of the value of European production and 10 per cent of employment. In the light metal casting sector – which also includes zinc, copper, magnesium, brass, and bronze, but of which aluminium accounts for 82 per cent of production – Italian industry accounted for 18 per cent of production value and 13 per cent of employment. Taking the two sectors together, in 2019 Italy accounted for 13.5 per cent of production value and 11 per cent of people employed in the European Union.
According to Assomet data for 2021, the sector has a total turnover value of 13.9 billion euros (up from 12.8 in 2018), mainly composed of plate and billet production (*remelting*), foundry alloy cake production (*refining*), foundry casting production, and the manufacture of extrusions and rolled products.
The aluminium industrial sector is characterized by the presence of a very small core of medium-sized companies – mostly refiners and remelters and integrated companies in the supply chain – and numerous small and medium-sized family-owned companies, especially in casting.
There are 25 remelters, 15 refiners and about 50 rolling and extrusion companies operating in Italy, while there are more than 400 aluminum casting foundries.

Italian aluminium sector turnover in 2021 (million euros)



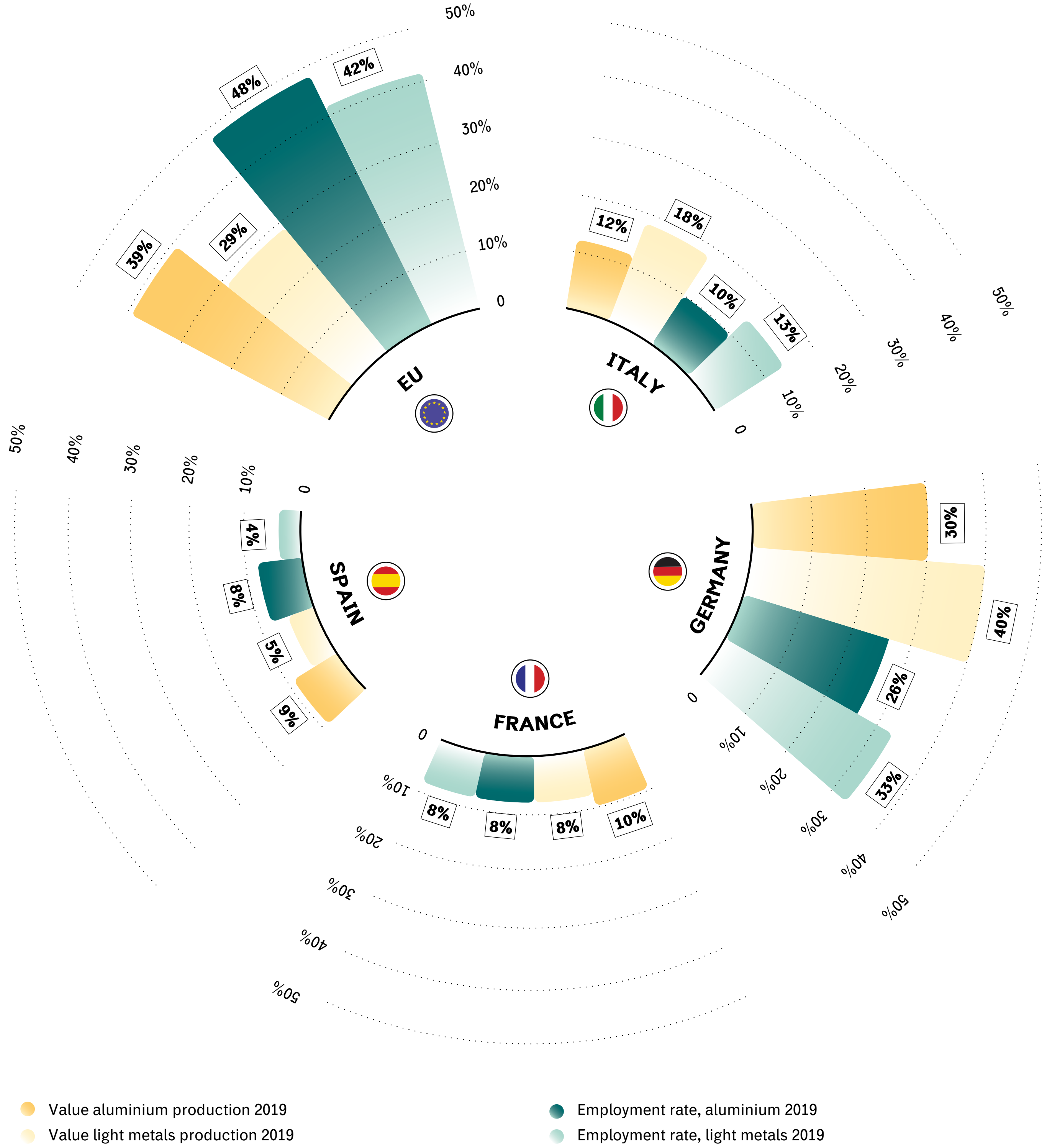
mln € = million euros

Italian production of extruded, rolled, and castings for foundries



kt = thousands of tons

Production value and employment in aluminium production and light metal casting in Europe



The recycled aluminium supply chain

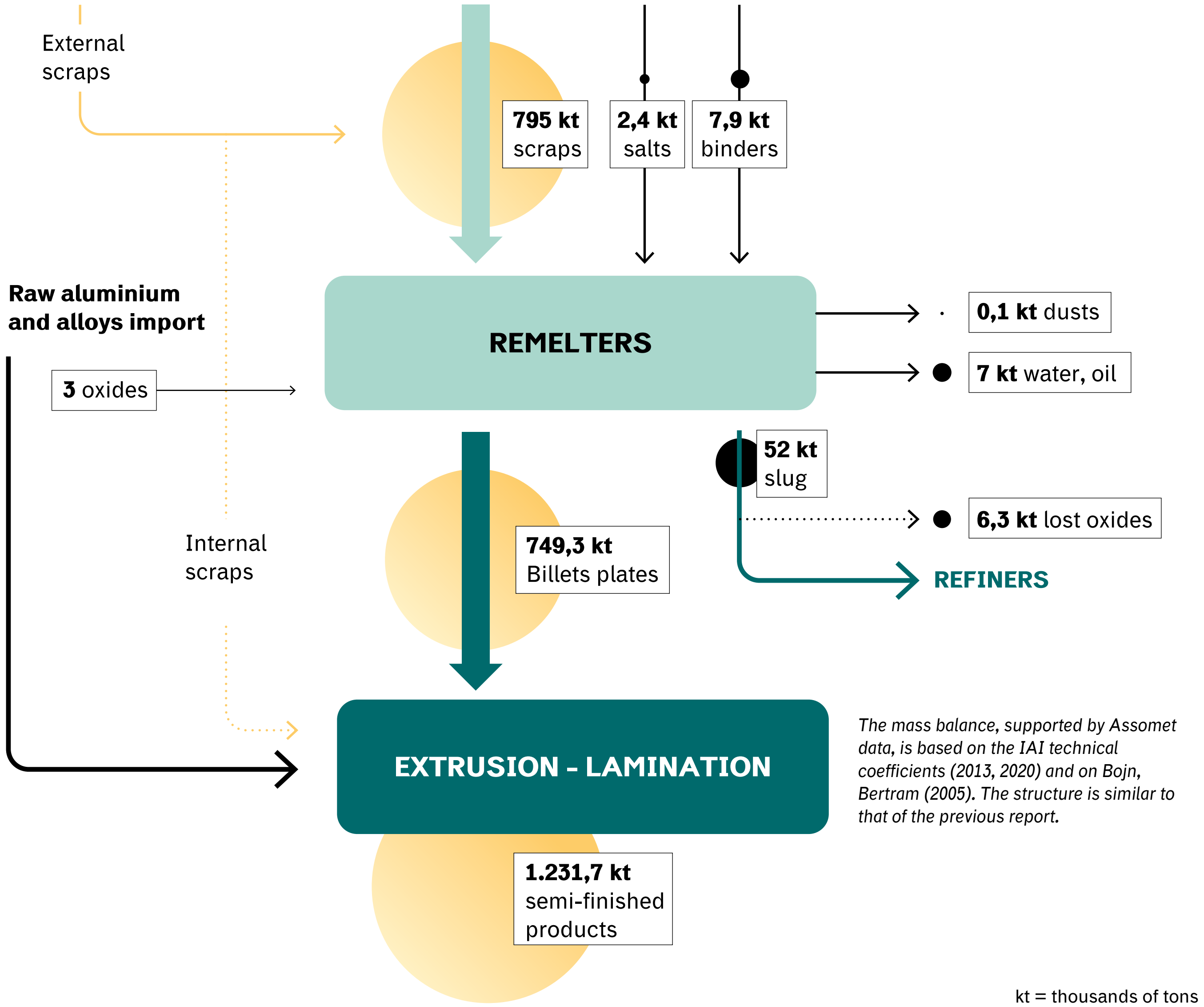
The recycled aluminium supply chain is based on two categories of companies: remelters, which produce the alloys from which extrusions and rolled products are derived, and refiners, which produce the ingots for foundry castings.

Remelters process scrap from plastic processing alloys, thus obtaining new plastic processing alloys. Domestic production is 954,600 tons (2021) and was 749,300 tons in 2019.
The scrap feeding the remelters consists mainly of internal scrap (from rolling and extrusion in integrated plants) and pre-consumer and, to a lesser extent, post-consumer scrap. Process losses (as oxidized aluminium) are less than 1 per cent.
The main products of remelters are: billets (cylinders between 50 and 500 mm in diameter and up to 7 meters in length) from extrusion, for the production of sections, tubes, bars; plates (slabs) from rolling, from which thin sheets (up to 5 microns for thin foil) are obtained.

Refiners process pre- and post-consumer scrap for the production of smelter cake alloys and deoxidation aluminium used in steel metallurgy. Domestic production is 769,500 tons (2021) and was 697,700 tons in 2019.
The scrap feeding the refiners is derived from pre-consumer scrap from semifinished and manufacturing production, remelters' slag, salt slag recovery, and post-consumer scrap from demolition and packaging.
Due to the lower purity of the input alloys, the process requires larger quantities of salts and binders and generates average process losses of about 6 per cent on a European basis (but estimated lower for Italy).
The main products of refiners are: cakes (ingots) for foundry, for the production of castings; aluminium for deoxidation in steelworks.

Secondary aluminium production is fed by three types of scrap:
1. 1. Post-consumer scrap, consisting of old scrap, including mixed with other substances (paint, other materials), from demolition, decommissioning, and separate collection of municipal waste. In 2019, about 582,000 tons of post-consumer scrap is estimated, including the import share; in 2021, post-consumer scrap is estimated at 654,000 tons.
2. Pre-consumer (marketed) scrap, consisting of clean and new alloys in the form of scrap, turnings, and shavings from rolling, extrusion, and foundry processes (similar to those considered as "internal recoveries") and production waste from manufacturing processes of using rolled, extruded, and castings. As of 2019, there were an estimated 476,000 tons of pre-consumer scrap, including imports; by 2021, pre-consumer scrap had reached 650,000 tons.

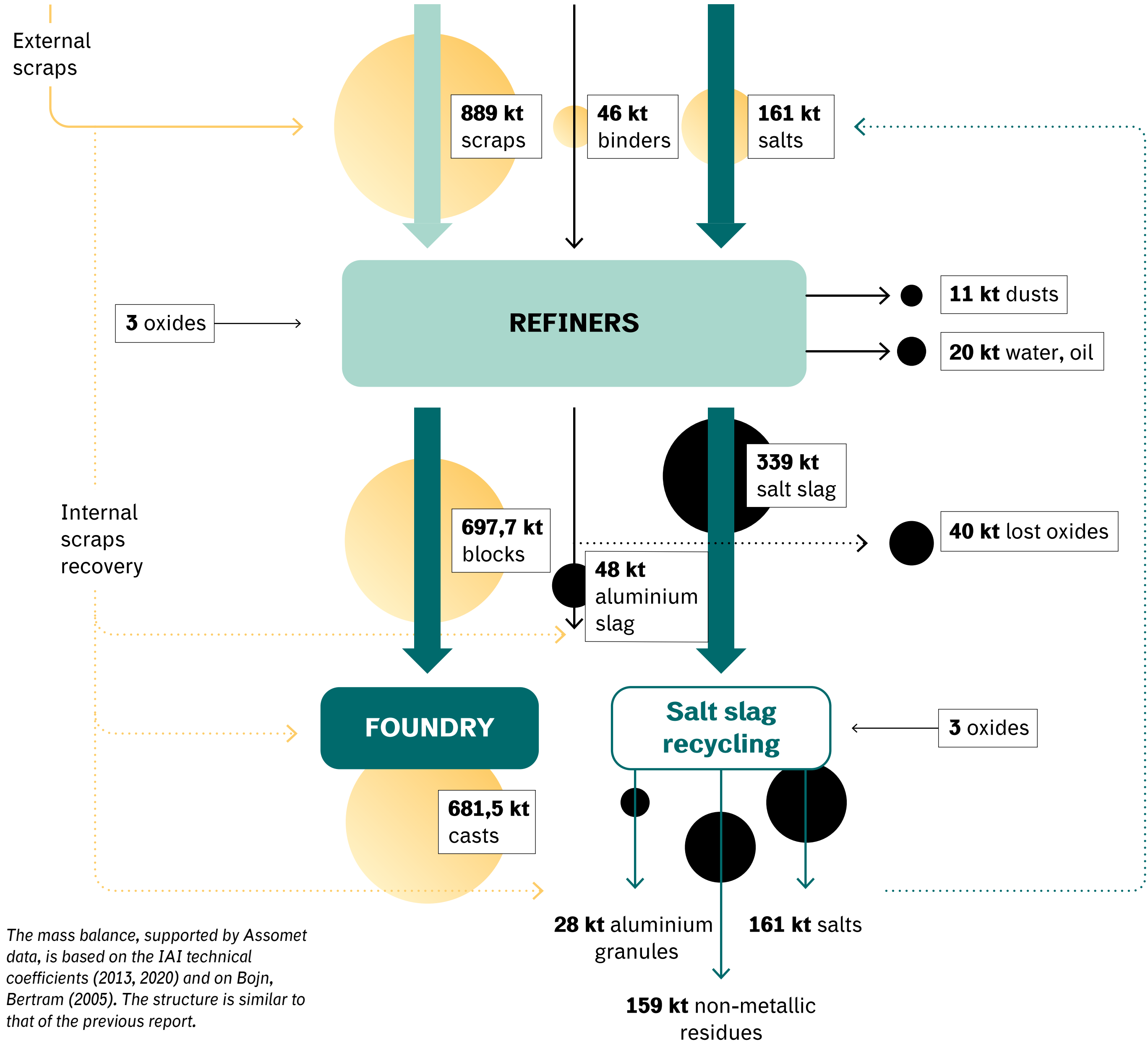
Remelters - Material balance: recasting, extrusion and lamination (estimates 2019)



The mass balance, supported by Assomet data, is based on the IAI technical coefficients (2013, 2020) and on Bojn, Bertram (2005). The structure is similar to that of the previous report.

kt = thousands of tons

Refiners - Material balance: refiners and foundry castings (estimates 2019)



The mass balance, supported by Assomet data, is based on the IAI technical coefficients (2013, 2020) and on Bojn, Bertram (2005). The structure is similar to that of the previous report.

