Tackling recycling aspects in en15804

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Abstract

With the current political focus on resource efficiency, the proper consideration of recycling aspects in LCA is becoming increasingly important. In this respect, two contrasting approaches are generally used: the recycled content approach [100:0] and the end of life recycling approach [0:100]. This allocation issue for recycling has been already largely discussed in numerous papers demonstrating the impossibility to make a fully objective and justified choice. Similarly, while ISO standards and ILCD handbook recommend using the end-of-life recycling approach, at least for metal products, the French Standard NFP01 -010 applies a cut-off rule at the end-of-life stage which leads to the recycled content approach. During the development of the EN15804 standard, which defines the core rules for the product category of construction products, it was initially proposed to use this cut-off rule at the end-of-life stage. However, in order to reach consensus and bring EN15804 more into line with ISO standards, a complementary independent module reporting environmental aspects of the net flow of secondary materials and secondary fuels leaving the product system have been added. Whilst this module quantifies the net benefits of the end of life recycling of metal products, it also provides a unique opportunity for acknowledging the “design for recycling” concept, and for selecting environmentally sound end-of-life scenarios and strategies for building products.

1. INTRODUCTION

Considering the growing concern regarding resource efficiency and raw material supply, recycling is seen as key to move to a more sustainable European Union. In 2011, the EU adopted a second Communication on Raw Materials which sets out measures to secure and improve access to raw materials for the EU where recycling definitely plays a key role [1]. In coming years, the recently voted construction product regulation [2] will likely require in addition to technical information also environmental information related to building products as reported in its Basic Work Requirement 7 addressing the "sustainable use of natural resources". The expansion of the EU eco-design directive towards energy related products could also affect several building products in the coming yeas [3]. From a market perspective, several building sustainability certification schemes, like LEED, BREEAM, HQE or DGNB now have a growing influence on the building market in Europe [4]. The waste framework directive [5] is also targeting the building sector in a significant way, since article 11 requires that 70% of EU demolition waste shall be treated beyond 2020. All these legal and market developments show that it is of prime importance to properly consider the recycling aspects of building products when assessing life cycle environmental impacts.

2. METAL BUILDING PRODUCTS: "CRADLE TO CRADLE" LIFE CYCLE.

Metals are used in the building and construction sector [6-7] for structures, reinforcements, cladding, roofing, window frames, plumbing, heating equipment and many other applications. Metals can be found in old and historic buildings as well as in new, modern architecture. Due to their high strength and high stiffness, metals can bear high loads, be used to reinforce other materials or can span great distances, allowing design freedom. Metal building products, with appropriate surface treatment when necessary, are weatherproof, seismic proof, corrosion resistant and immune to UV rays, ensuring a long service life without degradation.

In addition to their technical properties, metal products have also a unique characteristic which is their ability to be efficiently and economically recycled without altering their properties. Already, today, more than 95% of the metal products used in buildings are collected at end-of-life. As an example, a study [8] performed on several demolition sites in Europe has demonstrated that more than 96% of the aluminium-content of these buildings was selectively collected and sent to recycling facilities. A survey carried out among UK demolition contractors [9] has shown that 99% of steel sections and 92% of steel rebars are recycled or reused. Even smaller steel components used inside the buildings reach collection rates exceeding 85%. Fig.1 illustrates this "cradle to cradle" life cycle of metal building products, which saves significant resources.

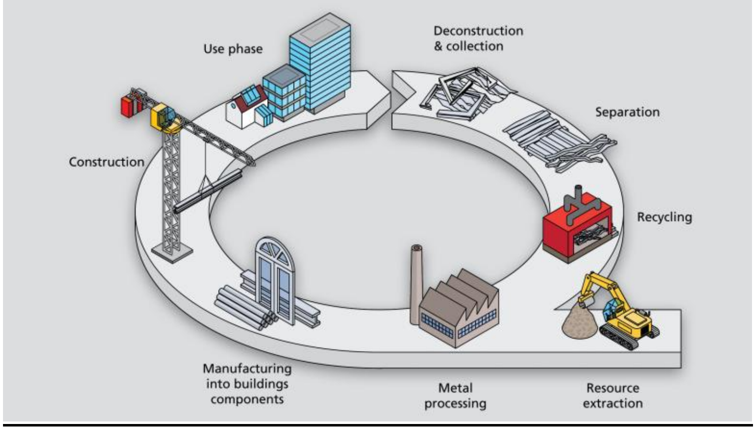

Figure 1: Typical "cradle to cradle" life cycle of metal building products

Small and medium-sized companies play a key role in the collecting and processing of metal-containing products, on their journey to metal-recycling installations. High economic value is the main driver for this systematic dismantling, collection and recycling. As metal recycling provides energy savings of between 60% and 95% compared to primary production [10-11], depending on the metal and the metal-bearing product, metal recycling creates a win-win situation for both the environment and the economy.

