HYDRO

Aluminium,

environment and society

Foreword

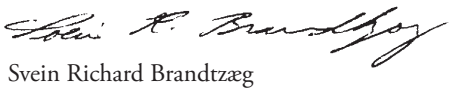
Hydro's mission is to create a more viable society by developing natural resources and products in innovative and efficient ways. Throughout Hydro's more than 100 years history we have developed businesses that begin by harnessing vital natural resources and end in benefits to the everyday lives of people around the world. We continue to improve the production of durable goods through innovative uses of aluminium.

We have a responsibility in making a conscious effort to balance the need for profit with the needs of society. We believe business demands and societal demands are inseparable and interdependent. We cannot have true, long-term business success without societal success.

Any extraction of raw materials and all production processes entail some degree of impact, on the environment and on societies, and the use of non-renewable resources which remain vital for future generations. Aluminium production is no exception.

These are challenging issues both from a scientific and an ethical point of view. Facing the issues challenges our values. Some values are universal, while others are not. Values cannot be discussed without a basis in facts. This booklet intends to be a contribution to the fact basis and a contribution to the debate on how we shape our future.

We believe that aluminium is an important part of that future.



Svein Richard Brandtzæg
President and CEO

Oslo, December 2012


INFINITE
ALUMINIUM

Aluminium, *environment and society*

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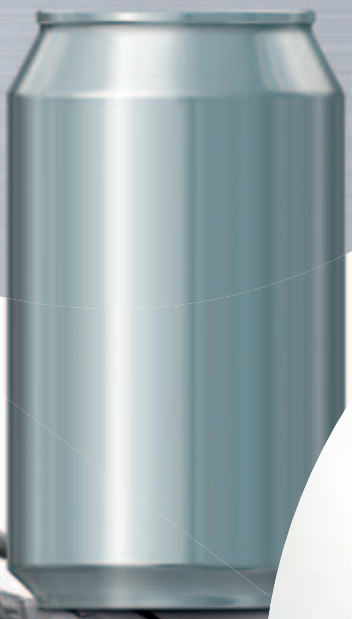
1 WHY ALUMINIUM?

Aluminium is present almost everywhere around us in a vast number of applications. We may not even be conscious about its presence, but we would definitely miss it.

The use of aluminium has many advantages, including from an environmental perspective. These are related to the metal's properties which benefit today's society:



STRONG AND LIGHT

Aluminium is a very light metal, with a specific weight of 2.7 (g/cm^3), which is one-third of that of steel. The strength of the metal can be increased by adding small quantities of other metals (alloys). The low weight reduces energy consumption related to transportation, and hence also emissions of greenhouse gases and other pollutants.

HIGHLY CORROSION RESISTANT

As the metal itself forms a protective oxide coating (that is immediately reformed if the metal is cut or scratched), it is highly corrosion resistant. This property can be further improved by various types of surface treatment. This property prolongs the useful life of aluminium in cars and buildings and reduces the need for maintenance. This also reduces environmental impacts related to replacement and maintenance.

GOOD CONDUCTIVITY

Aluminium is a good conductor of heat and electricity, and in relation to its weight, is almost twice as good a conductor as copper. These properties make aluminium the material of choice to achieve energy efficient systems for electrical transmission systems and other applications, such as heat transfer components.

GOOD REFLECTIVE QUALITIES

Aluminium can reflect both heat and light, and together with its low weight, makes it an ideal material for reflectors in, for example, light fittings. High energy efficiency in the reflectors contributes to reduced environmental burden.

EASY TO FORM AND PROCESS

Aluminium is ductile, and has a low melting point. It can easily be processed in a number of ways - both in a cold and hot condition. Its great ductility allows design flexibility and aluminium products to be integrated in advanced applications in transport and buildings industries.

IMPERMEABLE, NON-TOXIC AND ODORLESS

Aluminium foil, even when rolled to just a 0.007 mm thickness, is still completely impermeable and lets neither light, aroma nor taste substances in or out. Moreover, the metal itself is non-toxic, and releases no aroma or taste substances. Aluminium is therefore widely used in food and drink packaging. The efficient conservation of food reduces wastage of food, which is an important environmental and resource advantage. Furthermore, the low weight of the packaging reduces energy in transportation. The impermeability of aluminium foil also reduces cooling needs.

NON-COMBUSTIBLE

Aluminium used in buildings, constructions and transport equipment is non-combustible. It will only burn in a fine powder form or as very thin film. Aluminium will melt when temperatures exceed 660 °C - without releasing any gases.