3. Internal (non-marketed) waste from production processes. This refers to the recoveries of process and pre-consumer scrap that are not marketed (and therefore not captured by statistics) and occur within the same production cycle (such as the recovery of process or salt solution slag) or within the same enterprise if integrated downstream, e.g., by extrusion or rolling. The most significant recoveries are scrap, turnings and chips from rolling and extrusion and foundry. Rejects vary according to the type of product, routinely ranging between 20-30 per cent of the finished product. These flows are not statistically recorded and are estimated: as of 2019, the theoretical need for internal scrap is estimated at 627,000 tons.

National collection and import-export of scrap metal

The national collection of aluminium scrap is composed of both post-consumer and pre-consumer waste. Domestic pre-consumer waste has an almost total collection rate and, to a significant extent, is considered as internal waste and therefore not marketed and accounted for. The collection of post-consumer scrap is composed, with the exception of packaging, of the end-of-life of products placed on the market even several decades ago. The main sources of post-consumer scrap consist of: building demolitions and renovations (windows and doors, facades) and infrastructure decommissioning (piping and piling); vehicle demolitions (cylinder blocks, cylinder heads, pistons, brakes, wheels, heat exchangers) and transportation equipment (trains, subways); packaging (cans, tubs, foil); electrotechnical products (cables) and components of mechanical and thermal apparatus (radiators); waste electrical and electronic equipment (air conditioner components, computers); consumer durables (furniture products, lighting, cookware).

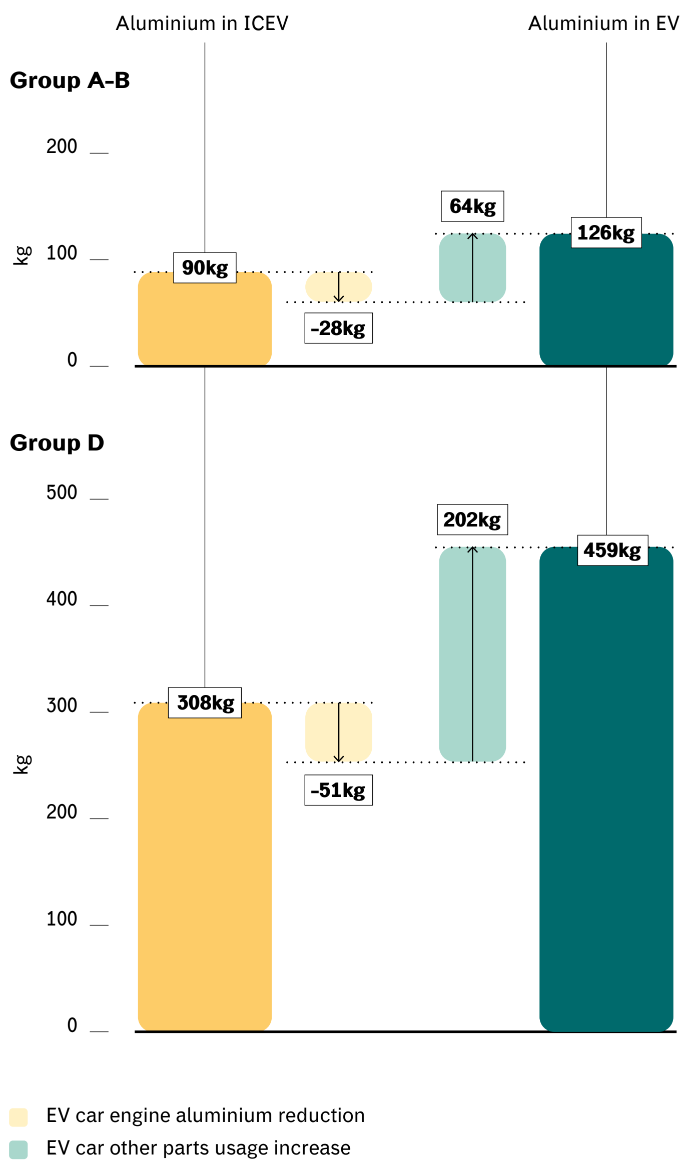
Collection and recycling rates vary, depending on the products, from less than 20 per cent (as in the case of thin foil) to more than 80 per cent (construction waste, cables, rigid packaging). As valuable a metal as aluminium is, some sectors still experience large waste (and thus metal losses) between waste produced and waste collected for recycling.
Domestic collection (post and pre-consumer) is estimated by the difference between domestic scrap consumption and the import-export balance of scrap (including ingot scrap); between 2016 and 2021, national domestic collection increased, with some fluctuations, from 651,000 to 809,000 tons. In domestic collection, a prevalence of post-consumption is estimated, while for imports only estimates with a certain degree of uncertainty are possible.
While for other non-ferrous metals domestic collection covers all or at least a large majority of the requirements (for copper it is 97 per cent), the Italian aluminium industry is a net importer of scrap (in 2021 about 38 per cent), with the all-time high reached in 2019 (486,000 tons) and with values very close also in 2020 and 2021 (values understood net of ingot scrap). In economic terms, due to the sharp increase in raw material costs, the trade balance reached its all-time high in 2021 with a balance of 668 million euros. ●

@Envato Elements

@Nicolas Teodori

Aluminium for green and circular transition

Comparison of aluminium content by fuel type and car "level"

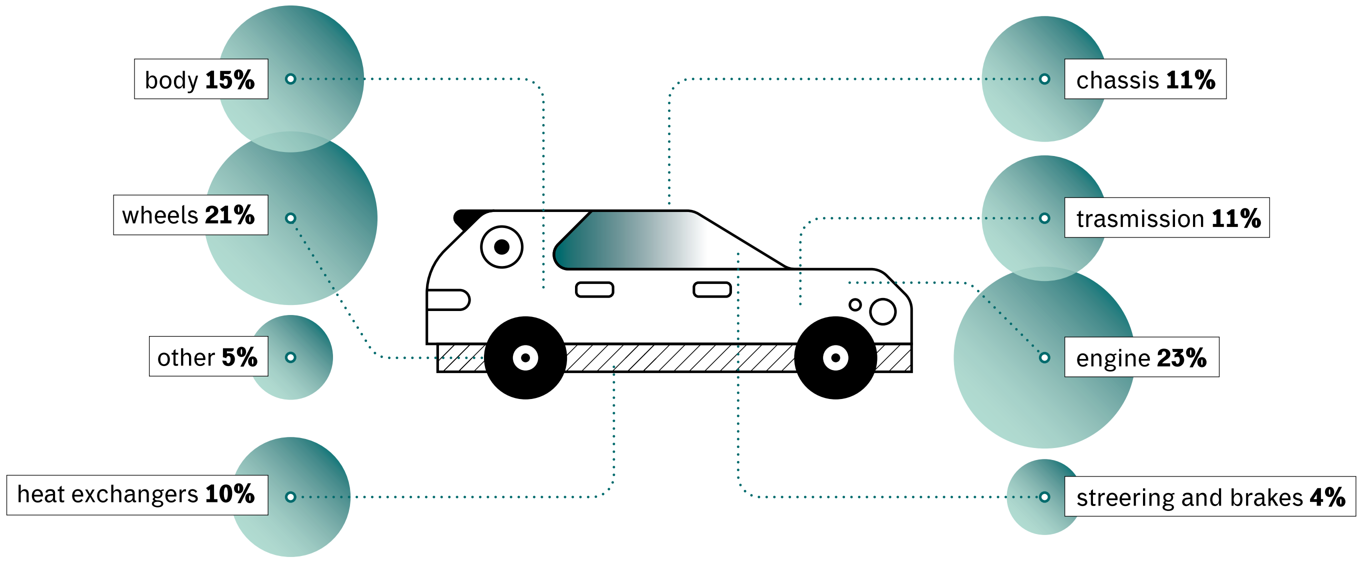


Aluminium is a key material for the energy transition and circular economy.
Because of its durability and almost infinite recyclability, it can be an inherently circular and low-impact material (both production and management in the use phase and then disposal) in multiple applications, including the production of consumer durables and packaging.
Because of its technological characteristics, as well as its circularity, it will be one of the critical and fundamental materials for the energy transition, for more efficient and electric means of transportation, for energy-efficient and zero-consumption building, and for the creation of an energy system based on renewable sources.
International demand projections for the coming decades underscore the centrality of energy transition and decarbonization in the development of aluminium demand.

Green mobility

Aluminium has a wide use in transportation equipment. In Italy, just under 40 per cent of production has transportation as its end use, with strong production of engine blocks and other cast components. On a European scale, more than 40 per cent of aluminium is used for transport equipment, with predominant use for passenger cars, but also important for heavy vehicles, subways, trains, planes and ships.
In motor vehicles, the average aluminium content has risen from 120 kg in 2006 to 140 kg in 2012 to 180 kg today (2019 European average). The main aluminium components are wheels, engine blocks, transmission and, increasingly, also chassis and bodywork.
The ongoing change in the types of components produced from aluminium (which will undergo a further shift with electrification) also means a change in the type of aluminium consumed: fewer foundry castings, more rolled and extruded. This development – though not sudden and in many

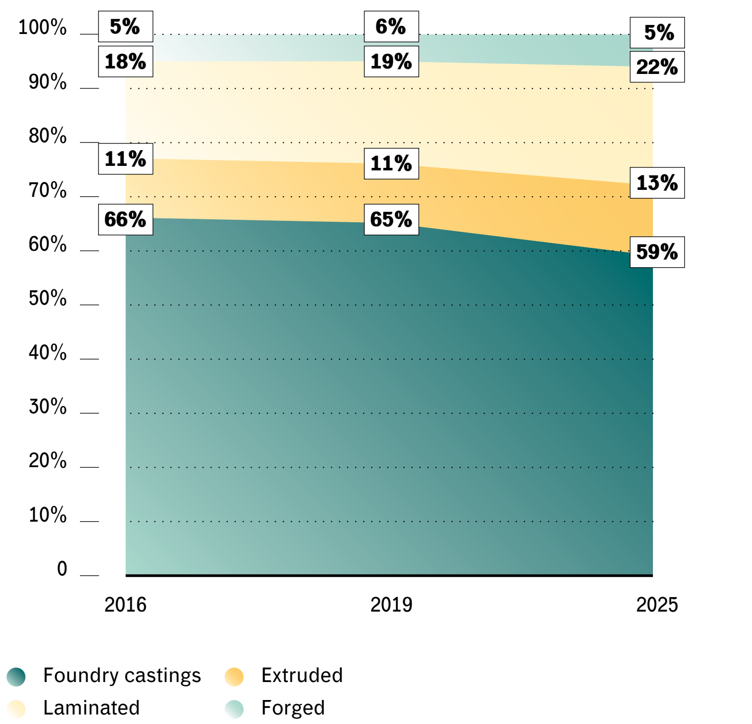
Use of aluminium in the European automobile fleet (2019)



ways predictable – will, however, significantly impact the Italian casting industry, which is Europe's leading producer of foundry castings and in particular automotive castings.

With the gradual electrification of the car fleet – accelerated in part by the blocking of combustion cars from entering the market from 2035 – the greatest structural change in automotive history will occur.
Electrification will entail a drastic simplification of components, but also a search for ever lighter and more energy-efficient solutions to reduce battery consumption and increase mileage capacity.
The overall impact on the demand for aluminium will be positive, with an expected growth (overall in the mobility sector) of about 55 per cent by 2030 and growing further in the following decades as the existing vehicle fleet is also progressively electrified.
Demand for aluminium, however, will be predominantly directed toward new components, related to electrification itself, as well as to the "body" of the car, with a further increase in demand for extruded, rolled, and forged aluminium. With the further electrification of the automobile fleet, there will be an increase in aluminium content in all the various automobile segments, from compact and economical cars to premium cars of higher power and cost.

Evolution of aluminium type used in passenger cars with forecast to 2025



Eco-efficient construction

Construction applications account for about 23 percent of end uses in both domestic and European production. Building products consist mainly of laminates and extrusions.
At present, relevant construction employments are window and door frames, supports for curtain walls, and supports for air conditioning and heating elements.
One of the most industrially relevant uses is window and door frames, where aluminium accounts for about 32 percent of the market by volume and 37 percent by value in 2021. Since 2015, the metal windows and doors market has been on a positive growth trend. This was interrupted in 2020, and resumed in 2021 with +22.5 per cent over 2020, reaching 1.7 billion in sales (adjusted for the increase in the cost of relevant inputs, this gives a real growth of 9.6 per cent).
In terms of "standard pieces," fixtures produced in Italy reached their all-time high in 2021, and in value terms they account for more than 25 per cent of the European market (Eurostat-Prodcom data, 2022).
In 2021, sales of aluminium windows accounted for 64.6 per cent of total sales, shutters 11 per cent, and facades 9 per cent (this is a marginal sector for window and door manufacturers).
In 2022, tax incentives determined 51 per cent of metal window and door manufacturers' sales.
Curtain walls are also an important architectural

@Envato Elements

element, largely based on the use of aluminium, with increasing use in the non-residential sector.

