european aluminium association

ENVIRONMENT, HEALTH AND SAFETY

Aluminium Recycling in LCA

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Table of Content

1 Introduction

Within the concept of sustainable development, the closing of the material loops plays an essential role. Therefore, the recycling of used products and scrap associated with product systems is of crucial importance. The European aluminium industry puts a lot of effort into continuously enhancing the recycling of used aluminium products and scrap including the reduction of the environmental impacts associated with recycling processes. This document may assist LCA practitioners, experts and users to adequately reflect today's reality for aluminium recycling and how to model this in LCAs.

Numerous factors affect the results of an LCA study of a specific product. Not only the material it is made of, the various production processes involved and the use phase but also its end-of-life treatment. The ISO 14040 and ISO 14044 standards aim at defining the rules and the methodologies for considering and integrating properly all these phases of a product life time but some necessary flexibilities are left to practitioners, especially in relation to allocation methods and system boundary definition. Regarding the end of life treatment of a product, different scenarios like re-use, recycling, incineration, or land filling can be envisaged. This document aims at a more detailed analysis how to consider recycling within an LCA study

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where aluminium is involved and how to credit the recycling benefits to the product system under consideration.

The metallic structure distinguishes metals from other materials, as this structure is not affected by melting processes, which are at the heart of the recycling operations. That is why metals and their alloys can maintain their inherent properties after scrap melting and are in principle indefinitely recyclable into new products.

In practice, recycled aluminium alloys generally substitute primary aluminium alloys for new aluminium products. The system expansion and substitution method, which follow the guidance given in ISO 14044, aim at considering this ability of aluminium in LCA studies.

2 Aluminium recycling today

In order to assess the aspects associated with aluminium recycling in an LCA study, the following issues should be considered:

a) The quantity and quality of the new scrap from the fabrication of semi-finished products, components or final products. This scrap typically arises, e.g. during the production of semis, fabrication processes of parts or components from semi-finished aluminium products (sheet, foil, extrusions, etc.) or through machining operations.

b) The available quantity and quality of old scrap, e.g. end-of-life aluminium scrap. This is generally determined by the efficiency of the collection and sorting prior to the scrap melting itself.

c) The efficiency of the scrap melting process and its corollary, the quantity of aluminium lost in the recycling process. To assess this quantity accurately, it is necessary to define the end of life treatment of the product under consideration as well as the recycling operations in detail, based on realistic scenarios, because it depends of a number of factors such as scrap type or melting process. Except for a few high volume types of scrap, recycling is commonly not product-specific, i.e. process scrap and scrap from different end-of-life products are often mixed in the recycling process stream input with the intention of producing an alloy according to a specification. A careful check of the particular aluminium product situation is always recommended.

These various elements are necessary to evaluate the complete efficiency and the environmental consequences of the recycling process.