ABUNDANT RESOURCES

Aluminium is the third most abundant element in the earth's crust, after oxygen and silicon, constituting about 7 percent by weight of the earth's crust. Bauxite is the only commercial ore used for the production of alumina today, but other sources may be feasible in the future. Known bauxite reserves will last more than 100 years at current rate of extraction.

EASY TO RECYCLE

The re-melting of aluminium requires little energy, and metal loss in the re-melting process is less than 3 per cent. Only about 5 per cent of the energy required to produce the primary metal initially is needed in the recycling process. Around 75 per cent of the aluminium ever produced is still in use, and constitutes a resource bank for use in the future.

2 LIFE CYCLE ASPECTS OF ALUMINIUM

Hydro has a long term aspiration of no net loss of biodiversity in the areas where we operate, and to develop and provide products which may contribute to reduced burden on the environment in the use phase.

Extraction of natural resources and production and fabrication of products will cause some degree of environmental disturbance. Aluminium is no exception. However, our focus is to minimize the impacts and having a longer term aspiration of no net loss for the biodiversity and ecosystems where we operate. At the same time we strive to maximize the positive environmental contribution of aluminium used in various applications. These benefits may more than offset the initial impacts of extraction and production.

In this booklet, we will present information related to environmental and social aspects of all the steps in the value chain of aluminium, as well as some examples related to Hydro's activities and products, enabling the reader to assess the pros and the cons associated with our value chain and aluminium as a material.

A detailed scientific account of the environmental footprint of aluminium production is published by the European Aluminium Association[1)]

3 BENEFITS OF USING ALUMINIUM

ALUMINIUM IN TRANSPORTATION

Transportation is one of the largest energy consuming sectors, using about 19 percent of the world's energy demand. Use of aluminium helps to reduce the weight of cars, buses, trucks, planes, trains and boats. When the weight is reduced, energy consumption during transport is reduced. Thus the extra energy and the extra greenhouse gas (GHG) emissions related to the production of aluminium compared to alternative materials may be paid back many times through the life cycle of the product.

Here are a few examples:
According to a study by IFEU [2)], each 100 kilograms of weight savings from the use of aluminium in an average family car (gasoline), amounts to an average life time fuel saving of 27.2 GJ corresponding to a reduction in fuel consumption of 800 liters. It takes about 7.7 GJ more energy to produce primary aluminium than the amount of steel it substitutes. This results in a net lifetime saving of 20 GJ, corresponding to 600 liters of gasoline.

However, aluminium in cars is to a large extent recycled metal, where the energy used for recycling loop is much less. The typical recycled content in a car is 40 percent, which means that the net lifetime energy saving is 22.7 GJ or 680 liters of gasoline. If one gives full credit to the fact that nearly all the aluminium in a car eventually will be recycled, the savings are even greater.

Similar calculations for CO_2 give a net lifetime emission saving of 1,700 kilograms of CO_2 for primary metal only and 1,950 kilograms CO_2 for a car with 40 percent recycled aluminium.

The above study also looked at the effect of light-weighting in other transportation media, such as busses, trucks, trains, air planes and ships. In many of these applications, the energy saving per kilogram weight reduction is even more pronounced. As an example, weight reduction in an aircraft has in the order of 1000 times the effect as in an average passenger car. And this is why aluminium and other light weight materials are already extensively used in airplanes. Because of the great number of cars worldwide, the greatest global saving potential is in lightweighting the cars. Light-weighting in air crafts is already implemented to a great extent.

The IFEU study acknowledged that general technology trends are bringing the fuel consumption per km in cars down. Just replacing the current fleet of cars with new vehicles (without further weight reduction) would reduce fuel consumption by 7.5 percent. But exploring realistic potentials for further weight reduction would reduce the fuel consumption by another 3.1 percent.

On a global scale, and including similar potentials in all transport sectors, this translates to an annual saving potential of 220 million metric tonnes of CO_2. This is about four times the annual greenhouse gas emissions of Norway.[3)]

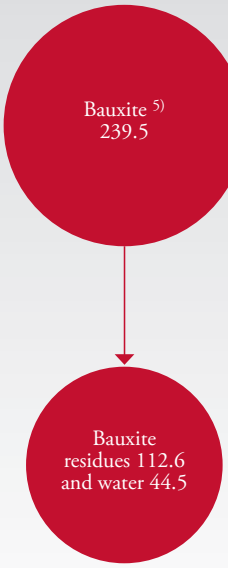
Since the IFEU study, the aluminium industry and the car makers have made further advances in finding aluminium substitution possibilities in cars. Up to 40 percent reduction of the cars body weight can be achieved by extensive use of aluminium without compromising the strength[4)]. This would reduce fuel consumption by 10 percent. Some car models with aluminium bodies are already in the market.

