THE GLOBAL AND EUROPEAN DIMENSION OF ALUMINIUM RECYCLING

Marlen Bertram

International Aluminium Institute,
European Aluminium Association,
Organisation of European Aluminium Refiners and Remelters

Global demand for aluminium continues to expand, due to the increasing diversity of aluminium's applications and the important contribution of its products to modern life. In 1990 total aluminium production was around 28 million tonnes (with over 8 million tonnes recycled from scrap) and today the total is close to 45 million tonnes (with over 15 million tonnes recycled from scrap). By 2020 metal demand is projected to have increased to around 70 million tonnes (with around 30 million tonnes recycled from scrap). In the last two cases, around 50% of the scrap is old scrap (i.e. scrap from end-of life products). The challenge for the industry is to satisfy this ever-increasing demand for aluminium and also to boost the benefits it delivers to people everywhere, while at the same time reducing any negative environmental impacts. Recycling is a key element of reducing the negative environmental impact and continues to be at the core of the global industry's path to sustainable development.

The recycling voluntary objective is as follows:

> *The International Aluminium Institute has developed its Material Mass Flow Model to identify future recycling flows. The Model projects that global recycled metal supply (back to the industry) from old scrap will double by 2020 from today's (2004) level of 6.8 million tonnes. The global aluminium industry will report regularly on its recycling performance.*

More than half of all the aluminium currently produced in the EU-25 originates from recycled raw materials and that trend is on the increase. In view of growing end-use demand and a lack of sufficient domestic primary aluminium production in this part of the world, Europe has a huge stake in maximising the collection of all available aluminium, and developing the most resource-efficient scrap treatments and melting processes. The importance of efficient aluminium recycling will even further increase in the future because of rising energy constraints in this region. Due to this fact a regional model was developed and national scrap generation data generated.

THE ALUMINIUM RECYCLING INDUSTRY

A developed aluminium recycling industry treats and transforms aluminium scrap into standardised aluminium. It includes (see Figure 1) the collectors of scrap and end-of-life products, the dismantlers of parts for reuse and recycling and the metal merchants, who are accumulating and redistributing scrap and are responsible for most of the foreign trade in aluminium scrap. In the middle are the scrap processors and recyclers of by-products and residues. The final links in the recycling chain are the refiners and remelters who ensure that an alloy is produced that can be reabsorbed into the aluminium cycle.

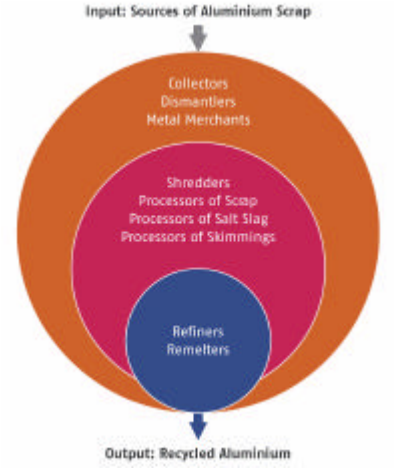


Figure 1 Structure of a well developed aluminium recycling industry

With some exceptions refiners produce deoxidation aluminium and casting alloys and remelters wrought alloys. As shown in Figure 2, there is a well-established market for recycled aluminium with firmly defined distribution chains. Hence, the refiners supply the foundries with casting alloys and the remelters supply the rolling mills and extruders with wrought alloys, where the processing of alloy-specific pieces can ensue. Typical products made from recycled aluminium include castings like cylinder heads, engine blocks, gearboxes and many other automotive and engineering components on the one hand, and extrusion billets or rolling ingots for the production of profiles, sheets, strips and foil on the other. Another prominent user of recycled aluminium is the steel industry which utilises aluminium for deoxidation purposes.

From a technical point of view, there is no problem to produce a new aluminium product from the same used product. There is no quality difference between products entirely made of primary metal and products made of recycled metal. However, many of the alloying elements do, however, limit the usability of recycled aluminium in the production of fabricated goods, like extrusion billets or rolling ingots. Therefore, aluminium scrap with an alloy composition corresponding to that of wrought alloys is separated whenever possible.