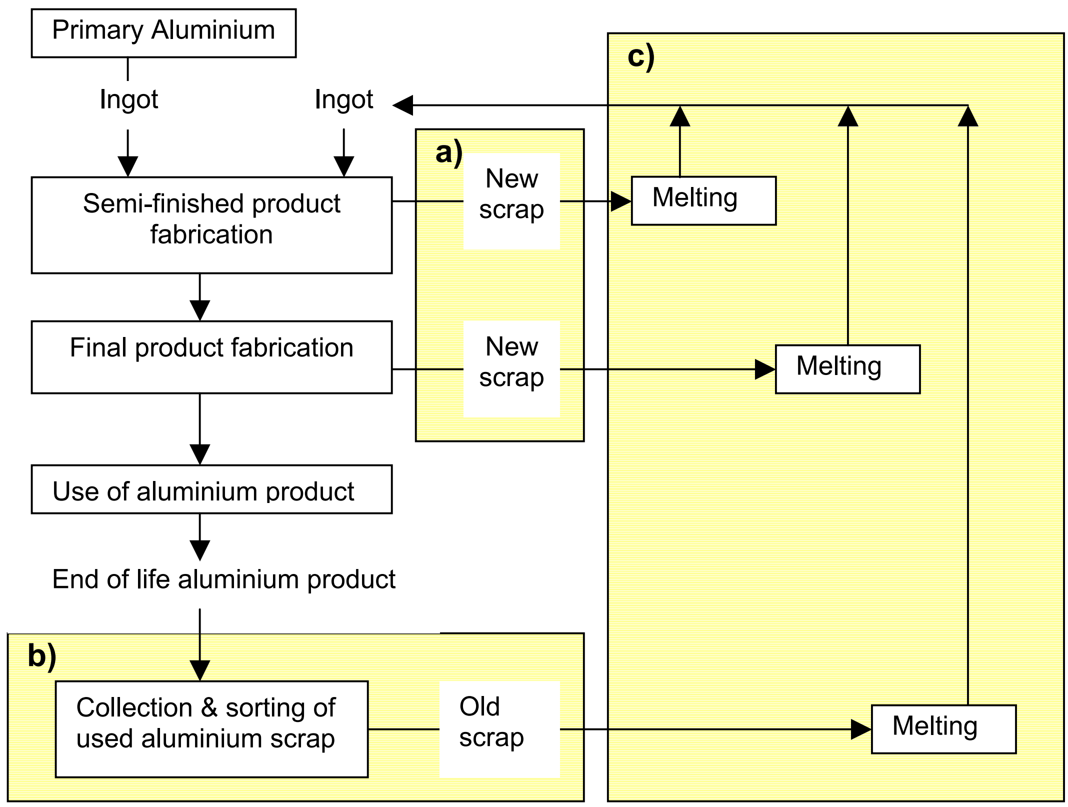

Figure 1: Recycling process, new and old scraps substitute primary aluminium

The output of scrap melting is a recycled aluminium alloy ingot. This material can be used interchangeably with ingots produced from primary aluminium. In other words it substitutes primary aluminium.

Those aspects are relevant when bringing aluminium products into an LCA context.

3 System expansion and substitution method

An LCA deals with product systems which model the full life cycle of a product, including raw material acquisition, fabrication, transportation, use, recycling/disposal and the operations of energy supply, ancillary material supply, transports, etc. Thus recycling is part of any LCA. It is often a complex issue which requires specific considerations.

An easy case is if one product with a short lifetime is recycled into the same product, such as an aluminium can. However, in reality this is often the exception. Therefore modelling approaches have to be applied, which reflect or come close to the reality.

The aluminium economy is a cycle economy. Therefore, a life cycle of an aluminium product is not "cradle-to-grave", but rather "cradle-to-cradle". This means that the life cycle of an aluminium product usually ends when the recycled aluminium is rendered in a form usable for a new aluminium product e. g. an ingot used to fabricate and manufacture new aluminium products.

According to ISO 14044 allocation procedures for recycling can be addressed as follows:

- *a closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems, where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials.*

Because of their metallic nature, aluminium and its alloys have – contrary to solid organic materials or refractories – the ability to maintain their inherent metallic properties during recycling. As a consequence, system expansion and the substitution method are applicable to the LCA of aluminium products. Thus, ISO 14044 standard recommends to expand the system under study to include the end-of-life recycling, resulting in substitution of primary material by recycled material.