3. CONSIDERING RECYCLING ASPECTS FOR METAL PRODUCTS

Today, two contrasting approaches are generally used to tackle recycling aspects: the recycled content approach [100:0] and the end of life recycling approach [0:100]. These two approaches have been largely discussed in numerous papers [12-17].

On one hand, the recycled content approach [100:0] uses a cut-off rule for secondary materials or fuels exiting the product system, meaning that any secondary material flow does not convey any environmental aspect. As a result, this approach considers recycling aspects from the unique production angle, i.e. based on the recycled material used at the production phase of the product. Situated at the beginning of the supply chain, i.e. at the manufacturing stage of a product, this approach neglects the recycling performances of the studied product at the end of its life stage.

On the other hand, the End-of-Life (EoL) recycling approach [0:100] assesses the environmental aspects of secondary materials or fuels leaving the product system based on the corresponding savings of primary material or fuel. This end of life recycling approach considers the recycling rate of the studied product as the key parameter for tackling the environmental aspects of recycling. For metal products, the recycling rate corresponds to the actual amount of metals obtained from recycling with the amount of metals theoretically available at the end of the life of a product, including metal losses during use, collection, scrap preparation and melting. Provided that metal losses during the product use phase are negligible, it directly reflects the specific recycling performance of a metallic product independently from market growth or its lifespan. Within the corresponding LCA methodology, the recycling benefits are then calculated based on proven and documented end of life recycling rate, possibly with a correction factor if intrinsic material properties are not fully maintained during recycling.

The metal industry considers that this end of life recycling approach is the most relevant for metal products in order to maximise and preserve metal availability for future generations as explained in the common Metals Declaration on Recycling [18], published in 2006. This end of life recycling approach is also well accepted in the scientific community as UNEP [19] and ILCD [20].

4. WHY RECYCLED CONTENT DIFFERS FROM EOL RECYCLING RATE

Even if end of life recycling rate of metal building products is pretty high today, e.g. around 90%-95%, the recycled content in metal building product does not reach on average such a level. In reality, the recycled content is currently limited by the scrap availability which is the bottle neck of the metal supply from recycled metal sources. Indeed, the upper limit of what is recycled today is governed by what was produced in the past. The rapid growth in the use of metals over many years and the fact that metal building products typically have a service life of decades means that there is an actual shortage of metal scrap coming from buildings. As there is insufficient recycled material to satisfy the growing demand, virgin material has to be introduced into the supply chain. Hence, the average recycled content in metal supply is still today relatively limited, usually between 30 and 50%. As an example, the aluminium production in Europe for the year 2010 [21], excluding imports, reaches 4,4 Mt of primary aluminium and 4,3 Mt of recycled aluminium, showing that on average about 50% the aluminium supply comes from recycled aluminium. These figures show that the recycled content grasps inadequately the recycling aspects of metal building products. Thus, the recycled content should be used only to reflect the average share of recycled metal in the overall metal supply chain, i.e. from a “cradle to gate” perspective.

5. STANDARDS AND GUIDANCE DOCUMENTS

ISO 14044 [22], governing the LCA methodology principles, and the associated ISO 21930 [23], aimed at developing Environmental Product Declarations for building products, recommend applying allocation rules or system expansion in case of recycling. The ILCD handbook [20] is also in line with ISO standards and recommends using the end of life recycling approach [0:100] at least for metal products. However, some standards or guidance documents use the so-called recycled content methodology, e.g. the French standard NF P01-010 [24] or the first version of PAS2050 [25], by applying a cut-off rule at the end of life stage. This cut-off rule was also initially chosen in EN15804 [26] so that the “recyclability” of building products could not be reported within the original modules A to C.