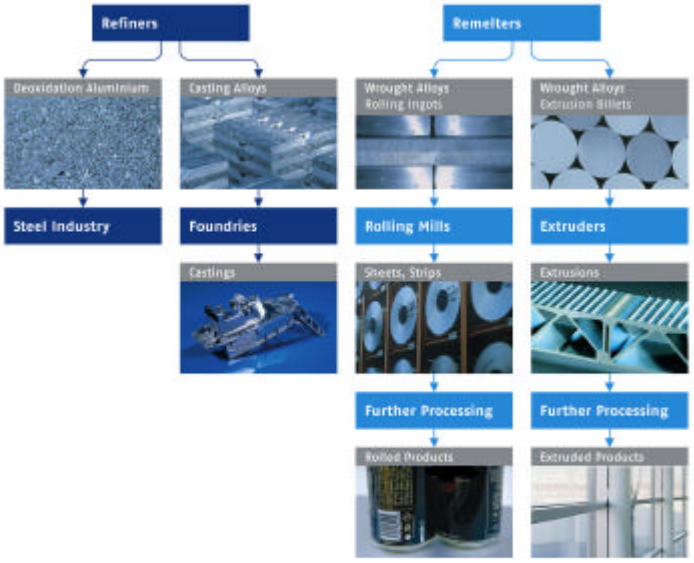


Figure 2 Customers of the aluminium recycling industry

GLOBAL RECYCLED ALUMINIUM PRODUCTION

In 2004, the global aluminium recycling industry numbered about 1200 recycling plants (sum of refiners and remelters) as compared to around 200 primary aluminium smelters, see Figure 3. Only industrial recycling plants are counted and not back yard smelters but of course the size of these plants varies greatly. Most plants are located in Europe, North America and Asia.

The total global recycled production is shown in Graphs 4 and 5. The aluminium recycling industry has effectively tripled its output from 5 million tonnes in 1980 to over 15 million tonnes in 2004 from old and traded new scrap (Figure 4). During the same time primary metal use has grown from 15 to 30 million tonnes.

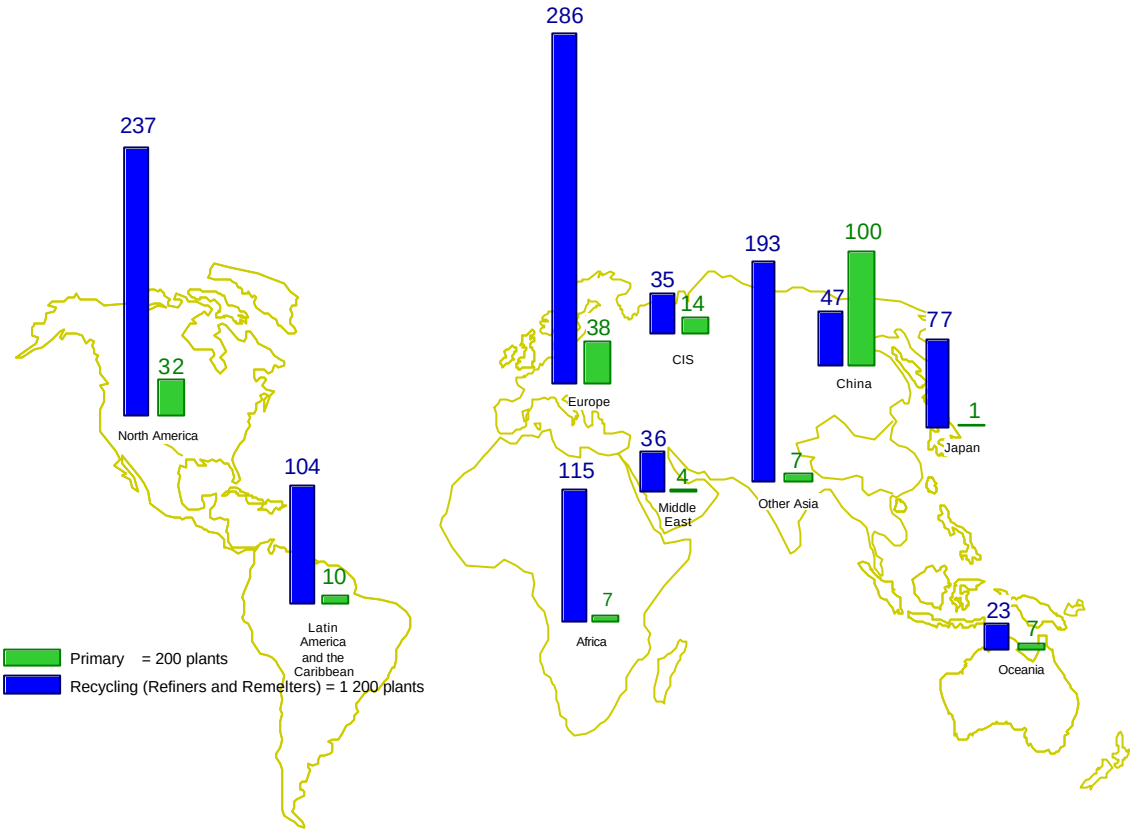


Figure 3 Global primary smelters and recycling plants

Aluminium recycling is of special importance for developed countries with limited energy resources. In the EU-15 and North America, scrap has been generated in sufficient quantities over the past 70 years to develop an economically strong and technically outstanding aluminium recycling industry. Following the oil shocks and energy cost increases of the 1970s, Japan ceased domestic primary aluminium production and switched to aluminium recycling in the 1980s. In addition to these traditional recycling centres, increasing recycling activities are evident in China, India and Russia. As shown in the regional