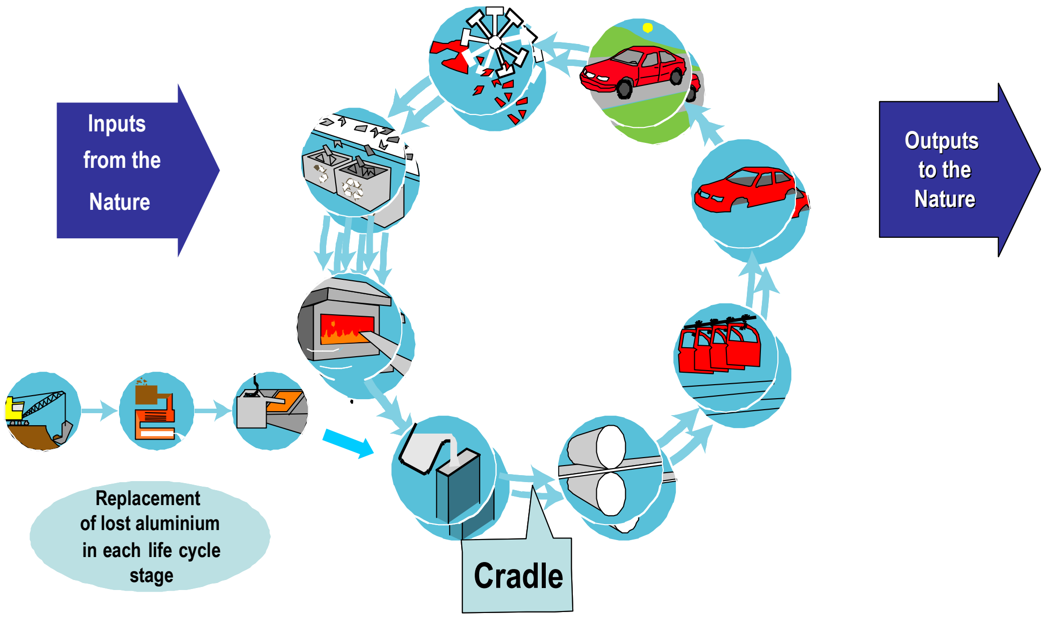

Figure 2: Closed-loop aluminium material flow

Example 1 illustrates Figure 2.

> **Example 1**: System expansion and substitution method for recycling
>
> 100 kg of aluminium is required for a product system
>
> 90 kg of recycled aluminium ingots (with the same inherent metallic properties as primary aluminium) are obtained after collection and sorting of the end-of life product and scrap melting.
>
> → 90 kg of recycled aluminium ingots substitute 90 kg of primary aluminium ingots.
>
> Thus, the environmental burdens of the production of only the lost aluminium, i.e. 10 kg of metal, have to be charged to the product system under study, together with the burdens of the recycling operations.

Recycled aluminium as input

ISO 14044 requires that allocation procedures have to be uniformly applied to similar inputs and outputs of the system under consideration. The rules on how to treat incoming recycled aluminium have to correspond with the methods for treating recycled metal leaving the system.
The maintained inherent metallic properties also mean that the system expansion and the substitution method can be applied here. Therefore, there is no need to consider the incoming portion of recycled aluminium, since only the metal loss during the complete life cycle of the product must be taken into account.

> **Example 2**: Substitution method & recycled metal as input
>
> 100 kg of aluminium is required for a product system. It may consist of 40 kg of primary aluminium and 60 kg of recycled aluminium with the same inherent properties as the primary aluminium.
>
> 80 kg of recycled aluminium ingots result from recycling, including scrap melting.
>
> → 20 kg of aluminium is littered or landfilled.
>
> The environmental burdens of the production only of the lost aluminium, i.e. 20 kg of primary metal, have to be charged to the product system under study, together with the burdens of the recycling operations. These environmental burdens are valid whatever the input of the recycled metal.

Long life time products

Aluminium products often have extended life times because of their high corrosion resistance, e.g. in mass transportation systems or buildings. Such products may not be mistreated in LCA studies by omitting recycling credits as described in Section 3 above.
Any uncertainty about recycling rates and recycling techniques for long-life aluminium products is not sufficient to refuse recycling credits. It rather has to be dealt with by applying different recycling scenarios in the form of sensitivity analyses, which must include the state-of-the art recycling technique for the product under study and the expected recycling situation in the future.

4 Market value analysis

For specific product systems and depending on the material, the recycling operations can lead to a change of the inherent properties of the recycled material compared to primary (virgin) material. In this case an allocation procedure may be appropriate and can be addressed according to ISO 14044 as follows:

- *an open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.*

If inherent properties are changed, the standard ISO 14044 (subclause 4.3.4.3.4), recommends to use primarily physical properties or secondly economic value as basis for allocation procedure. In practice, only the second allocation procedure which compares the market value of the recycled material with that of the primary material, is applicable for aluminium. If the market value analysis shows that the market value of the material obtained from recycling end-of-life products is the same as the market value of primary material, then the system expansion and the substitution method can be applied, effectively treating the product system as a closed loop system.