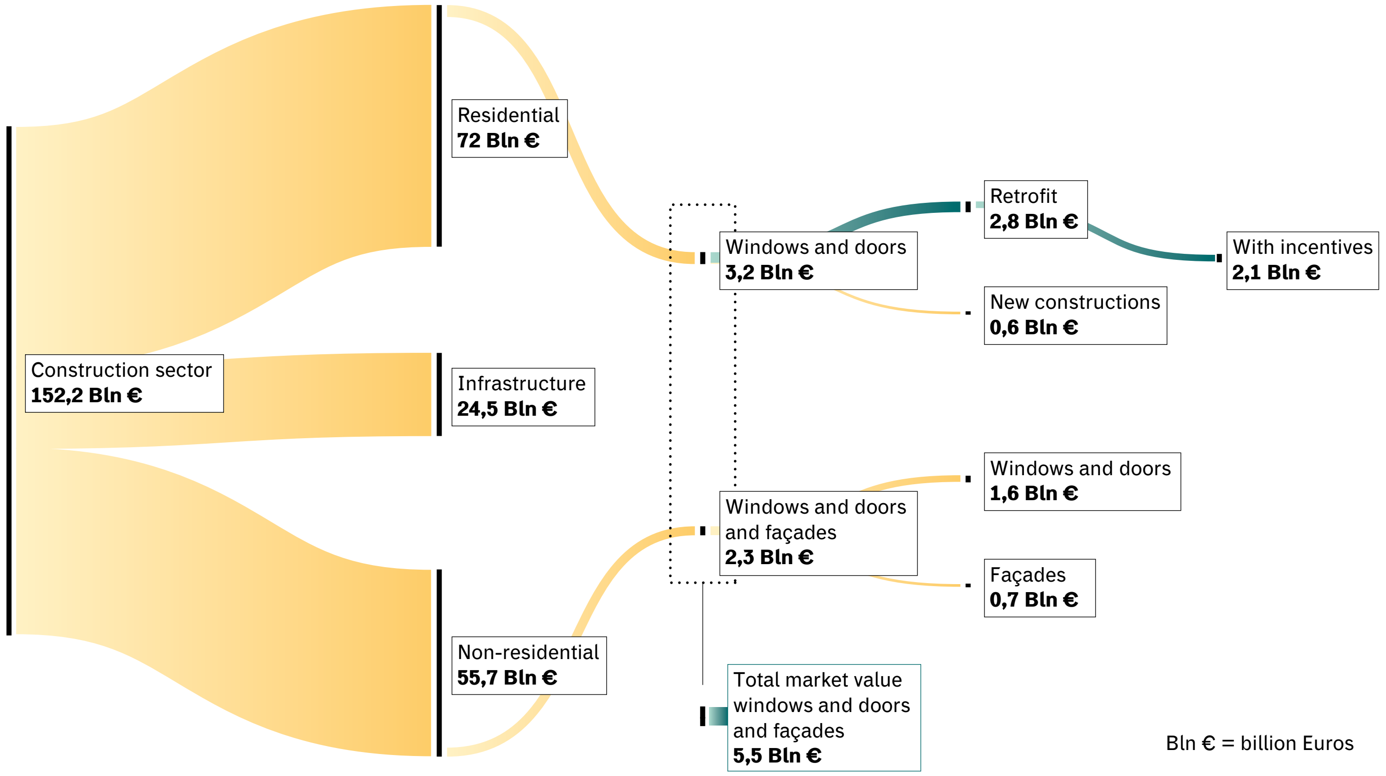
Development in construction will be driven by green conversion and the need for energy-efficient buildings, especially in a country like Italy where renovation prevails over new construction (71 per cent vs. 29 per cent of total investment in 2021, continuing a now long-lasting trend), both in residential and non-residential. A date, after all, already made evident by the effect of the home bonus and super bonus, which have seen a growth in the production and domestic consumption of building elements.

The increasing use of aluminium as a material for green home construction will depend on four elements (EA 2019, Wang 2015).

Energy efficiency – The use of aluminium optimizes the energy efficiency of a building by helping to control and manage factors related to heating, lighting, cooling, and ventilation. This can be achieved through the installation of framing systems, curtain walls, windows, light shelves, shading systems and shutters, as well as the installation of solar thermal and photovoltaic panels, of which aluminium is quantitatively the largest component.

@Envato Elements

Value of demand for windows and doors and façades in the construction sector (Italy, 2021)



Indoor environmental quality – Several elements affect the comfort of those who live or work in a building, among them fresh air, natural light and views. The use of aluminium contributes to this in the form, for example, of folding windows or sliding doors, which improve the quality of airflow, the amount of natural light entering the building, and provide unobstructed views that enhance the quality of life.

Life cycle of materials and resources – Aluminium as a building material is a very sustainable solution during its life cycle, from design to construction, use and demolition. Since it has a long lifespan, secondary aluminium can be used, and it is fully recyclable.

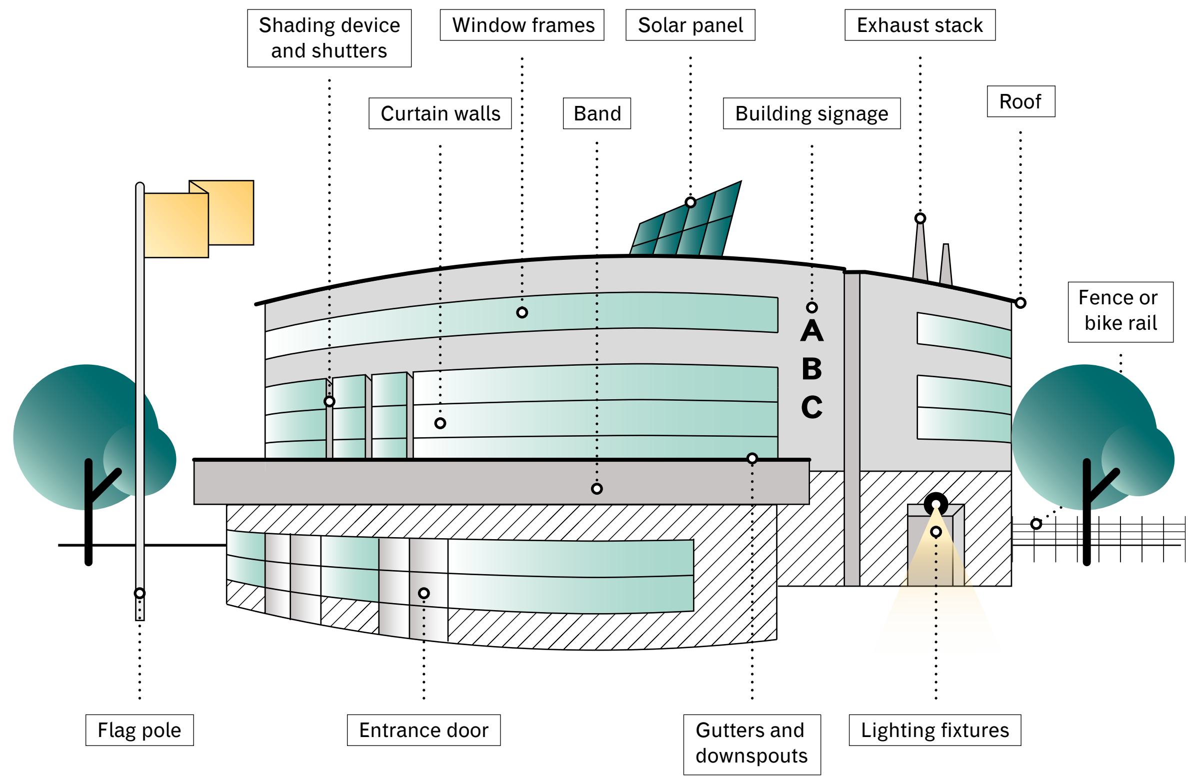
Innovation – The durable, flexible and robust nature of this metal lends itself to new innovative approaches to building design and construction. These properties allow for customization and enable architects and designers to develop innovative green building solutions.

Thus, in green building, aluminium finds multiple uses: window and door frames, structural elements such as curtain walls, roofing sheets, laminates for ceilings, profiles or castings for air conditioning and heating systems. Light weight, corrosion resistance, stress resistance, and conductivity are particularly relevant in these types of uses.

The greater environmental sustainability of aluminium window frames

The degree of environmental sustainability of window frames has been the subject of several studies. When lifecycle analyses consider full-service life, maintenance, and end-of-life recyclability when comparing material types, the impacts of aluminium window frames are lower than those of other material options for all types of environmental impacts. An important factor in the benefits of aluminium – even considering a prevalence of primary aluminium (67 per cent in this study) – is the product lifespan and the impact of maintenance of the window frame itself. In particular, regarding climate-altering emissions (the so-called *global warming potential*), even the worst-case management scenario for aluminium is preferable to any scenario for other materials. An aluminium window frame with medium maintenance has 68 percent lower climate-altering emissions than the best-case scenario for PVC and 50 percent lower than the best-case scenario for wood.

Energy-efficient uses of aluminium in construction



Endlessly recyclable packaging

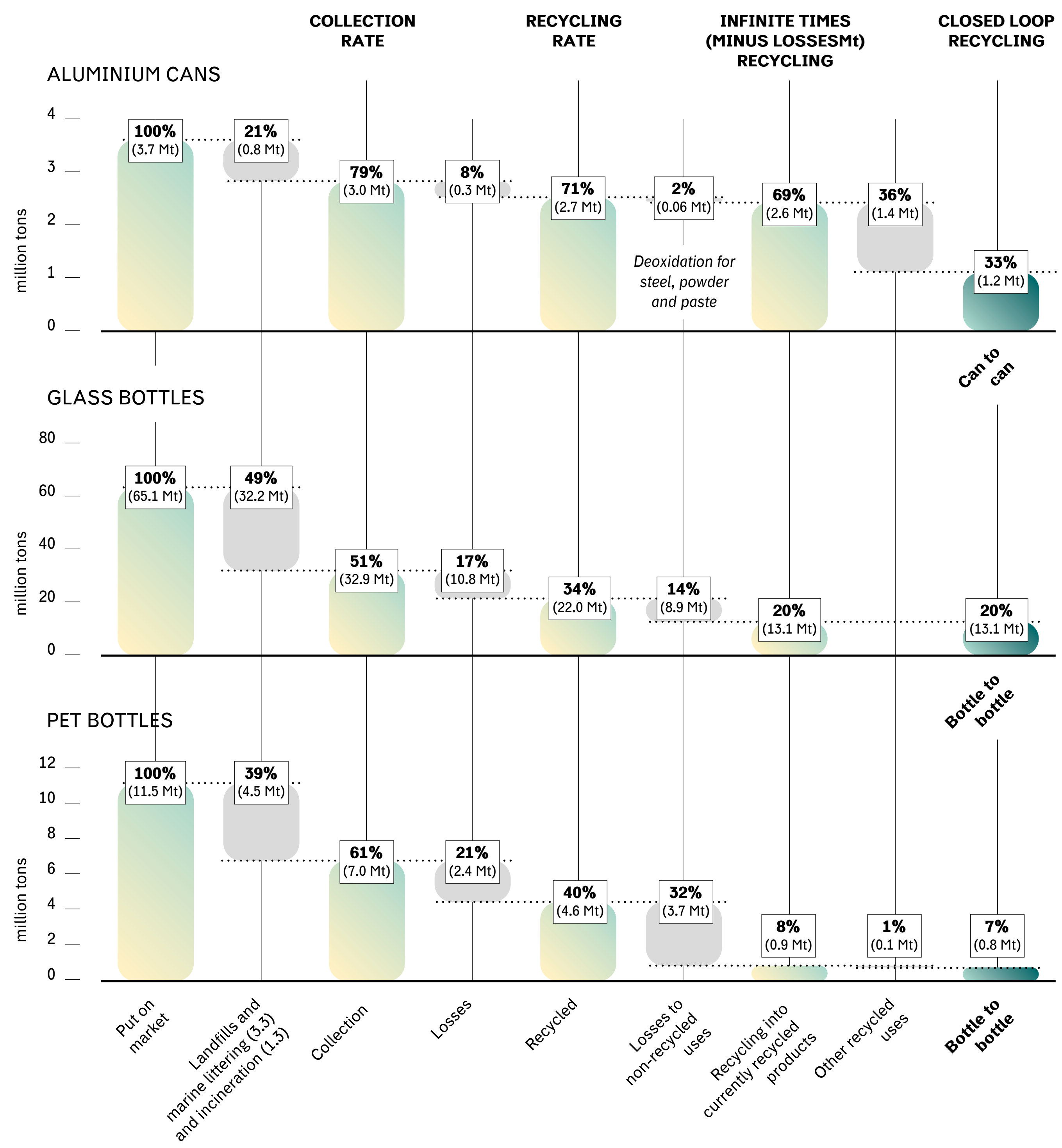
Aluminium is used in packaging for the production of containers (typically cans and canned goods for beverages or solid food, but also larger containers), trays and tubes for both food and non-food use, foil for bulk packaging or as a component of poly-bags.
Aluminium has suitable characteristics for optimizing both product preservation (ensuring a high shelf life and thus less waste) and rationalization of transportation and material use (by virtue of its light weight).
Over the past twenty years, there has been a significant efficiency improvement in packaging, which – with the same performance – has reduced material consumption by more than 10 per cent in most applications.
Italian production of aluminium packaging – including converter foil – exceeds 200,000 tons per year and has a turnover of more than 3 billion euros. Apparent use of packaging is around 130,000 tons, but these quantities do not correspond to those actually consumed in Italy (i.e., those net of imports and exports of food and packaged goods), which are essentially stable between 70 and 80,000 t/y. The per capita consumption, just over 1 kg/inhabitant, is in line with France, but less than half of the UK and Nordic countries.
The predominant use of aluminium, according to surveys by the Italian Packaging Institute, is for beverages (about 64 per cent), food (about 20 per cent), and cosmetics and pharmaceuticals (about 16 per cent).
Packaging grade aluminium has an extremely short lifespan, conventionally within a year.

High recyclability now makes aluminium a more sustainable packaging material than others. Once the aluminium can is collected, the efficiency of the whole recycling process (sorting, reprocessing and heat treatment) is 90 per cent (Eunomia, 2021). The process losses for aluminium (approx. 10 per cent) are far lower than those known for glass (33 per cent) or Pet (34 per cent).

Recent research by Eunomia (2021) showed that aluminium cans are, on a global scale, the most collected beverage packaging, most effectively recycled net of losses, and with the highest closed loop (i.e., same use) recycling rate.
This performance makes aluminium the most "circular" beverage packaging material.
In Italy, with a very high overall recycling rate of aluminium packaging (including not only cans, but also semi-rigid and flexible packaging, from trays to sheets), an even more radical path can be taken, with a trending goal of 100 per cent recycling of packaging.