Overview (Figure 5a), Latin America, the Middle East, Oceania and Africa have a lower recycled aluminium production. Not because they do not recycle but mainly due to lower domestic scrap availability. In addition, much of the aluminium scrap in some of these countries (for example, Australia) is exported to other regions where a major recycling sector exists. As shown in Figure 5b only 8 countries are responsible for most of the aluminium recycling production globally.

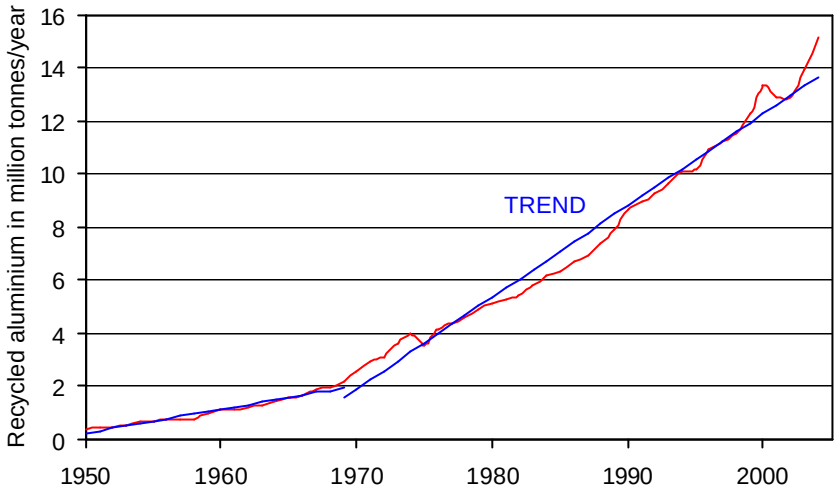


Figure 4 Worldwide evolution of recycled aluminium

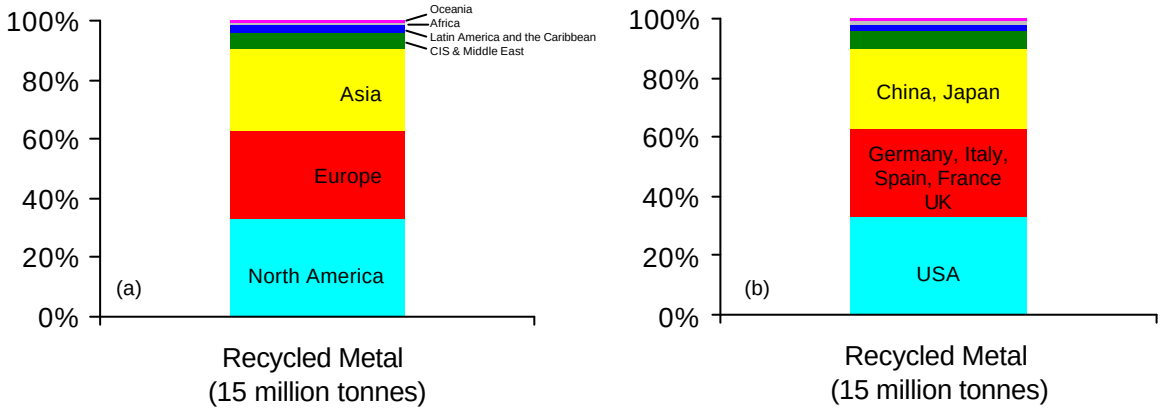


Figure 5 Regional (a) and national (b) importance of aluminium recycling

SCRAP FLOWS IN EUROPE

The availability of scrap in a certain region depends heavily on the amount of aluminium being produced, fabricated, manufactured and used.