Hence, it has been proposed to develop within EN15804, an additional module, the so-called ‘module D’, reporting transparently the additional benefits which result from the recycling or energy recovery at the end of life of the building product. Module D avoids any double crediting or counting since only the net benefits of recycling/recovery are reported, i.e. the recycling/recovery benefits at the end of life minus the recycling/recovery benefits already considered at the production stage. This module D is not restricted to metal scrap but it allows reporting the environmental aspects resulting from the net flow of any secondary material or secondary fuel which exit the building system at the end of life stage. If module D is integrated in the data consolidation, the LCA methodology corresponds then to the end of life recycling approach [0:100].

6. CALCULATING MODULE D OF EN15804

The next section shows the calculation rules governing such module D for an aluminium profile and a steel section. These rules can be applied to other materials like plastic products (decorative PVC sectional strip recycled in secondary PVC reused to produce tubes) or wood (energy recovery of wood products) as detailed in a guidance document developed by the French association of building materials (AIMCC) [27].

As described in section 6.3.4.5 of EN15804, secondary material flow exits the system boundary provided the “end of waste” state is reached, i.e. when the recovered material is commonly used for specific purposes, a market demand is clearly identified and its further use will not have any detrimental impact.

At the end of life stage, metal building products are usually inventoried, dismantled and collected in separate containers which are directly sold to metal merchants. Hence, in most cases, dismantled or deconstructed metal products, e.g. aluminium frames or steel sections, reach directly the ‘end of waste’ state and leave then the product system. For the sake of simplicity, these dismantled metal products are called metal scrap. For consistency reasons, recycled metal entering the product system has to respect the same criteria so that recycled metal enters the product system as metal scrap as well.

As described in section 6.4.3.3 of EN15804, Module D aims at assessing the benefits and loads resulting from the net flow of secondary fuels or materials exiting the product system. The environmental aspects of these flows are assessed through system expansion using the so-called “substitution methodology” or “avoided impact” methodology. In such methodology, the secondary material needs to be processed up to the point of functional equivalence where substitution of primary material takes place. In the case of metal, the point of equivalence is the ingot level. Hence, module D calculation needs to consider on one side the burdens of the recycling processes up to the ingot level while the benefits are reflected by the quantity of primary metal which is effectively saved. If needed, a correction factor may be applied when full substitution cannot take place, i.e. when properties are not maintained through recycling. Similarly module D can be used to assess the environmental benefits of fuels or energy leaving the system, such as wood used for energy recovery, or for surplus renewable electricity generated by a building fitted with PV panels [28].

6.1 Case 1: an aluminium profile from a window

Module D assesses the environmental aspects related to the net generation (or consumption) of aluminium scrap resulting from the product life cycle. Provided that it can be assumed that the scrap entering the product system have the same properties as the scrap exiting the system, the environmental aspects of the net flow of scrap are assessed.

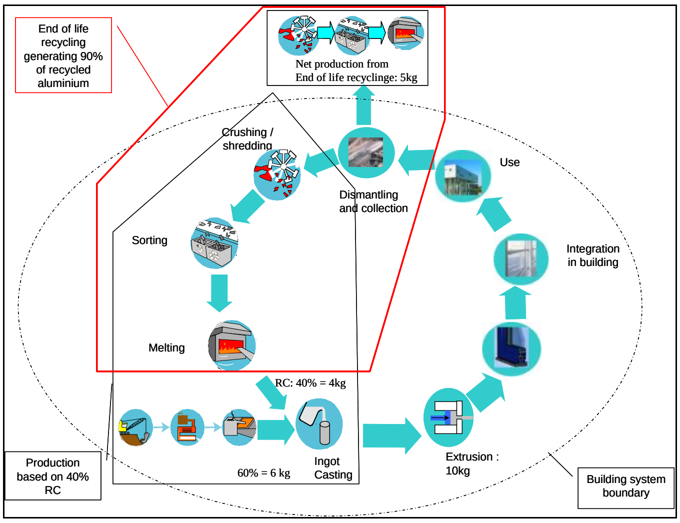

Figure 2: Simplified aluminium mass flow resulting from the window life cycle

In the aluminium window example reported in Fig. 2, it is estimated that the recycled content in the aluminium profiles reaches 40% while the recycling rate from such building product reaches 90% at the end of the product life cycle after deduction of all metal losses along the recycling route. Assuming that 10 kg of aluminium are needed for this window, the end of life recycling will generate 9 kg of recycled aluminium while only 4 kg of recycled aluminium has been used at the production stage (module A1). Hence, the product system is a net producer of 5 kg of recycled aluminium, i.e. 50% of the metal mass.