However, one of the problematic elements for aluminium packaging – and more generally for all packaging – is the presence of poly-bundles, which are difficult if not impossible to recycle.
For the 100 per cent recycling result to be achieved, action must be taken in three areas, those where the "loss" of packaging for recycling is realized. First, separate collection, which must become even more efficient. In the Italian context, the focus must be on the interception of semi-rigid and flexible packaging, since for cans and rigid packaging the collection rate for recycling is now close to 100 per cent. It is essential to conduct regular and targeted recycling campaigns aimed at changing consumer behaviour.
Second, aluminium recovery from residual waste treatment needs to be implemented. The waste of aluminium in Italy is evident in the mechanical-biological treatment network precisely because of the absence and inadequate management of non-ferrous metal interception technologies. Interventions to make these plants efficient are technologically simple, for example, the provision of at least two high-performance eddy current separators in sorting plants.
Finally, recovery from slag and bottom ash should be maximized. For aluminium packaging that ends up in waste-to-energy plants, with the exception of the portion of aluminium that is oxidizable (which generates recoverable energy), all the aluminium is captured by incinerator bottom ash, which, if subjected to appropriate separation treatments, can allow for high recovery, additional to that achievable with separate collections.

Total and closed loop recycling rate of aluminium cans, glass bottles, and PET bottles



Mt = million tons

@Envato Elements

Consumer durable goods

Aluminium has a large use in furniture and household products. For household, kitchen and sanitary products alone (which includes part of the furniture products), Italian production in 2021 was 200,000 tons (it was 128,000 in 2013), with an apparent consumption (production + import – export) of 172,000 tons. This is a strong Italian specialization in terms of both production and (to a lesser extent) consumption.
Aluminium is used in the production of furniture, bookcases, chairs, tables – for indoor and outdoor use – kitchens, cookware and tableware, coffee makers, and hygiene products. In the production of kitchenware, it is used both pure and as a base for non-stick pots and pans with Teflon coatings or other materials; in combination with steel, it is now also suitable for the most modern induction cookers.
These uses, partly driven by environmental factors, are also growing, especially in countries outside Europe. The possibility of producing goods that are entirely from recycled (and in turn recyclable) could become another element in the expansion of this area of use, with an important role for Italy.
The life cycle of these consumer items is variable, generally between 3 and 20 years. The waste stream confers partly in municipal waste, partly in bulky items, and partly in industrial waste.

Renewable Sources

Aluminium is widely used both for the manufacture of power generation plants and for storage and distribution technologies. The supply of aluminium is therefore critical regardless of the intensity of decarbonization development, but it becomes critical in scenarios of increased renewable development.
Aluminium is the mineral of which the largest production is expected for renewable development, with production cumulatively between 150 and 320 million tons between now and 2050, equivalent to 6-13 per cent of annual production in 2019 under the least extreme scenarios.
The intensity of aluminium use (in terms of kg per kW of power) in renewables is extraordinarily higher than in fossil or nuclear sources. Aluminium consumption in electricity distribution networks is also high. Therefore, in any energy transition scenario based on decarbonization and increased use of electricity, there will be a marked increase in the use of aluminium.
The main demand for aluminium will be related to the development of solar, particularly solar photovoltaics. Aluminium accounts for about 88 per cent by weight of the metals used in the installation of photovoltaic panels (mainly frames and accessories) and is also used consistently in solar thermal and concentrating solar power. But it is also used in most other low-carbon technologies, such as wind, energy storage, and hydropower.

The size of the additional demand for aluminium, however imposing, will depend on two factors: the speed and intensity of deployment and the composition of non-fossil energy sources in the new energy scenarios; and, to a lesser extent, on technological developments in non-fossil energy production and distribution, with the inevitable uncertainties in long-term assumptions.

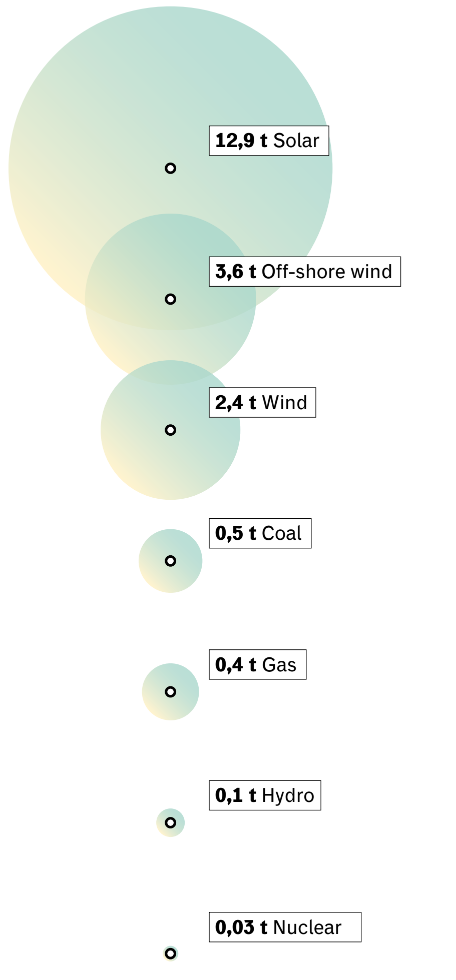
Energy transition scenarios are rapidly evolving toward zero-emission targets. For example, the first IEA 2°C scenario in 2017 projected renewables to account for 26 per cent of energy demand in 2030 and 46 per cent in 2050. By 2022, on the other hand, the IEA Net Zero Emission scenario envisions 67 per cent renewables in primary energy demand and about 88 per cent renewables in electricity generation in 2050. In this new context, the forecast of installed capacity of electricity generation from renewables also grows, reaching 14,458 GWh of solar (in addition to 426 GWh of concentrated solar) as well as 8265 GWh of wind.

@Envato Elements

Other sources, e.g., Bloomberg's *New Energy Outlook report* (2021), identify a Green Scenario more strongly oriented toward electrification (121,000 TWh of generation is expected by 2050, compared to 71,000 TWh in the IEA scenario), with an 84 per cent share of renewables. There is a further increasing installed capacity for both solar (19,800 GW) and wind (up to 25,000 GW). Some scenarios, developed from within PV manufacturers such as the *International Technology Roadmap for Photovoltaic* (VDMA, 2022), predict even greater penetration of PV, up to 63,400 GW.
Less significant, but not insignificant, are also the impacts related to the prospects for direct thermal power generation. In a context of strong electrification, the expected growth of solar thermal is scaled back. Nonetheless, both IEA (2022) and IRENA (2022) see significant increase – from 714 million square meters of solar thermal in 2020 – in both residential and industrial uses to reach 4-6.3 billion square meters of solar collectors for an installed capacity of between 2.8 and 4.4 TW by 2050. This growth translates, in terms of aluminium demand, to a cumulative 8 -12.6 Mt to 2050.
The other energy source that has a non-marginal use of aluminium is wind power. The prospects for wind development have also increased over the years (although less than for solar, due to greater locational and cost constraints), rising from 3.3 TW to 2050 in the 2017 IEA 2°C scenario to values of just over 8 TW in Irena's scenarios and the IEA's Net-Zero Emission (2021). Under assumptions of massive electrification (Neo-Bloomberg report's Green scenario), however, the wind market could grow to 25 TW by 2050.

In the development of renewables, electrification of energy services plays an important role.
In all scenarios, electricity use in industry, transportation, and buildings increases its share of total final energy to just under 50 per cent in 2050 from 19 per cent today.
Under these scenarios, the renewables market would develop exponentially. While the first 1,000 gigawatts of wind and photovoltaics took 20 years to implement, getting to net-zero emissions in 2050 would require about 1,400 GW of renewables to be deployed annually, on average, for the next three decades.
The size of demand for solar and, to a lesser extent, wind will be the deciding factor in the amount of aluminium required.
A less significant, but not insignificant, impact is also expected from technological developments in panel production (particularly the spread of rooftop vs. ground installations and the size of individual panels) and electrical distribution technologies.
Depending on estimates of aluminium requirements per MW of power1, these estimates can vary significantly.
Assuming intermediate values of specific Al use per MW, consistent with CRU estimates (equal to 12.9 t/MW for PV and 2.4 t/MW for wind), one can estimate a cumulative requirement ranging from 150 to 320 million tons in scenarios close to or equal to zero emissions in 2050. This translates into an annual requirement between 5.1 Mt and 10.6 Mt.
More extreme estimates of PV use (60 TW of ITRPW, 2021) could lead to a cumulative demand of about 500 Mt.
Finally, demand for renewables plants should be supplemented by demand for electrical distribution networks, which today is the main source of aluminium use in the power sector. ●

Aluminium intensity of different energy sources (t Al / MWh)



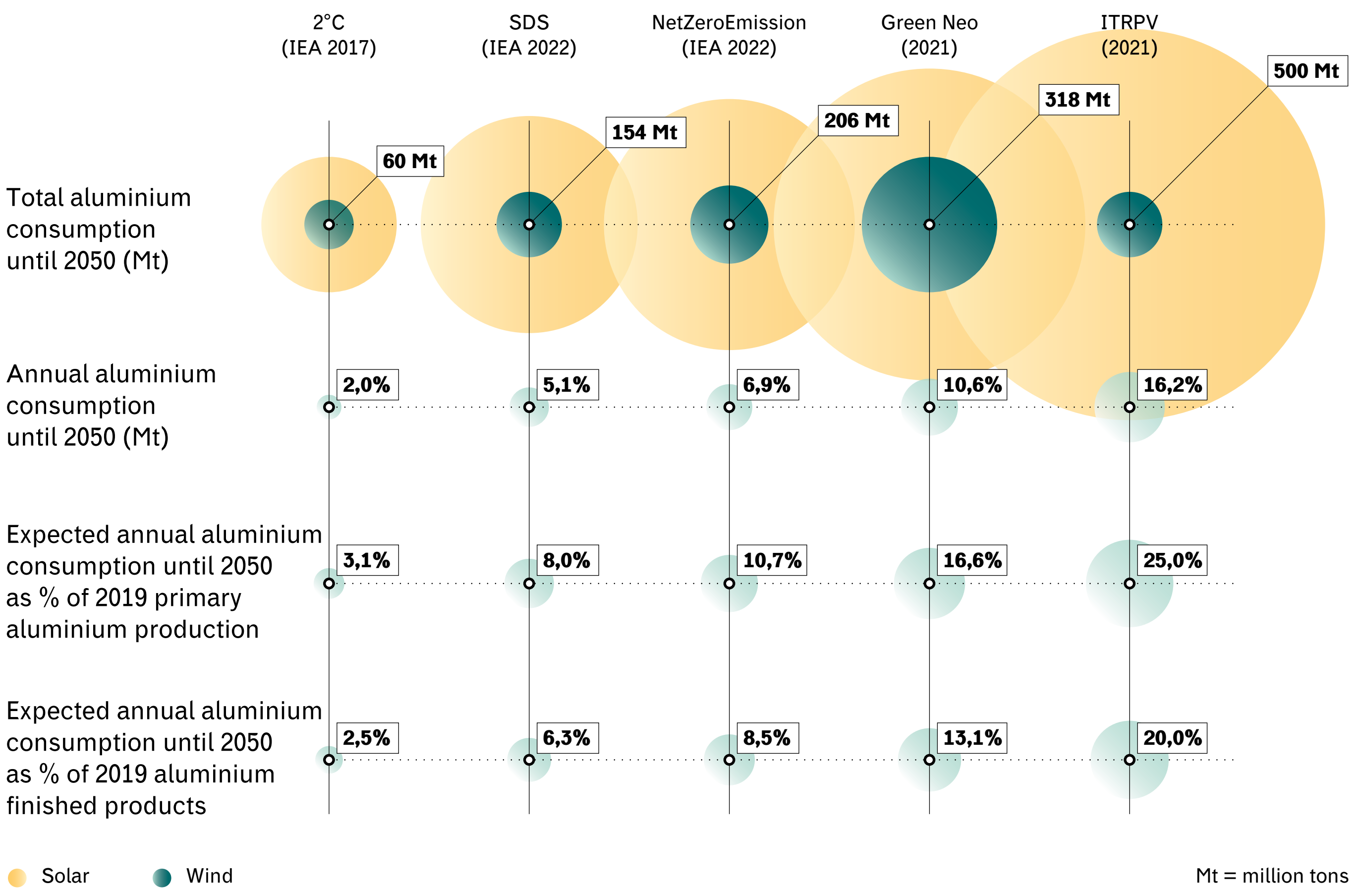
t = tons

Even among recent sources, there are significant differences in the estimation of aluminum content per MW of power in photovoltaic panels: ranging from 25 t/MW according to the World Bank (2017) to 12.9 t/MW in the CRU estimate (2022) for International Aluminium, and down to an estimate (assuming maximum photovoltaic diffusion of 63 TW) of 8.1 t/MW in the Lennon study (2022).
For wind power, the estimates, on the other hand, are more convergent, ranging from 2.4 t/MW (onshore) to 3.6 t/MW (offshore) according to CRU (2022) and approximately 0.5 to 3.5 t/MW according to the JRC EU (2020).

Distribution and connection electrical uses

The considerable expansion of power grids (effect of electrification of processes) will also require a large quantity of minerals and metals. Copper and aluminium are the two main materials used for wires and cabling and also in transformers. It is estimated that about 150 Mt of copper and 210 Mt of aluminium are "locked up" in power grids operating in the world today.
In 2020, an estimated 5 Mt of copper and 9 Mt of aluminium were used in power grids, more than 55 per cent of which can be attributed to distribution networks. Annual demand for aluminium for networks will grow from 9 Mt in 2020 to about 16 Mt in 2040 (in the IEA SDS scenario, which has still low electrification).
To reduce network costs, partial replacement of copper by aluminium is possible and likely, where technical and regulatory conditions permit. With wider use of aluminium in underground and submarine cables, demand for aluminium is expected to reach up to 21.8 Mt annually (IEA, *The Role of Crtical Minerals in Clean Energy Transitions 2022*).
In the most plausible scenarios, annual demand for aluminium in the electric power sector could roughly double. The additional annual demand in the electrical distribution and connection sector is roughly equivalent to or greater than the additional demand for aluminium in the production of renewable facilities.
Overall, annual consumption in the electricity sector could become comparable with that – still increasing – in the transportation and construction sectors.