To obtain a finished aluminium product from raw materials, the aluminium undergoes a variety of processes from bauxite mining, alumina refining and aluminium smelting to fabrication and manufacture. Some of these processes generate aluminium by-products: skimmings during melting and casting; edge trimmings and billet ends during rolling and extruding; turnings, millings and borings during various machining processes; off-cuts during stamping and punching processes, as well as defective goods at all production stages. This material is termed “new scrap” because it is generated during the initial

processing and production stages, not having yet reached the use phase. A large quantity of new scrap in Europe is generated and recycled in the same company or company group. It is then referred to as internal scrap and is not covered in statistics.

Once aluminium is turned into a final product, it is purchased by the consumer and used for a certain lifetime. The lifetime of aluminium products ranges from a few weeks for packaging items like cans, to decades for permanent fixtures like window frames and building façades. However, lifetime averages can be distorted by products going into "hibernation", that is to say, they are not discarded but rather stored in households. Furthermore, a proportion of products that have reached the end of their intended life may be reused as replacement parts, a common practice with vehicles. Sooner or later, aluminium products are discarded and find their way into the recycling loop. After collection, this material is termed "old scrap" because it has been used.

New scrap is collected in its entirety, as collection is in the hands of the aluminium industry. The collection of aluminium at end-of-life depends, however, on consumer initiative to collect aluminium for recycling, as well as the co-operation of industry, legislators and local communities to set up efficient collection systems.

The availability of internal, tolled and purchased scrap (new and old) on a country level in Europe is shown in figure 6.

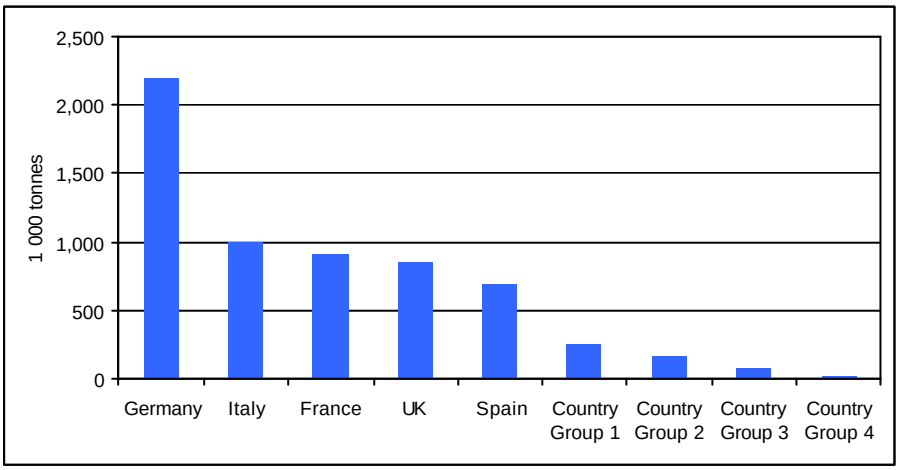


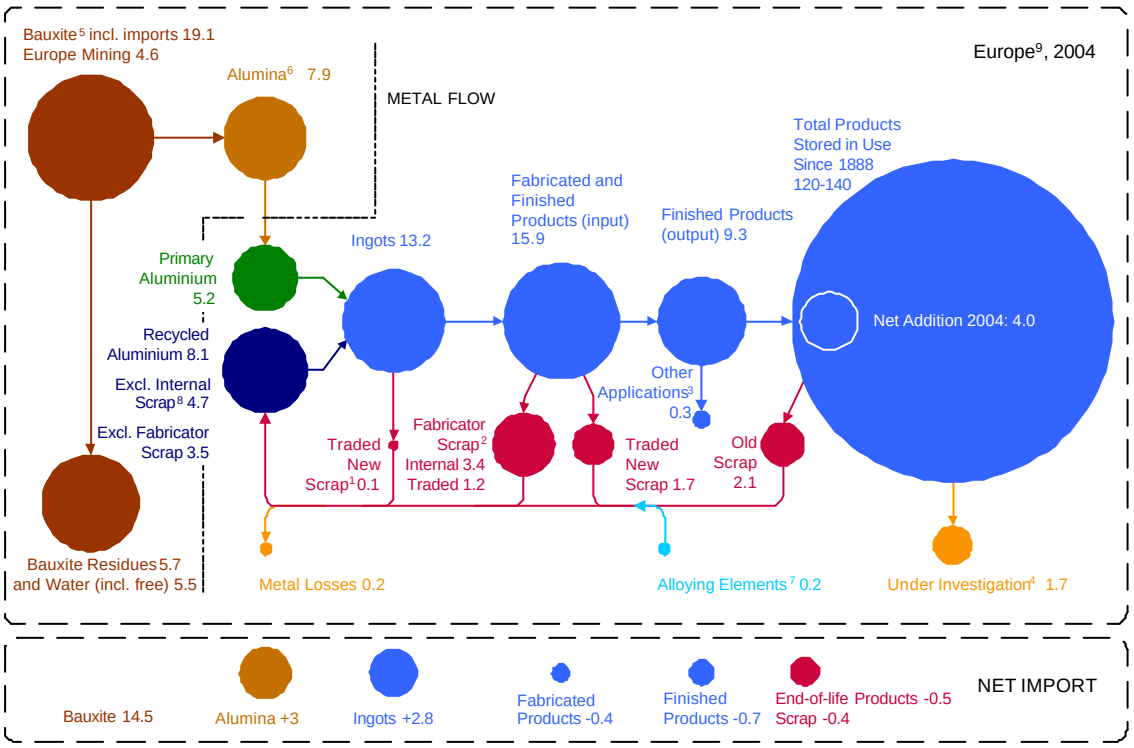
Figure 6 European aluminium scrap generation (including internal, traded and tolled scrap)
1 = Poland, Belgium, Greece, Austria, Netherlands
2 = Sweden, Turkey, Switzerland, Hungary, Norway, Czech Republic
3 = Slovenia, Portugal, Romania, Denmark, Finland, Luxembourg
4 = Slovakia, Croatia, Ireland, Bulgaria, Lithuania, Cyprus, Bosnia-Herzegovina, Serbia-Montenegro, Latvia, Estonia, Iceland, Malta