4 ALUMINIUM RECYCLING

Aluminium metal is sourced from primary aluminium and from recycled aluminium. In a resource constrained world, recycling is critical to sustainable development. It allows resources to be saved and waste to be reduced. Aluminium in use is an energy and resource bank, but due to the long life of many aluminium products, and due to growing demand, this "bank" can only supply 20-25 percent of the current demand. The rest must be produced from primary aluminium.

MATERIAL FLOW BALANCE FOR ALUMINIUM

Global aluminium flows in 2010. Taking into account the finished products entering into use (50.5 million metric tons) and the old scrap recovered for recycling (11 million metric tons), the global recycled content for aluminium is about 22 percent.



Values in millions of metric tons. Values might not add up due to rounding. * Change in 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 deoxidation aluminium (metal property is lost)
4) Area of current research to identify final aluminium destination (reuse, recycling, recovery or disposal)
5) Calculated based on IAI LCI report – update 2010. 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) Either incinerated with/without energy recovery, material recovery or disposal
9) Estimated stock decrease 890,000 metric tons.

(Source International Aluminium Institute IAI)

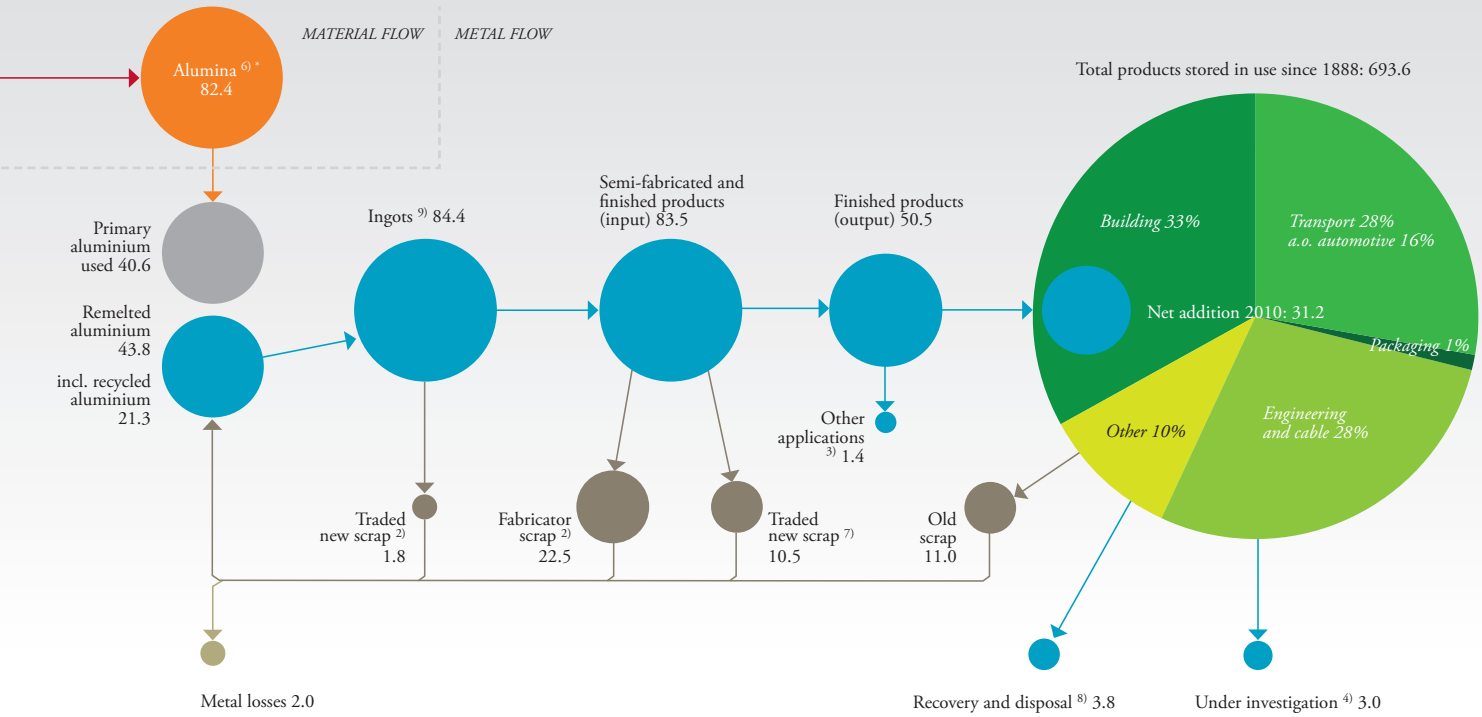
BENEFITS OF RECYCLING – AND SOME LIMITATIONS

Used aluminium is valuable – it can be easily and endlessly recycled without quality loss. Aluminium recycling even benefits present and future generations by conserving energy and other natural resources. Only 5 per cent of the energy required to produce primary aluminium is needed to re-melt aluminium. In addition to the energy savings, emissions of greenhouse gases and pollutants are reduced, and encroachments in the landscape related to bauxite mining and refining are avoided. Today, recycling of post-consumer aluminium products saves over 90 million metric tons of CO_2 and over 100,000 GWh of electrical energy annually compared to primary production of the metal, equivalent to the annual power consumption of the Netherlands.