Aluminum consumption in various scenarios of development of renewable energy sector



Decarbonizing production

The expected growth in aluminium consumption, driven primarily by the energy transition, will also require deep decarbonization of production processes.

Global emissions from the industry

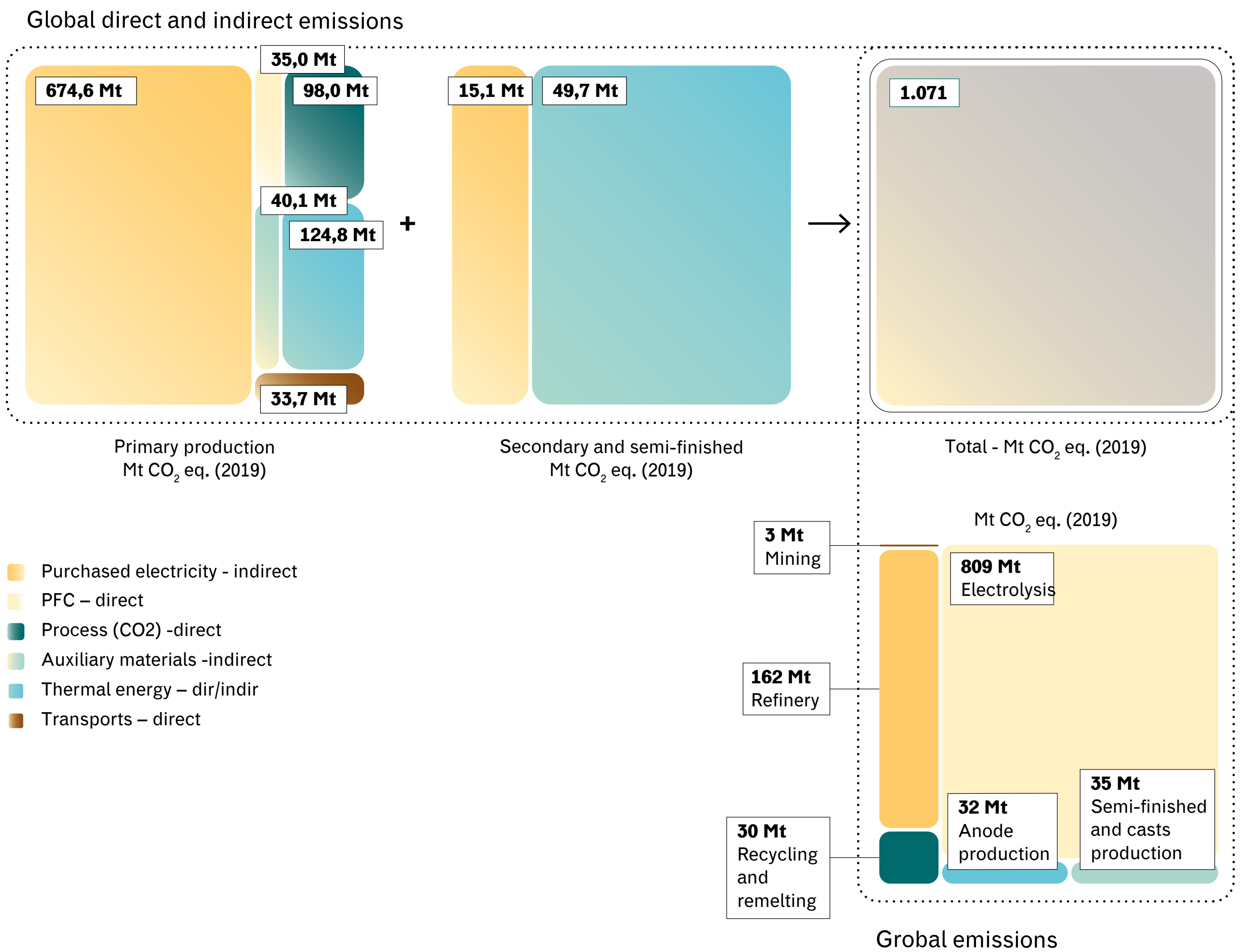
Total climate-changing emissions (CO2eq) from the sector amounted to 1071 Mt in 2019 (a similar value is also estimated by IEA for 2021), up 88 per cent since 2005. The size of emissions from aluminium production is just under three times those of Italy.

Emissions derive 64 per cent from electricity consumption, 26 per cent from industrial aluminium production, and 3 per cent from perfluorocarbon (PFC) consumption in electrolytic processes (IAI 2019 data).

Emissions for primary production are worth 94.7 per cent of total emissions (electrolysis alone is worth 75 percent of total emissions), while secondary aluminium production is worth less than 3 percent and semifinished and castings production is worth 3.3 per cent.
The origin of emissions is 64 per cent from electricity consumption. But an important share of these emissions is in the direct control of the aluminium industry, as 55 per cent of the energy consumed is self-generated rather than purchased from the grid. The share of self-generation is particularly high in Asia (> 65 per cent in China, > 95 per cent in the rest of Asia) and more moderate in North and South America (about 45 per cent). In contrast, in Europe, most electricity is purchased from the grid.
The structure of energy sources in the aluminium sector is therefore substantially different from the global average composition of energy sources, and also shows strong regional differences.
Overall, coal (56 per cent) and hydropower (30 per cent), i.e., the two traditionally cheapest sources of electricity production, are prevalent in the aluminium system.

Over the past 10 years, however, the share of renewables (particularly hydro) has declined by nearly 10 percentage points, while the share of coal has grown. This change has resulted from the growth of Chinese generation (whose electricity production still depends 80 per cent on coal). In Europe, North and South America, hydropower provides more than 75 per cent of the electricity consumed in the aluminium sector.
The sector's energy autonomy thus results in consistent regional differences in emissions associated with aluminium production.
CO_2 emissions in coal-fired primary production are 20 t CO_2eq/ t aluminium, world average emissions are 16.9 t CO_2eq/ t aluminium, and European emissions are 6.7 t CO_2eq/ t aluminium.

Sector CO_2 emission



Mt CO_2 eq. = million of tons CO_2 equivalent

But the substantial difference is between primary production and secondary production, from recycling.
Emissions per ton of aluminium produced from recycling (0.6 tCO_2eq/t aluminium) are 3.6 per cent of those of the world's average primary production. Secondary production would have a unit emission of less than 15 per cent of that of a hypothetical "carbon free" electricity-fired primary production. On a world scale, CO_2 emission intensity in the primary production sector has had a very modest reduction of 6 per cent in about 15 years (from 16.9 to 15.9 tCO_2eq/t Al), mainly due to the higher share of production coming from China and other fossil-intensive countries, particularly coal.

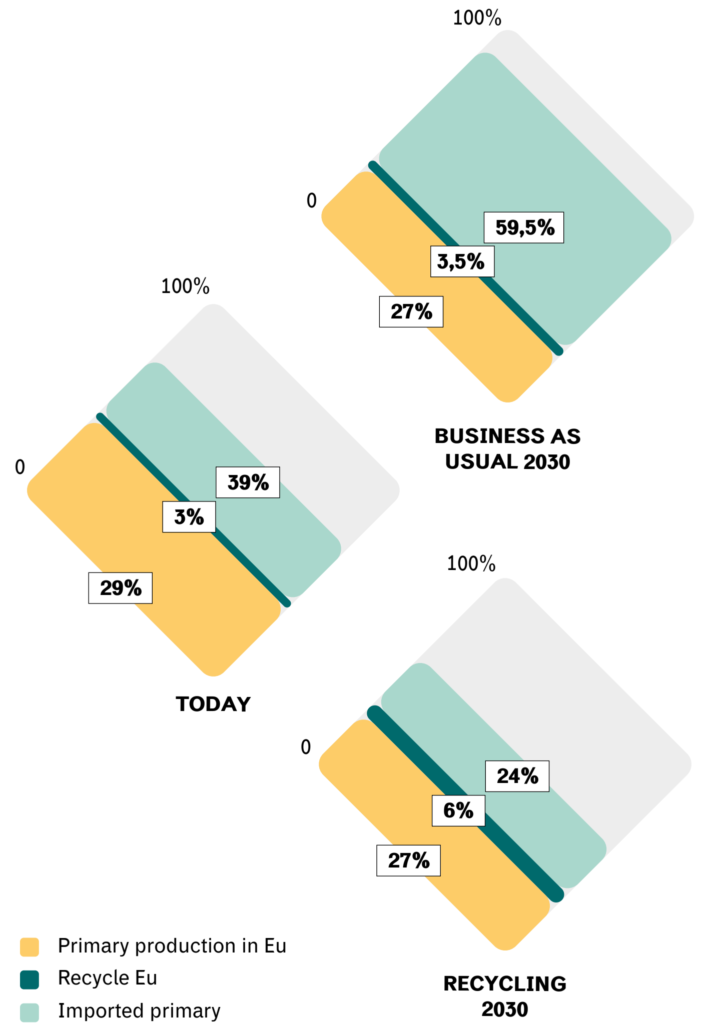
European emissions for aluminium production

In Europe, the trend differed, with more pronounced reductions in emissions in all the various sectors of both primary and secondary aluminium production.
In primary aluminium production in Europe, there has been growth in the use of renewables (from 50 per cent in 2010 to 70 per cent in 2015), and climate-changing emissions from PFCs have been further reduced (down 97 per cent compared to 1990). As a result, all environmental indicators of primary production in Europe have improved. Between 2010 and 2015 (last complete data released) CO_2eq emissions per ton produced decreased by 21 per cent from 8.5 to 6.7 t CO_2eq per ton of aluminium.
In semifinished product production and production from recycling, there has also been a generalized improvement. In production from remelting, there was a 9 per cent reduction. However, in refining (smelters), where Italy is the European leader, the improvement in performance (driven by production efficiencies and energy sources) amounted to a 14 per cent reduction in climate-altering emissions (in 2017/18 compared to 2010) per ton of aluminium produced, down to 438 kg CO_2eq.
Even in production from recycling, unit emissions (per t of aluminium) of CO_2eq from secondary production in Europe are just over 50 per cent compared to the world average.

The prospects for reducing emissions

Alignment with a Zero Emissions scenario for the aluminium sector, particularly for primary production, requires a technological leap, which cannot be achieved by progressive optimizations of existing processes alone.

CO_2eq emissions avoided by replacing the import of primary aluminum with aluminum recycling in Europe



Although energy efficiency, decarbonization of power generation and scrap-based secondary production are important for alignment with the Zero Net Emissions scenario by 2050, they alone cannot decarbonize the aluminium sector, which-for objective reasons-will also have to resort to further increases in primary production.
The IAI scenario for moving toward zero emissions calls for dramatic reductions in unit emissions from primary production (from 16.1 to 4.2 tCO_2eq/t Al) by 2035, and then to unit emissions of 0.5 tCO_2eq/t Al for primary production and 0.1 for secondary and semifinished production (for which power system energy conversion is a significant part of the reduction).

The necessary change requires that the groundwork for revolutionary technologies be laid by 2030. In recent years, however, considerable progress has been made on this front. Currently, almost all primary aluminium casting uses carbon anodes that release CO_2 as part of the electrolysis process. These anodes can be replaced by inert anodes that release oxygen as they decay. During 2021, industrial-scale production of primary aluminium with inert anodes was successfully tested at plants in Russia and Australia.
Commercialization and early implementation of this technology are critical in the coming years to come in line with the Net Zero scenario, which sees inert anodes used for just under 10 per cent of primary production by 2030.
In addition, it will be important to develop alternative methods for heat production in alumina refining, which currently relies mainly on fossil fuels, relying on biomass or green hydrogen or renewables such as concentrated solar.
Another method for reducing emissions from aluminium smelting is through carbon capture and storage (CCS) technology, although this is much more difficult to achieve for aluminium than for other industrial processes because of its lower CO_2 concentrations.
Given the high incidence of electricity consumption, the "carbon free" conversion of the power system would make a major contribution to reducing emissions from aluminium production itself as well.
Emissions can be further reduced by increasing the percentage of recycled production. On a global scale, the share of secondary production has remained fairly constant at 31-33 per cent (excluding domestic scrap production) for most of the past two decades, but has recently seen modest increases: in 2021 the share was 34 per cent.
However, primary production will still remain important in the future, as more aluminium will be needed than was produced in the past, so the availability of scrap will remain insufficient to meet demand solely from recycled production, even if collection rates are maximized.
For Italy, however, given the absence of primary production, optimizing scrap recovery and internal EU consumption of all scrap (now partly exported to non-EU countries) is of crucial importance for the development of the production system.
For Italy and Europe, even with a substantial increase in aluminium production, the elimination of exports (legal and illegal) of aluminium outside the EU and an improvement in collection capacity and internal post-consumer recycling could allow, in EA's estimates, to reduce primary aluminium imports by 37 per cent to 2030.
Again, it is worth mentioning that reducing these imports has not only an environmental and economic benefit but also a geopolitical autonomy implication. ●

@Nicolas Teodori

Urban aluminium mines in Italy

Processing scraps on one hand and waste and used products on the other constitute the large secondary aluminium mines.
These mines have high intrinsic value, both economically and environmentally.
Processing (pre-consumer) waste is recovered almost in its entirety.
For post-consumer waste, on the other hand, a reconstruction of the flows can only be done at present with some complexity, partly because of the possibility that there is a large gray area of recovery and trade, which also escapes detection for fiscal reasons.
With more reliability, the amount of post-consumer scrap generated in urban areas (packaging, consumer durables, WEEE) can be estimated. Not all of this waste-at least apparently-is actually recovered; indeed, urban secondary aluminium mines still appear to be very rich. The overall apparent loss of aluminium is about 40 per cent.
Especially among the streams that are delivered into the municipal waste circuit there is strong evidence of significant waste and material loss: aluminium packaging foil and other flexible and semi-rigid packaging, household and furniture items, components of waste electrical and electronic equipment, and aluminium in incineration slags are only partially recovered. Another seemingly critical area in terms of recovery potential (subject to the possibility of incomplete data) is the end-of-life of motor vehicles.

Post-consumer scrap in the municipal waste stream

There are four main streams of aluminium products (or at least those with a share of aluminium) potentially flowing into waste: packaging, foil (non-packaging), household consumer goods and furnishings, and WEEE (waste electrical and electronic equipment, where aluminium generally makes up a minority share of the total product).