THE ALUMINIUM FLOW

The collection of global recycling statistics has been proven difficult since most aluminium recycling smelters are of small and medium size and work mostly on the regional and national level. These companies are therefore less interested in global statistics. Hence aluminium flow models were developed to calculate the aluminium scrap flows.

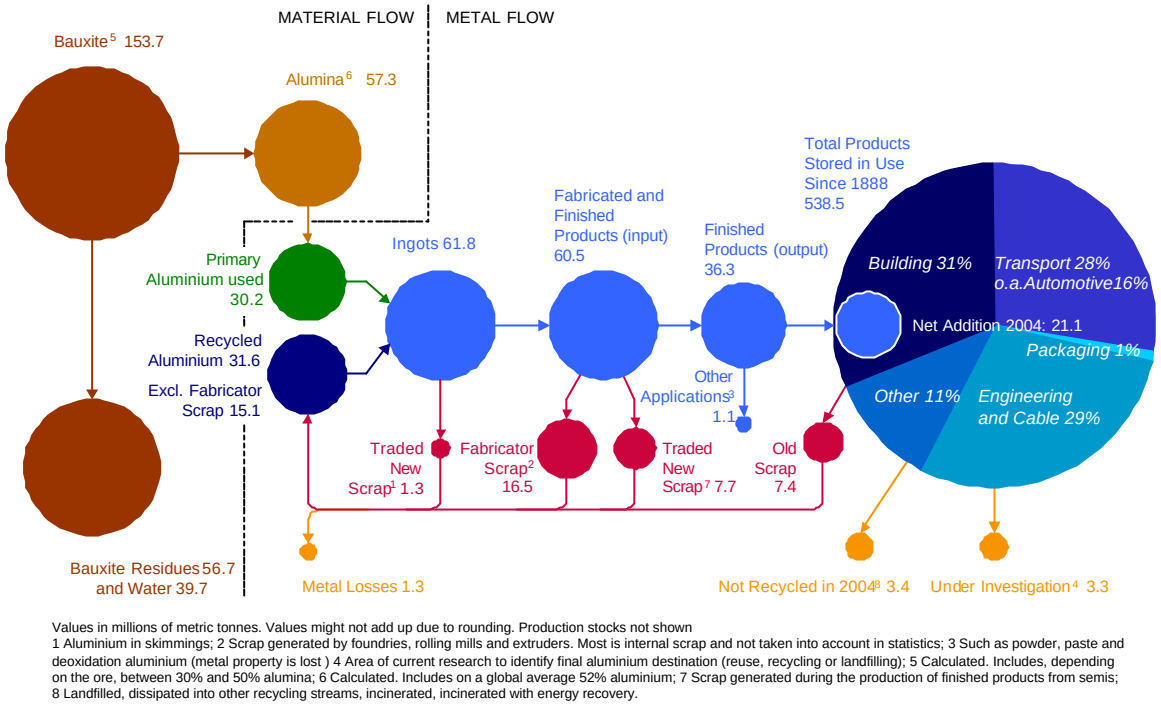
Figures 7 and 8 show the European and global model respectively. They track aluminium through ought its lifecycle from mining to use and recycling. Some interesting results on the global level are:

- For every kilogram of final aluminium product 700 grams of scrap are generated and recycle
- In 2004, 36.3 million tonnes of final product are produced
- The net addition to the stock in use equals 21.1 million tonnes (= finished products – other applications – old scrap – not recycled in 2004 – under investigation)
- The not recycled amount of aluminium includes aluminium that is not collected for recycling, that is lost within the recycling process such as losses in a car shredder, circuit boards melted down in a copper smelting furnace which results in a loss of aluminium and steel and aluminium included in the general municipal solid waste stream which is incinerated with or without energy recovery.
- In 2004, approximately 3.4 million tonnes of end-of-of life aluminium are recycled
- 3.3 million tonnes of end-of-life aluminium are still under investigation and two studies are currently carried out.
    - Truck recycling (European Aluminium Association and Troy University, France)
    - Waste of Electrical and Electronic Equipment (International Aluminium Institute and Yale University, USA)



Values in millions of metric tonnes. Values might not add up due to rounding. Production stocks not shown
1 Aluminium in skimmings from primary production only; 2 Scrap generated by foundries, rolling mills and extruders. Internal scrap is not taken into account in statistics; 3 Such as powder, paste and deoxidation aluminium (metal property is lost) 4 Area of current research to identify final aluminium destination (reuse, recycling or landfilling); 5 Based on statistics. Includes, depending on the ore, between 30% and 50% alumina; 6 Based on statistics. Includes on a global average 52% aluminium. Includes non-metallic uses; 7 alloying elements are only shown for recycling; 8 Based on statistics; 9 West and Central Europe (Former CIS excluded, except Baltic states)

Figure 7 European aluminium flows 2004



Values in millions of metric tonnes. Values might not add up due to rounding. Production stocks not shown
1 Aluminium in skimmings; 2 Scrap generated by foundries, rolling mills and extruders. Most is internal scrap and not taken into account in statistics; 3 Such as powder, paste and deoxidation aluminium (metal property is lost) 4 Area of current research to identify final aluminium destination (reuse, recycling or landfilling); 5 Calculated. Includes, depending on the ore, between 30% and 50% alumina; 6 Calculated. Includes on a global average 52% aluminium; 7 Scrap generated during the production of finished products from semis; 8 Landfilled, dissipated into other recycling streams, incinerated, incinerated with energy recovery.

Figure 8 Global aluminium flows 2004

The growing markets for aluminium are supplied by both primary and recycled metal sources. The proportion of recycled aluminium to the global demand for the metal (sometimes known as the recycling input rate) has grown from less than 20% in 1950 to up to 34% in 2004. The increasing demand for aluminium and the long lifetime of many products mean that, for the foreseeable future, the overall volume of primary metal will continue to be substantially greater than the volume of recycled metal (Figure 9).

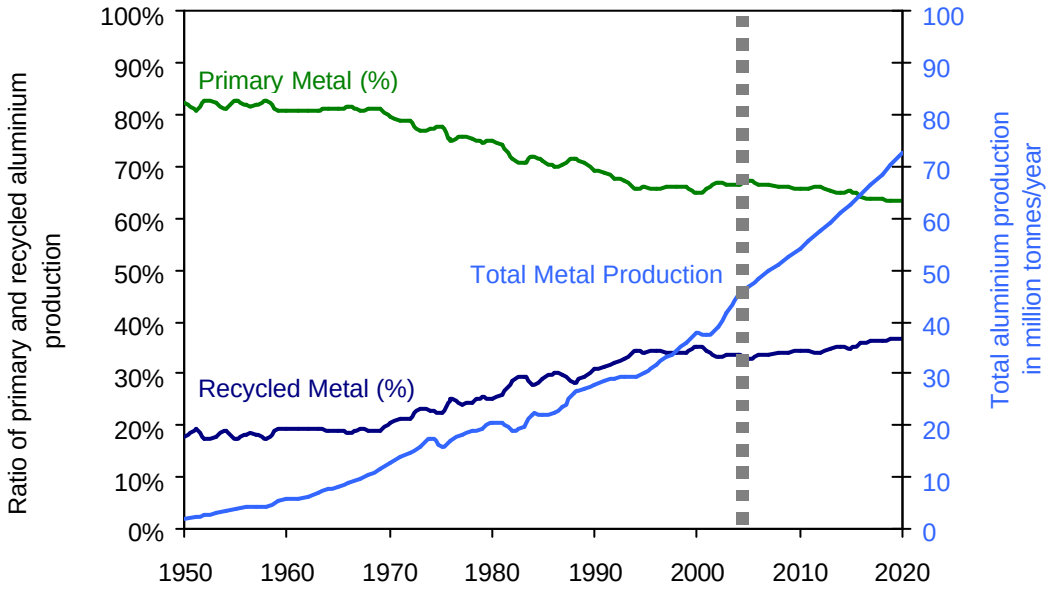


Figure 9 Share of global primary and recycled aluminium production

END-OF-LIFE RECYCLING RATES

At the end of their useful life, if scrap is processed appropriately, aluminium products can be recycled for use in almost all aluminium applications since the metal's atomic structure is not altered during melting.