The world's increasing stock of aluminium in use acts like a resource bank, over time delivering more and more practical use and value from the energy embodied in the metal. Around 75 percent of the almost one billion metric tons of aluminium ever produced is still in productive use, some of it having been through countless recycle loops through its lifecycle.

Most of the aluminium being produced today enters long-life products like vehicles and building products. With average lifetimes of about 15 to 20 years for vehicles and 40 to 50 years for buildings, this means that most of the aluminium will not be available for recycling for many years. As a result, access to aluminium scrap is limited. Globally, less than 25 percent of the aluminium being produced came from post-consumer scrap sources in 2010. With an expected continued growth in aluminium demand, this share is not expected to increase significantly in the future.

The figure below illustrates the material flow balance of aluminium.[9)]



4 ALUMINIUM RECYCLING

INDUSTRY'S ROLE IN RECYCLING

The recycling industry plays an essential part of the aluminium life cycle. The amount of recycled metal has increased steadily in recent years, and the recyclers have implemented newer and better technologies to avoid harmful emissions from the smelting of scrap. Authorities in many countries have implemented incentives to enhance the recycling rate. Hydro has set strategic goals to increase its production of recycled metal.

Since 1980 the aluminium recycling industry has quadrupled its annual output of metal from old (post-consumer) and traded new scrap, from 5 million metric tons to almost 20 million metric tons. Over the same period, annual primary metal production has grown from 15 to 44 million tonnes.

A fully developed aluminium recycling industry includes both refiners and remelters. Refiners use more sophisticated processes, allowing them to produce alloys to customers' specifications from a range of scrap sources. Remelters mainly use clean and sorted wrought alloy scrap and make products of the same type as the scrap sources (such as used beverage cans into new cans or window profiles into new window frames).

The recycling industry also involves collectors, dismantlers, metal merchants and scrap processors, which deal with the collection and treatment of scrap.

In Europe and North America, scrap has been generated in sufficient quantities over the past 70 years to develop an economically strong and technically advanced aluminium recycling industry. Following the oil price 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 production centers, increasing recycling activities are evident in China, India and Russia.

RECYCLING OF ALUMINIUM PRODUCTS

At the end of their useful life, the recycled product may be the same as the original product (such as window frame recycled back into a window frame or can to can), but is more often a completely different product (for example a cylinder head recycled into a gearbox).

Transport

Around 25 percent of aluminium produced every year is destined for the transportation sector. The amount of aluminium used per car produced in Europe almost tripled between 1990 and 2012, increasing from 50kg to 140 kg. This amount is predicted to rise to 160 kg by 2020, and even reach as much as 180 kg if small and medium cars follow the evolution recorded in the upper segments of the automobile industry.[10)]

At the end of a vehicle's useful life some aluminium parts, such as wheels and cylinder heads, are removed and the remaining car body is fed into a shredder, after which the aluminium fraction is separated using various technologies. Mixed alloy aluminium scrap collected in this way is generally processed into casting alloys for the production of engines and gearboxes. Due to the increasing use of wrought alloys in car bodies, a growing volume of such scrap is anticipated and hence the separate collection of specific alloys from cars is likely to become economically viable in the future. In Europe, 95 percent of the aluminium scrap from cars is currently being recycled.[11)]

Building and construction

Today around 13 million metric tons of aluminium a year are used in construction, while it is estimated that globally some 220 million metric tons of aluminium are currently in use in buildings.

In contrast to many other building materials, which are mostly landfilled after demolishing a building, aluminium may be recycled in a way that is economically and environmentally sustainable. A 2004 study by Delft University of Technology found that collection rates for aluminium in European buildings were between 92 percent and 98 percent.[12)]

4 ALUMINIUM RECYCLING

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Hydro is a global supplier of aluminium with activities throughout the value chain, from bauxite extraction to the production of rolled and extruded aluminium products and building systems. Based in Norway, the company employs 22,000 people in more than 40 countries. Rooted in a century of experience in renewable energy production, technology development and progressive partnerships, Hydro is committed to strengthening the viability of the customers and communities we serve.

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