Packaging – The amount of packaging placed on the market is estimated at 78,400 tons. The quantity of aluminium packaging is estimated annually by CIAL considering the apparent domestic consumption of packaging, adjusted for the quantities of packaging exported and imported with products (similar to what is done for other types of packaging).

Foil – Sheet and roll film, not classified as packaging, although functionally similar to flexible packaging, estimated at 14,400 tons.
Flexible classified packaging is assumed to be 40 percent of total sheet and film placed on the market (CIAL, annual report). The total amount of foil and film considered (excluding the amount of aluminium film included in composite packaging predominantly made of other materials) is thus 24,000 tons. The total apparent domestic consumption of aluminium foil up to 0.2 mm (200 microns) was approx. 150,000 tons in 2021,

including 54,000 tons of converter foil (however, the apparent domestic consumption does not consider import-export of full packaging).

Household and furniture waste – The quantity of these products, generally classifiable as consumer durables, is estimated at 41,175 tons. The value is estimated as equivalent to the average apparent consumption in 2005 - 2007 (estimated 15-year average lifespan) of Prodcom codes 25991255 and 25991257. aluminium products for sanitary and hygienic use are not included here. This waste stream is likely to be delivered not only in undifferentiated waste (or for some minor components in the separate collection of aluminium packaging as a similar stream), but also in bulky waste collected separately or delivered directly to Collection Centers.

WEEE – The theoretical amount of aluminium in WEEE calculated is about 33,000 tons.
The estimate here is based on the aluminium content recovered from WEEE treated by the Erion Consortium for groupings R1-R4 (representing 69.2 per cent of total household WEEE) and Ecolamp for grouping R5. The content of aluminium recovered in each grouping was multiplied by the previous three-year average of put on the market (this is how current regulations estimate "end-of-life" production). Note that the theoretical aluminium present in WEEE tends to be underestimated because it corresponds only to the actual stream recovered, but the amount placed on the market at end-of-life may be overestimated.

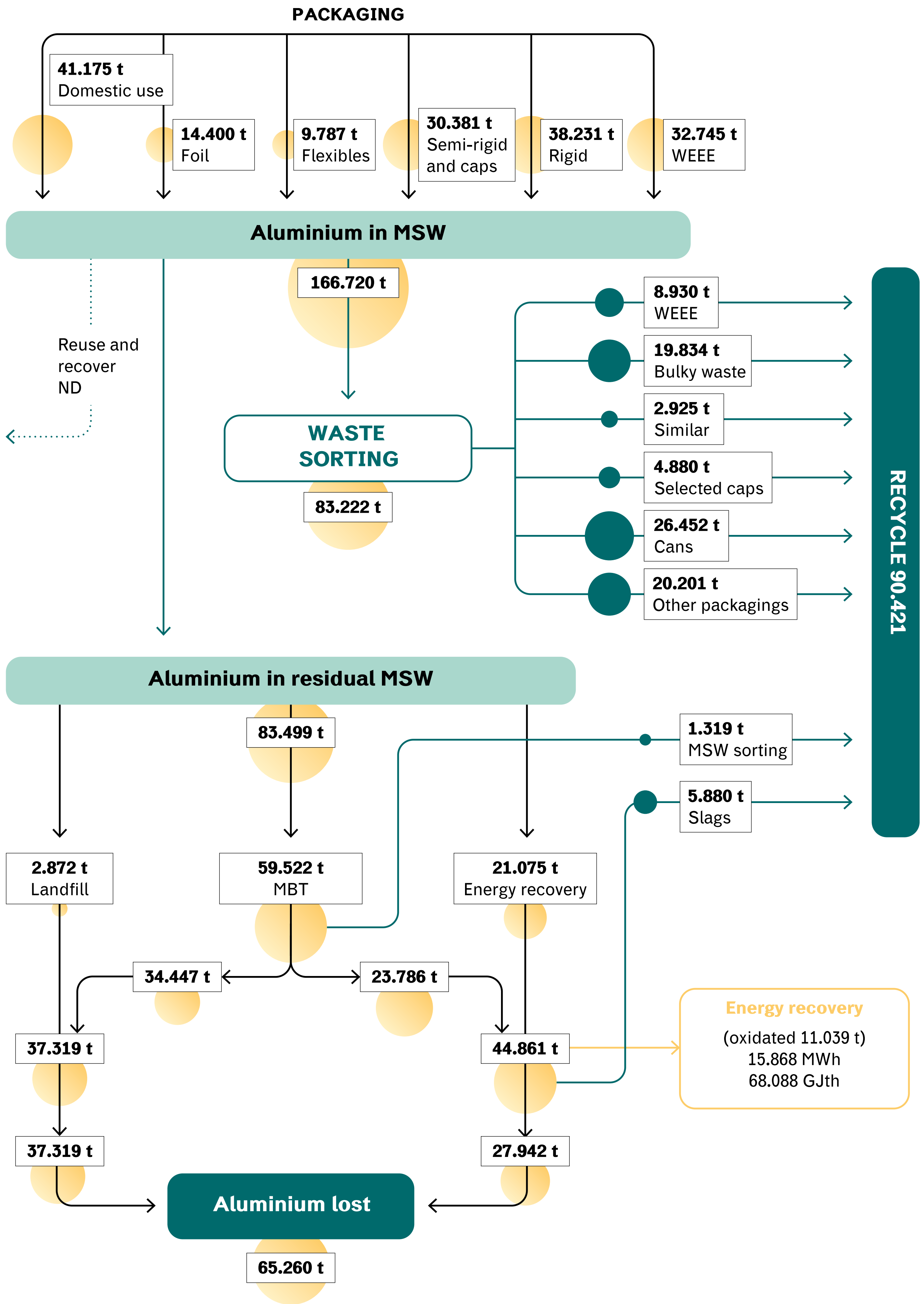
The total amount of aluminium generated as potential waste in municipal waste is thus 166,720 tons.

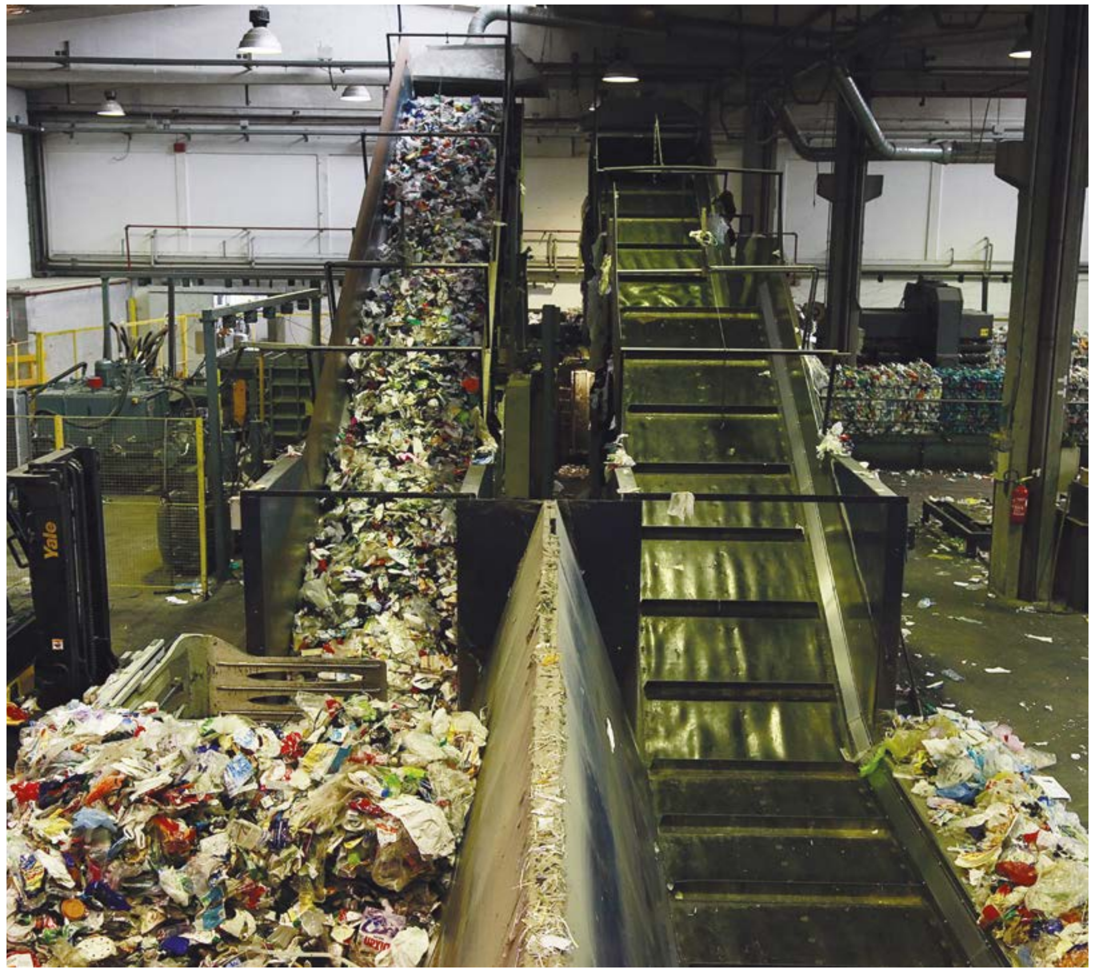
The recovery of post-consumer aluminium from municipal waste

Recovery of aluminium products for recycling (or partly for energy recovery), through separate collection and thus before treatments on Residual Urban Waste, is estimated on the basis of recovery data of packaging, WEEE, and bulky waste in separate collection or at Collection Centers.

Packaging – Total recycled packaging collected before the formation of Residual Urban Waste amounted to 46,653 tonnes/y in 2021 while recycled packaging (caps and closures) from RD sorting (primarily glass) amounted to 4,880 tonnes/y. Residual packaging contained in RUR amounted to 26,687 t/y, from which, 1367 t/y were recovered for recycling consisting of recoveries in TMBs and incineration slag. Total packaging recycling corresponds to 67.5 per cent of the released for consumption.
Based on commodity analysis, CIAL certified the recycling of 26,452 t/y of cans, accounting for 90.4% of the released for consumption of cans. Cans account for 56.7% of packaging RD and 50% of total packaging recycling. The least collected type of packaging-and with the lowest recycling rate-is flexible packaging.
These values correspond to the amount of packaging sent for recycling as determined by Cial, which includes not only urban separate collection, but also separate collection and mechanical sorting of caps and post-Rd deliveries from TMB and slag. The separate collection values do not include extraneous materials and similar fractions (non-packaging proper). Similar fractions, according to the commodity analyses

The aluminium cycle in municipal waste: recoveries and dispersion





carried out on separate packaging collection, amount to 5.9 per cent of the total collected in 2021 and correspond to 2,925 t/y.

Similar fractions – Similar fractions are aluminium products that are not considered as packaging (they can be either household items, from coffee pots to cookware, or aluminium film that cannot be classified as packaging), but collected together in urban collection. Based on the commodity analysis they are estimated to be 2925 t/y.

Bulky waste – The estimate of 19,834 tons of aluminium products recovered through the bulky waste and collection center circuit (assumed to consist of "aluminium products for household use and hygiene") adds up the share of direct recovery of bulky waste and recovery of non-ferrous fractions in collection centers.
Out of a total stream of 900,700 t (2020) of mixed bulky items for recovery (Ispra 2022), an amount of aluminium was estimated to be 1 percent of the total, equivalent to about 9,000 t/y. To this quantity was added that relating to deliveries to collection centers of "non-ferrous metals," estimated by extrapolating the figure recorded in the Lombardy region and assigning aluminium a share of 75 per cent of the total, to obtain a total estimate of 10,827 t.

WEEE – The amount of aluminium recovered from WEEE is estimated at 8930 tons. The figure, not available from CDC WEEE, was estimated for groupings R1 - R4 on the basis of the recycling rate (3.1 per cent, 1.7 per cent, 1 per cent, 3.6 per cent of the WEEE stream, respectively) detected by ERION (the most relevant collective consortium of the groupings); for grouping R5 the recycling rate detected by Ecolamp (equal to 5 per cent).

Total recovered for recycling before the formation of residual municipal waste

In total, we estimate 83,222 tons of aluminium recovered for recycling (net of foreign fractions) before the formation of residual municipal waste

and then additional recoveries in treatment plants. Hence, the amount of residual aluminium in municipal waste is 83,499 tons.

Recovery from residual waste management

The residual stream of aluminium waste is almost entirely transferred to Mechanical or Mechanical-Biological Treatment plants and, for the part not recovered or degraded, sent to incineration and co-firing or to landfill.
Specifically, in accordance with the breakdown determined by Ispra on urban residual waste, it is estimated that waste sent to TMB is 71.3 per cent, waste sent directly to incineration is 25.2 per cent, and waste sent directly to landfill is 3.4 per cent. Of the waste sent to TMB-an intermediate treatment-unvalued or non-degraded residues (for aluminium, these are equal to input minus recycling recoveries) 40.8 per cent is sent to incineration and 59.2 per cent is sent to landfill. aluminium sent to TMB in 2021 is estimated to be 59,522 tons. From this stream, there is some recovery and then subsequent sending partly to incineration or CSS treatment and to landfill. CIAL's estimated figures for aluminium from TMBs are 1319 t/y in 2021 (993 t/y in 2020). These are exceptionally low values considering the amount of aluminium theoretically present in municipal residual waste. Of the total TMB, aluminium interception is 2 per cent of the expected aluminium in the waste.
In total, aluminium waste sent to incineration, either directly or after treatment, amounts to 44,861 tons*.

*Ipla estimates for Conai 37 thousand tons of aluminium packaging and non-packaging (including 28,316 t of packaging and 9,021 t of non-packaging) with a different ratio of packaging to non-packaging than reported here. The total numbers are roughly consistent.

From the incineration-initiated stream, there are two forms of recovery: aluminium slag nodules; energy generated from the oxidizable fraction of aluminium.
Regarding recovery from slag, the estimated amount is 5880 tons (the potential recovery could be about 28,000 t; however, the recovery for recycling assumed by CIAL, as packaging, is only 48 t in 2021, but this is primarily due to the failure to quantify material recoveries from slag and ash). The fraction of oxidizable aluminium subject to energy production and recovery is estimated at 11,039 tons.