The so-called “value corrected substitution method” is applied if the market value analysis shows a difference between the market value of the primary material and the market value of the corresponding recycled material obtained at the end-of-life. This method assumes that the substitution ability is reflected by the ratio between the market prices of the recycled and primary material. As an example, if the market price of the recycled material is 90% of the market price of the primary material, 1 kg of recycled material will substitute only 0,9 kg of primary material.

If the value-corrected substitution method is applied for recycled material at the output side, then the value of the incoming recycled material has to be considered, as well, in order to ensure methodological consistency. Example 3 illustrates the calculation method.

Example 3: Value-corrected substitution method

100 kg of material is required for a product system.

90 kg of recycled material with 90 % of the value of primary material result from recycling, including scrap melting. 10 kg of material is lost, e.g. littered or land-filled.

The **net material loss** is calculated as **Mass of input material** minus **value-corrected mass of output material**

- Mass of input material: 100 kg
- Value-corrected mass of output material: 90 kg x 0.9 = 81 kg.
- Net material loss is 100kg - 81 kg = 19 kg.

The environmental burdens of the production of the lost material, i.e. 19 kg of primary material, have to be charged to the product system under study, together with the burdens of the recycling operations.

NB: This example only considers value-correction on the output side. If the input material has a lower value than pure primary material, a value-correction needs to be applied on the input side as well.

The market value analysis can be applied for any specific situation, as the recycled material which leaves the product system is usually traded on the market.

In comparative LCA studies, the result is often highly dependent on the treatment of recycling of the different materials. For such studies, a market value analysis allows to clarify the question to what extent the substitution method can be applied.

5 Recycled metal content: the inappropriate method

“Recycled content” is a phrase with a certain ecological appeal. What, however, does “recycled content” actually mean in the context of the aluminium market?

If all aluminium applications were grouped together, the average global recycled content (excluding internal scrap) would stand at around 35% overall. But, in reality, recycled content varies substantially from one product to another. With the continued growth of the aluminium market and the fact that most aluminium products have a fairly long lifetime it is not possible to achieve high recycled content in all new aluminium products, simply because the available quantity of end-of-life aluminium falls considerably short of total demand.

Furthermore, recycled aluminium is used where it is deemed most efficient in economic and ecological terms. Directing the scrap flow towards designated products, in order to obtain high-recycled content in those products, would inevitably mean lower recycled content in other products. It would also result in inefficiency in the global optimisation of the scrap market, as well as wasting transportation energy. Calls to increase recycled content in specific categories of aluminium products make no ecological sense at all.

As an example, if an external region buys large quantities of aluminium scrap in Europe or North America, the recycled content of their own aluminium products increases and the recycled content of the aluminium products in other regions decreases. Thus it would be clearly misleading to conclude from this fact that the aluminium products of this specific region have become "greener"!

The above example shows that the "recycled metal content” approach is not appropriate for decision making.

6 Key positions

1. The high value of aluminium scrap is a key incentive and major economic impetus for recycling. In practice, recycled aluminium alloys substitute primary aluminium alloys for new aluminium products. The system expansion and the substitution method are adequate to reflect this.

2. If in comparative LCA studies there is any doubt for one of the materials that the recycled material does not have the same inherent properties as the primary material, then it should be clarified by a market value analysis whether it is necessary to apply a value correction or not.

3. From an LCA point of view the “recycled content” approach does not refer to end-of-life recycling and thus not to the life cycle of an aluminium product. From an environmental point of view, the demand for an increase in the amount of recycled material in some aluminium products does not make sense because of the limited available quantity for recycling. Thus this approach is not appropriate and cannot be justified by environmental considerations.

4. In practice, aluminium is not consumed but rather used. Therefore, the life cycle of an aluminium product is usually not "cradle-to-grave", but rather "cradle-to-cradle". This means that the life cycle of an aluminium product usually ends, when the recycled aluminium is rendered in a form usable for a new aluminium product e.g. as an ingot which is used to fabricate new aluminium products. In this context, the substitution methodology appears the most adapted method to integrate in LCA studies the recycling of aluminium products.

7 References

ISO 14040 Environmental management - Life cycle assessment - Principles and framework

ISO14044 Environmental management - Life cycle assessment - Requirements and guidelines