The rate at which end-of-life aluminium is recycled varies depending on the product sector, scrap processing technology and on society's commitment to collect aluminium containing products at end-of-life. Each application sector requires its own recycling solutions and the industry supports initiatives that seek to optimise the recycling rate. Industry continues to recycle, without subsidy, all the aluminium collected from end-of-life products as well as from fabrication and manufacturing process scrap. However, with the help of appropriate authorities, local communities and society as a whole, the amount of aluminium collected could be increased further.

Estimated recycling rates for aluminium used in the transport and building sectors are very high (85% to 95%) and represent more than 50% of finished goods entering use in 2004. Recycling rates for packaging range from about 25% to 85%, depending on the region.

GLOBAL EMISSION SAVINGS THROUGH LIGHT WEIGHTING AND END-OF-LIFE ALUMINIUM RECYCLING

Improving the overall recycling rate is an essential element in the pursuit of sustainable development. Today, recycling of old scrap now saves close to 80 million tonnes of greenhouse gas emissions per year, equivalent to the annual emissions from 15 million cars. As shown in Figure 10 since its inception, the recycling of old scrap has already avoided over one billion metric tonnes of CO2 emissions.

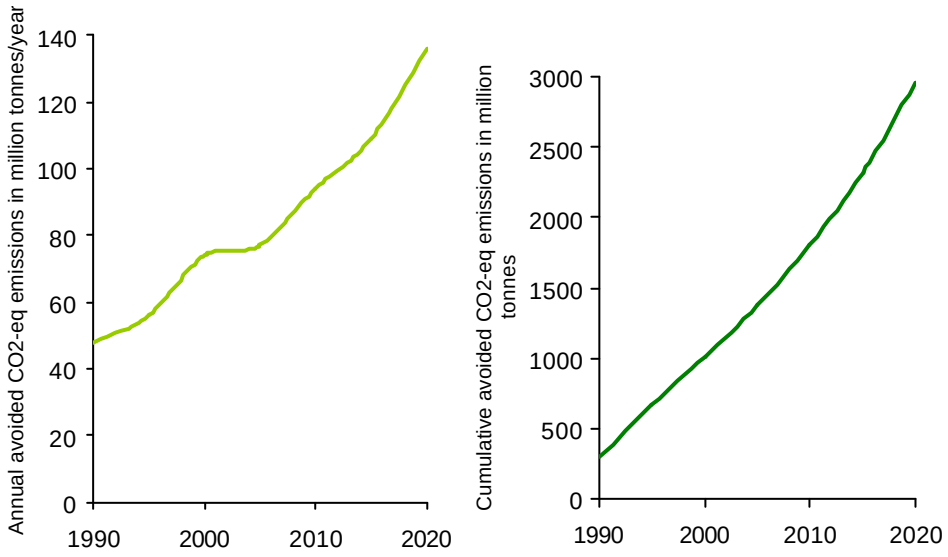


Figure 10 Annual and cumulative impact from end-of-life aluminium recycling

The challenge is to address the continued rise in CO2 emissions from power generation, as the aluminium Industry's internal process emissions are levelling off. This can be done

partly by recycling, but it is also important to take account of the aluminium products contribution to reducing greenhouse gas emissions.

For instance, every kilogram of aluminium that is used in substitute for heavier materials in a car or light truck, has the potential to avoid the release of 20kg of CO2 over the lifetime of the vehicle. Greenhouse gas emissions savings for transport other than passenger cars through light weighting are even greater. For instance, buses, delivery trucks, short distance commuter trains have similar potentials, ocean vessels greater by a factor of 5 to 10 and high speed ferries and aircraft well over 10 times that of passenger cars. Aluminium shipments to the automotive and light truck industries increased by 5.5% between 2002 and 2003. Global greenhouse gas savings from the use of aluminium in light weighting vehicles have the potential to double between now and 2020 to 500 million tonnes of CO2 per year (Figure 11).