Loss of aluminium

Aluminium loss is quantified as the amount of aluminium potentially present in municipal waste and not recycled or recovered (oxidized) as energy. Out of a total of 166,720 tons of municipal aluminium waste, loss is 39 per cent (65,000 t), while recycling is 54 per cent (90,000 t) and energy use is 7 per cent (11,000 t). ●

An alternative calculation of the presence of aluminium in municipal residual waste

Commodity analyses of waste generally do not have high reliability, as they are often carried out on a limited sample whose representativeness is not known.
Moreover, in the structure of the commodity analyses, the aluminium item is rarely highlighted.
However, there are some recent and significant commodity analyses from which it is possible to infer-at least as an "order of magnitude" – the specific presence of aluminium in residual municipal waste, i.e., net of separate collections.
Commodity analyses are routinely conducted on the so-called dry or undifferentiated fraction of municipal waste, within which bulky waste is not included (where important shares of household aluminium and also WEEE should be found).
Based on these data, it can be estimated that the presence of aluminium in residual urban waste varies between 0.3 per cent (Bolzano, 2020) and 0.75 per cent (Veritas, Venice, 2017). These data also show that in urban residual waste, the ratio of aluminium to total metals ranges from 16.5 per cent (Bolzano) to 50 per cent (Veritas). Other, higher estimates come from areas with lower separate collection rates. Overall, the window for this estimate is very wide – from 30,000 to 197,000 t – but intermediate values, such as Veritas (Veneto)'s value of 0.75 per cent of urban residual waste, are 79,0000 t and therefore fully consistent with our "top down" estimate of about 83,000 t of aluminium in residual waste.
A further and different approach can be based on the IPLA assessment ("Assessment on the amount of packaging sent to energy recovery in the year 2021") of the amount of aluminium in waste fed to waste-to-energy and alternative fuel plants.
Relating the IPLA estimate to the total of 10.6 million tons of residual municipal waste (part of which goes to landfill after TMBs), this would give an estimate of 88,263 t of aluminium in residual municipal waste, which is slightly higher than the estimate (83,000 t) obtained by Top-Down method.

@Nicolas Teodori

Separate collection and recycling: methods and technologies

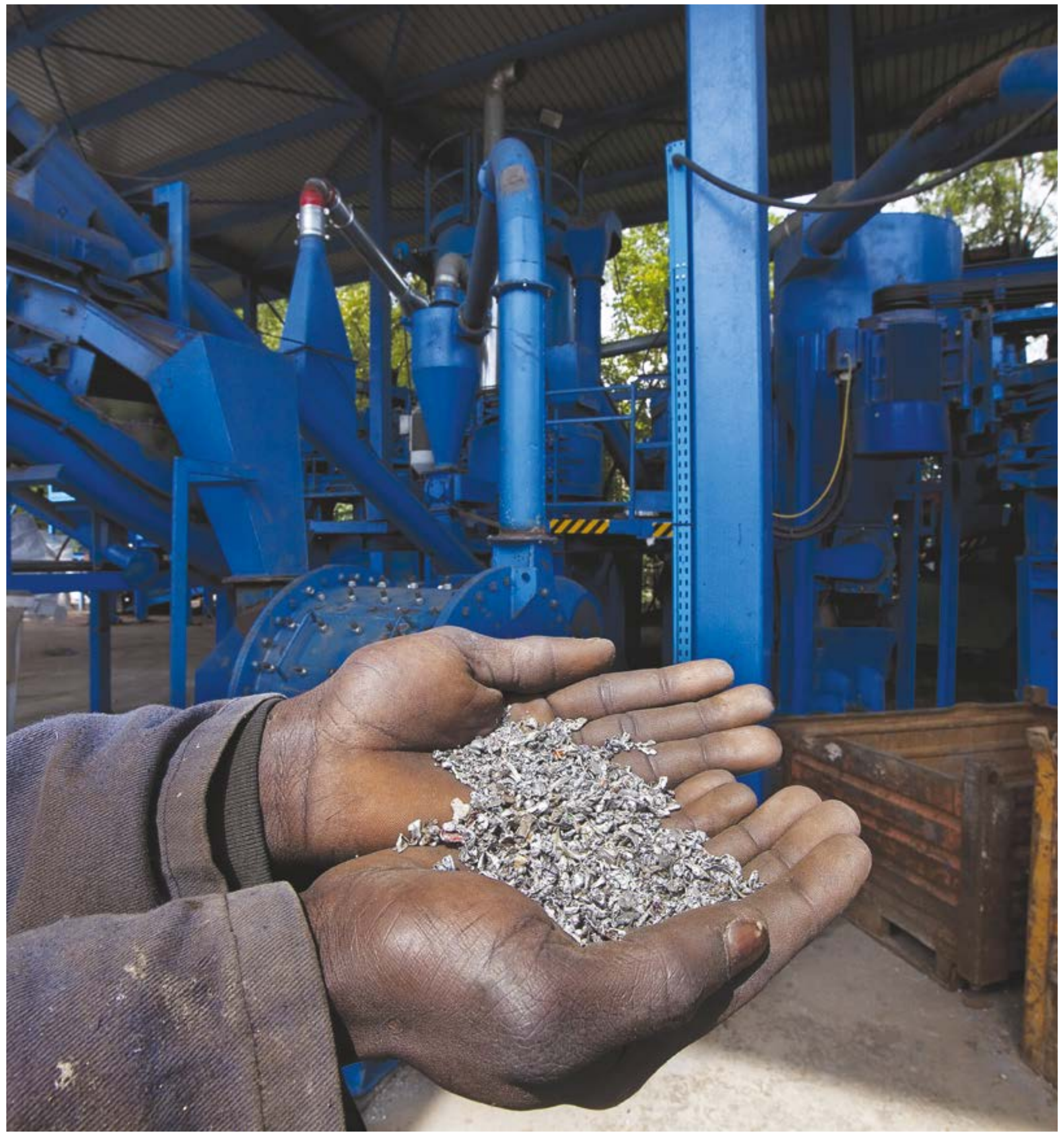
The separate collection of aluminium is, in most municipalities, understood as the collection of "aluminium packaging," and in particular the collection of cans, although CIAL also accepts so-called "similar fractions," i.e., other household items made of aluminium other than packaging (containers, coffee pots, cookware, foil, etc.).
Separate collection of aluminium is carried out in four ways:
light multimaterial (aluminium, steel and plastic packaging), which is now the most common mode;
heavy multimaterial (aluminium, steel, glass and plastic packaging), which is still present in some areas of the country, but is shrinking;
glass and metals (aluminium, steel and glass packaging), which is mostly widespread in street mode;
mono-metals (aluminium and steel), less widespread and present only in some areas of the country.

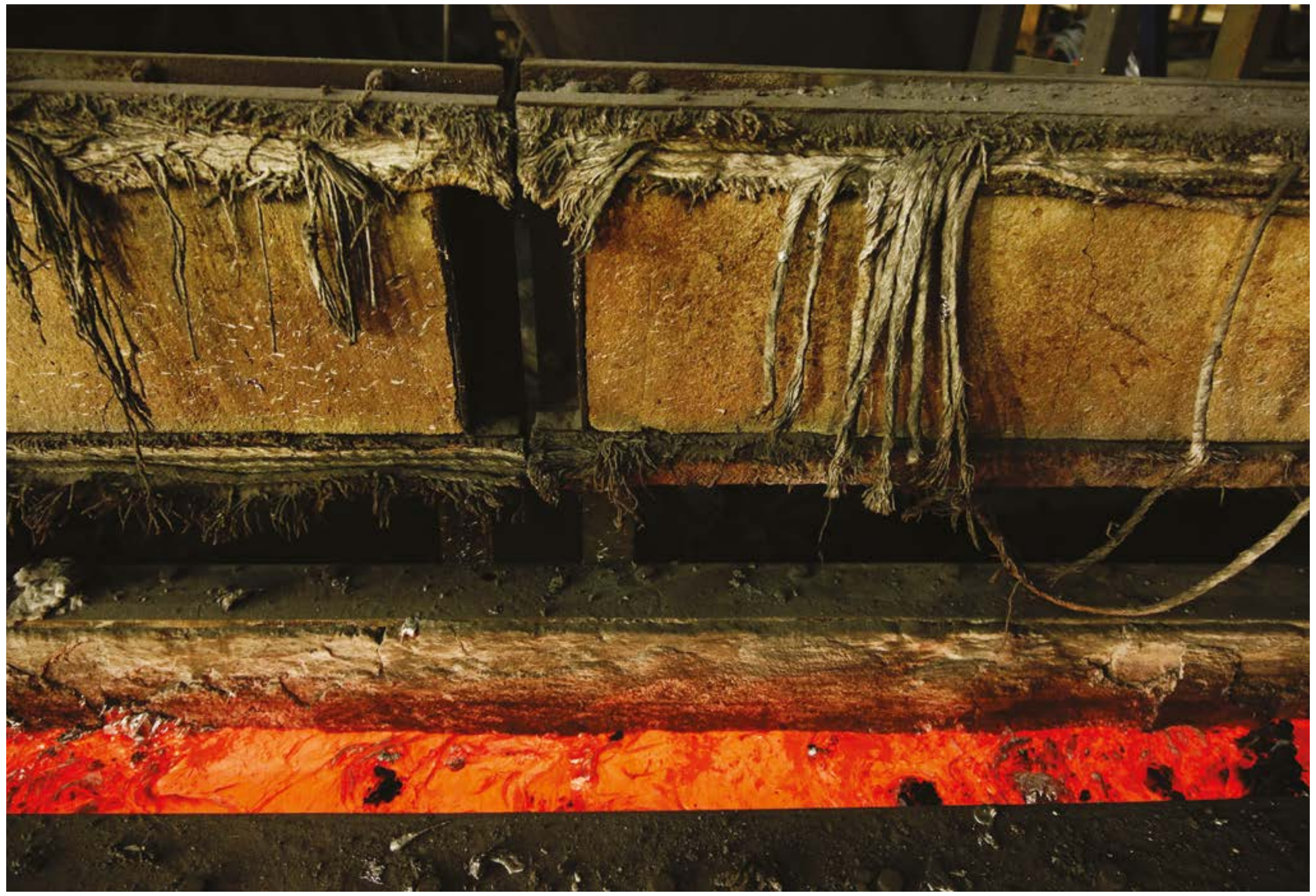
Since aluminium collection is always joint with other materials, quantification of the aluminium collected occurs downstream of sorting operations.
The separate collection of packaging (net of foreign fractions, similar fractions, and recoveries from residual waste management) consists largely of rigid packaging (cans, cans, and canned goods), and the remainder of semi-rigid packaging such as tubs, tubes, caps, and capsules, and flexible foil packaging.
Data from commodity analyses show that the recovery rate relative to consumption is very high for cans (>90 per cent), while it is lower for other fractions, particularly flexible packaging.
Thus, in the packaging sector there is a high dispersion of flexible packaging, which is not valorized either because it is not collected separately or because it is not adequately separated by ECS facilities on the sorting lines of multi-material collections and mechanical-biological treatments.
Overall, considering also recovery from slag and energy conversion of part of the aluminium, the loss of matter contained in packaging is about 25,000 tons, or about 32 per cent.

Mechanical recovery from municipal waste

The recovery of aluminium – and other non-ferrous metals – takes place through ECS separators based on the principle of induced (or passive or Foucault currents) generated by a rotating magnetic field.
ECS separators are widely present in multi-material sorting plants, between plastics and metals or between glass and metals.; while they are rarely present in TMB (mechanical-biological treatment) plants, from which, too, just under 10 million tons of municipal waste transit, and in bulky waste recovery plants.
In 2020, out of 132 operating mechanical and mechanical-biological treatment plants, based on data provided by the plants themselves, there was a presence of non-ferrous metal recovery in only 25 of them, which treated a total of 2.6 million tons of waste (27.3 per cent of the national total in TMBs). In these 25 plants, the total recovery of non-ferrous metals was 1451 tons and the total recovery of ferrous metals was 32,760 tons.
CIAL estimates that about 65 percent of the Non-Ferrous is aluminium. Therefore, the share of aluminium recovered from TMBs corresponded to 993 tons in 2020 . This value is 0.04 per cent of the waste treated in the 25 TMBs.
The values recorded show a very strong variability both in the ratio of Non-ferrous to Total treated waste and of Non-ferrous to Ferrous. The share of Non-Ferrous recovered ranges from 0.01 per cent of the waste to 0.21 per cent of the treated waste, the median being 0.06 per cent .
For ferrous metals, the variability is less pronounced, although it goes from 0.1 per cent to 4 per cent, with an average value of 1.3 per cent, which, although lower than the expected amount of metals, is still at least in the lower end of the expected recovery window.
The inefficiency of the metal recovery system and, in particular, of non-ferrous metals in mechanical-biological treatment plants is responsible for the dissipation of a significant amount of aluminium.
The inefficiency is also evidenced by the fact that in 2010, with only 13 TMB plants with ESC sorting, recoveries still amounted to 869 tons of nonferrous metals. Despite the evidence of aluminium waste and despite the good valorization of aluminium, TMB plants have remained plants without a recovery and recycling section.
Based on the estimates of this study, about 60,000 tons of aluminium is expected in the residual municipal waste sent to TMB, an amount far exceeding that of cans alone. Of these, about 2 per cent are found to be recovered either due to the absence of devices or inefficient use of devices.

*CIAL estimate on the conferred from CIAL and independent collection.