The objective for 2020 or beyond (Figure 11) is for the aluminium industry to help in avoiding more greenhouse gas emissions than it creates directly and indirectly through its production by transport light weighting.

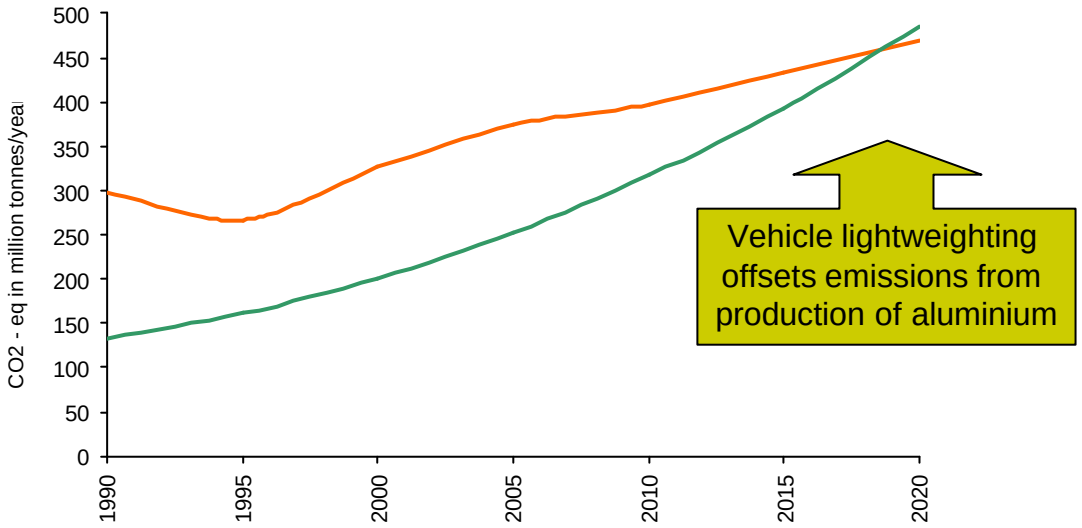


Figure 11 Potential of vehicle light weighting to offset emissions from the total aluminium production worldwide

GLOBAL ALUMINIUM RECYCLING MESSAGES

Aluminium can be recycled over and over again without loss of properties. The high value of aluminium scrap is a key incentive and major economic impetus for recycling.

aluminium recycling benefits present and future generations by conserving energy and other natural resources. It saves approximately 95% of the energy required for primary aluminium production, thereby avoiding corresponding emissions, including greenhouse gases.

Global aluminium recycling rates are high, approximately 90% for transport and construction applications and about 60% for beverage cans.

The growing markets for aluminium are supplied by both primary and recycled metal sources. Increasing demand for aluminium and the long lifetime of many products mean that, for the foreseeable future, the overall volume of primary metal produced from bauxite will continue to be substantially greater than the volume of available recycled metal.
Industry continues to recycle, without subsidy, all the aluminium collected from used products, as well as fabrication and manufacturing processes. However, with the help of appropriate authorities, local communities and society as a whole, the amount of aluminium collected could be increased further.

LITERATURE

Boin U.M.J. and Bertram M., 2005. Melting Standardized Aluminium Scrap: A Mass Balance Model for Europe. JOM 57 (8), pp. 26–33.

Bruggink P.R. and Martchek K.J., 2004. Worldwide Recycled Aluminium Supply and Environmental Impact Model. Light Metals 2004, Hamilton, Ontario, Canada.

EAA, biannually updated. Sustainability of the European Aluminium Industry. www.eaa.net
EAA and TU Delft, 2004. Collection of Aluminium from Buildings in Europe. Brochure and Final Report. www.eaa.net

EAA/OEA, 2004. Aluminium Recycling: The Road to High Quality Products. www.eaa.net

Gesamtverband der Aluminiumindustrie e.V. Fact Sheets, permanently updated. www.aluinfo.de
Kukshinrichs W. and Martens P. N., 2003. Resource-Orientated Analysis of Metallic Raw Materials. Series: Matter and Materials, Volume 17. Forschungszentrum Jülich GmbH, Jülich, Germany.

IAI, 2003. Life Cycle Assessment of Aluminium: Inventory Data for the Worldwide Primary Aluminium Industry. www.world-aluminium.org

IAI, 2005. Sustainability Update 2005. www.worldaluminium.org

VDS, 2000. Aluminium Recycling – Vom Vorstoff bis zur fertigen Legierung. Aluminium Verlag, Düsseldorf, Germany.