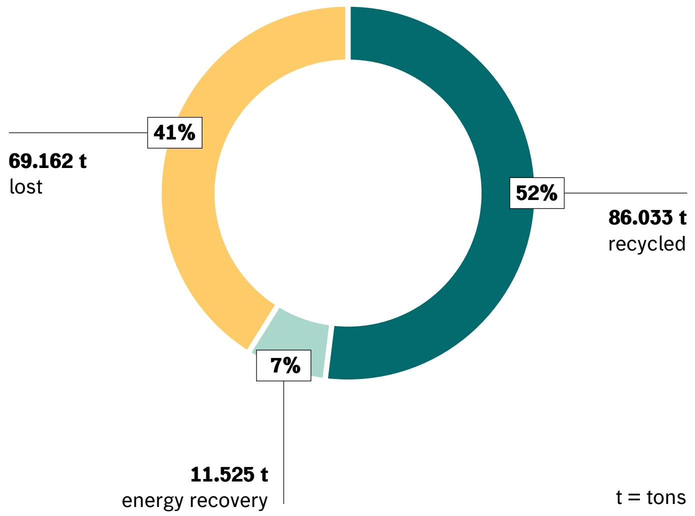




Recovery from municipal waste slag

During incineration processes, only a fraction of the aluminium is oxidized and releases energy. The remaining portion of unoxidised aluminium metal, theoretically available for recycling, is found in bottom ash (slag), fly ash, and reaction salts and deposits.
The highest content of metallic aluminium appears to be found in the non-fine fractions (greater than 0.5 mm) of bottom ash.
The percentage of theoretically recoverable aluminium varies according to the type of material: from over 80 per cent for cans to 51 per cent for semi-rigid to 27 per cent for foil (Biganzoli, Grosso et al, 2012, 2014). For products other than packaging, the yields characteristic of cans are considered applicable.
On the total incinerated waste, based on waste composition and separation rates, a potential recovery of up to about 27,000 t/y can be estimated, compared to the 1,053,000 t of bottom ash and non-hazardous slag generated in 2020 (Ispra), which is about 2.5 per cent of the generated slag (a value in line with European-level estimates of 2.3 per cent).
Regarding recovery from slag, the most recent analysis available (Ispra 2022, on 2020 data) reports only one amount of direct recovery of ferrous metals from slag (amounting to 25,049 t). However, aluminium recovery is usually carried out in third-party plants that specialize in slag and ash management. In 2019, 874,000 t of non-hazardous slag and bottom ash were sent for recovery treatment (at third parties). Since no specific data is available on the fractions recovered from these treatments, we assume an aluminium recovery rate of 0.7 per cent (similar to that used in 2013 based on data from some plants), equivalent to 5880 t.
The theoretical recoverability can only match the actual recoverability if properly designed ECS systems are in place to intercept the different particle sizes. At present, the recoverability recorded by some plants appears significantly lower than the theoretical one.
In fact, the estimated recovery potential is considerably higher than what is apparently recovered today (operating on only a portion of the slag and with inadequate technologies).
For comparison, it can be recalled that in 2019, 16,800 t were recovered from incineration slag in Germany and 31,997 t in France and, in 2018, 25,057 t in the United Kingdom.

Aluminium MSW Management (t and %, 2021)



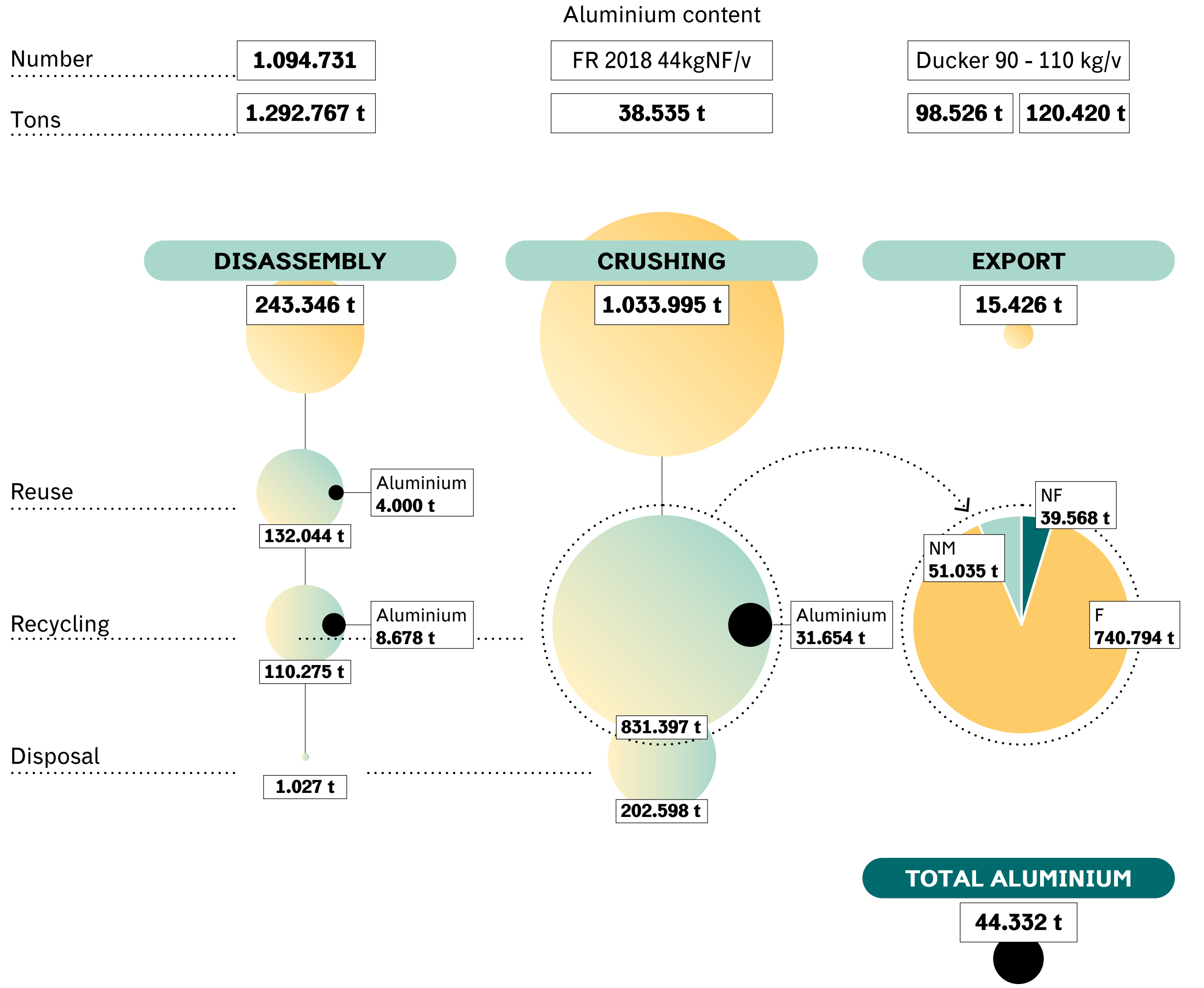
Energy recovery

Heat treatment of aluminium oxidizes part of the aluminium, particularly the thinner component (film and thin foil). In the oxidation process, aluminium releases energy, conventionally calculated to be equivalent to 31 MJ/kg, which is available for thermal recovery or electrical conversion. The rate of oxidizable aluminium is differentiated according to the products and their thickness.
Experimental estimates identify an oxidation rate for packaging materials ranging from 59 percent for foil to 9 percent for cans. For other aluminium items, the values for cans can be conservatively assumed.
Of the total aluminium waste sent for energy recovery (direct or as CSS), the energy content is about 342,000 thermal GJ. Oxidizable waste is 11,039 t out of an input of about 45,000 tons. Actual energy recovery, with current yields, is estimated at 15.9 electric GWh and 68,000 thermal GJ. ●

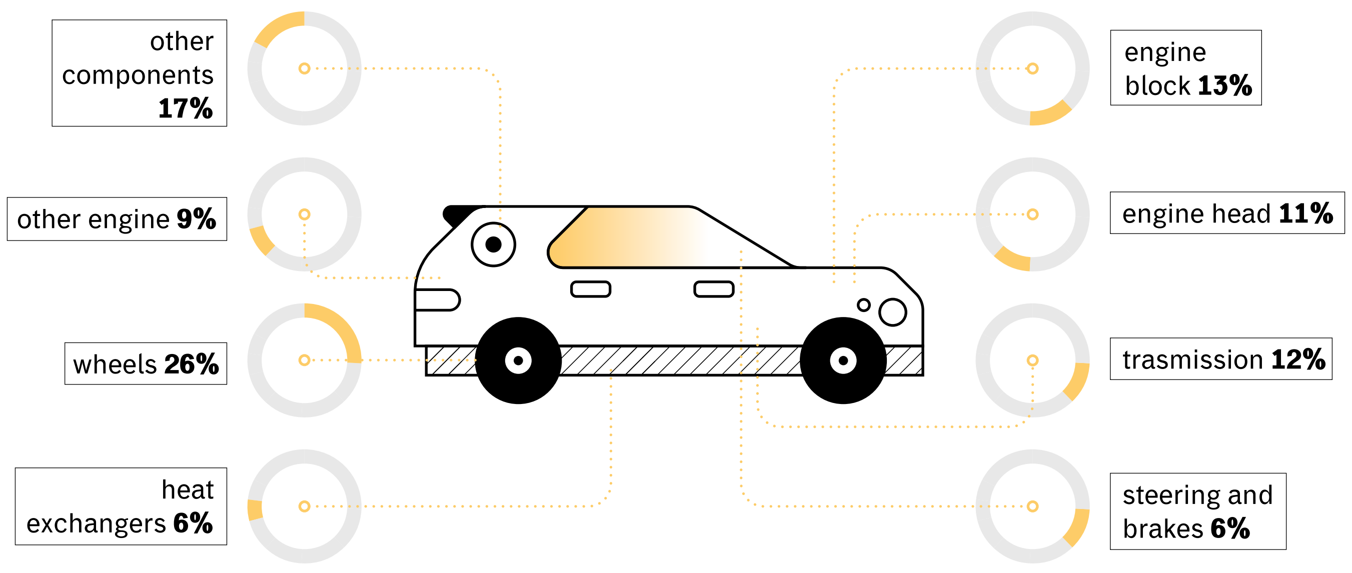
Recovering aluminium from car dismantling: a source only partially exploited?

Motor vehicles constitute a major source of aluminium scrap. The aluminium content in motor vehicles has gradually increased over the years.
In 2020, the average age of cancelled (scrapped) vehicles in Italy was 16.4 years. The reference fleet can therefore be considered to be that between the late 1990s and the early 2000s.
We should consequently estimate an average aluminium content ranging between 90 - 110 kg/vehicle. Based on the cars scrapped, this should translate to about 100 to 120,000 tons of aluminium.
The aluminium actually recovered is far less than expected.
This is a common figure for all European countries. A study recently conducted for European Aluminium (IRT M2P, 2021) confirms the large deviation between expected and actual aluminium recovery, in the order of about 60 per cent. This is due to a multiplicity of factors. Firstly, from the fact that the “decommissioned” car fleet in Europe does not have the same composition as the “scrapped” car fleet in Europe, because within the fleet sent for scrapping (in Italy as in other European countries) the share of cars in the higher segments (C, D), which have a higher aluminium content, are less represented than in the theoretical fleet, being the most subject to export at the end of life to countries outside Europe, for repair or direct reuse.

Vehicles at end of life (2019)



Distribution of aluminium by type of component in cars in segments A-B (2012)



Moreover, the amount of aluminium apparently recovered in Italy is similar to that found in France, where the available analytical reports (*Rapport annuel de l’Observatoire des véhicules hors d’usage*) quantify the presence of non-ferrous metals at about 44 kg/vehicle (predominantly, about 80 percent, consisting of aluminium, excluding electrical beams).
Italian auto dismantling plants processed 1,217,515 t/y of vehicles in 2020 (it was 1,292,794 t in 2019).
In 2019, the last year for which we have data on auto-demolition results, 1,616,039 vehicles were deregistered and 1,094,731 vehicles were sent for scrapping. The remainder, more than 500,000 vehicles, about one-third of the total written off, were exported.
The amount sent to end-of-life management operations in Italy is 1,292,767, equivalent to an average weight per vehicle of 1180 kg. Of the total flow to scrap there were 15,446 tons of vehicles directly exported, 243,346 tons of vehicles subjected to dismantling and de-pollution operations, and 1,033,995 residual tons sent to shredding.
Dismantling operations, preliminary to shredding, involve not only the removal of polluting elements (fuels, oils, etc.) but also the recovery of components for reuse or recycling.
In Italy, in 2019, 132,000 tons went to reuse and 110,000 tons to recycling.
Italy – unlike other countries – does not report data on the material composition of these streams.
More analytical data are provided by France and were used for an appropriate estimate for Italy.
Applied to Italy – again considering aluminium to be 80 percent of total non-ferrous – these coefficients allow an estimate of dismantling equal to about 13,000 t of aluminium.
At the shredding stage, on the other hand, data are also available in detail for Italy. Out of more than one million tons, with a predominant share obviously consisting of ferrous metals (740,000 t), non-ferrous metals here are quantified at about 40,000 t, corresponding to an aluminium content of about 32,000 t.
A total recovery of 44,332 t of aluminium is estimated, which roughly corresponds to 40 kg of aluminium per vehicle.
Assuming that the aluminium content in vehicles is higher – somewhere between 90 and 110 kg/vehicle, as can be conservatively estimated based on Ducker data – there would be a very significant gap between what is expected and what is actually recycled.
Finally, it is important to remember that the current end-of-life vehicle (ELV) recycling process-post shredding and sorting-results in the production of aluminium scrap containing a mix of alloys (from casting and plastic processing) and sometimes small amounts of other unwanted materials. Today, this scrap grade meets the requirements of European refineries for recycling into foundry castings, which can be remelted to produce parts for the automotive industry.
However, with an increasing share of extruded and rolled alloys in automobiles, if recycling practices remained unchanged there would be no possibility of recovery of these higher value alloys, which could instead be recycled to produce similar alloys with a large reduction in primary aluminium requirements.


Take.
IMBALLAGGI IN ALLUMINIO
NATURALMENTE
GREEN.
13
AL
100%
RESPONSABILE
CON GLI IMBALLAGGI IN ALLUMINIO, I PROTAGONISTI DELL'ECONOMIA CIRCOLARE SIAMO TUTTI NOI, CHE LI USIAMO, LI RACCOGLIAMO, LI RICICLIAMO.
Grazie alle qualità uniche e al valore intrinseco del materiale, gli imballaggi in alluminio sono una scelta quotidiana responsabile, che partecipa allo sviluppo di un'economia giusta e sostenibile. Insieme al contributo di tutti noi nella raccolta differenziata, delle imprese, dei Comuni e degli operatori del recupero e del riciclo che investono in ricerca, lavoro e servizi, gli imballaggi in alluminio generano ricchezza per le persone e per il pianeta. Una responsabilità circolare, che parte dalle nostre scelte e ritorna nelle nostre vite. Per una raccolta responsabile al 100%, segui le indicazioni del tuo Comune.
cial.it
CiAl
RESPONSABILITÀ CIRCOLARE