In this case, module D shall report the environmental aspects of 5 kg of recycled aluminium, i.e. 9 kg generated at the end of life minus 4 kg already used at the production stage in module A1.

Module D considers the environmental loads of the recycling processes which are needed to reach the point of equivalence. For aluminium, this means the scrap preparation, e.g. shredding, crushing and sorting, as well as melting and casting. The environmental benefits are calculated from the quantity of avoided production of primary aluminium, possibly considering a correction factor if full substitution is not possible. In Table I, it is assumed that a full substitution is taking place, i.e. no alteration of properties through recycling.

Latest EAA LCI datasets developed for the European aluminium industry [11] estimates the GHG emission of 9,7 kg of CO_2eq by kg of primary aluminium ingot produced in Europe while the production of recycled ingot from end of life scrap reaches 0,5 kg CO2eq by kg of ingot. According to these figures and the example reported in Fig.2, the GHG emission indicator for module A1 and module D can be calculated as reported in Table 1.

Table 1: GHG calculation of Modules A1 and D for the aluminium ingot

Module	GHG emission (kg CO2eq)			Comments
	Recycling	Primary	Total	
A1	4 x 0,5 = 2	6 x 9.7 = 58,2	60,2	Metal ingot production based on 40% recycled content
D	5 x 0,5 = 2,5	- 5 x 9.7 = -48,5	-46	Additional benefits from EOL recycling based on 90% recycling rate

Assuming a recycled content of 40% at the production stage, the aluminium supply of 10 kg of ingot leads to a GHG emission of 60,2 kg. This GHG emission corresponds to the “cradle to gate” metal supply, i.e. without considering the end of life recycling scenario of the product under consideration. Based on an end of life recycling rate of 90%, the product system is then a net producer of 5 kg of recycled aluminium. Module D calculation gives then an additional environmental benefit corresponding to 46 kg of GHG emission savings.

6.2 Case 2: a steel section

Fig. 3 presents the two routes of steel production: the blast furnace (BF) route and the electric arc furnace (EAF) route. Both routes are distinct and independent up to the continuous casting process. As described Fig. 3, steel scrap is feeding mainly the EAF route, but it is also used in a smaller proportion (up to 20%) in the converter after the blast furnace.

In 2010, the third set of LCI datasets has been released by the steel industry, together with a methodology report [27], which has been peer-reviewed by three independent experts. In this report, the recycling methodology is detailed in Annex 10. This version is fully compatible with ‘module D’, since the principle of system expansion is applied. For sections, the Worldsteel data is collected from sites of both production routes, with the majority being from EAF, and a minority from BF. The quantity of scrap used as an input is 85% and the GHG emission for the production (module A1) is estimated to 1,15 kg CO2eq/ kg of section.

Considering the EAF melting losses, it is estimated that 1,09 tonne of end of life scrap, saves the production of one tonne of slab made with 100% iron ore in a blast furnace (primary production) but it requests the production of one tonne of slab through EAF with 100%

ferrous scrap (secondary production). The avoided impact associated with the flow of 1 tonne of steel scrap, can then be calculated through the following expression:

Scrap avoided impact = (Xpr – Xre)*Y

- Y= 1/1,09, representing the metal yield in the EAF,
- Xpr=LCI for primary production, Xre=LCI for secondary production.

For GHG emission, the scrap avoided impact is 1,61 kg CO_2eq/kg. In order to calculate module D, the net flow of steel scrap generated by the product system needs then to be multiplied by this scrap avoided impact. In the case of steel sections, the use of steel scrap is quite high since it reaches about 85% of the metal supply. At the end of life, the recycling rate of section reaches at least 95%, so that a net scrap generation on the whole product life cycle reaches at least 10%, i.e. representing an additional saving of 0,16 kg of CO2eq/kg of section which is then reported in module D.

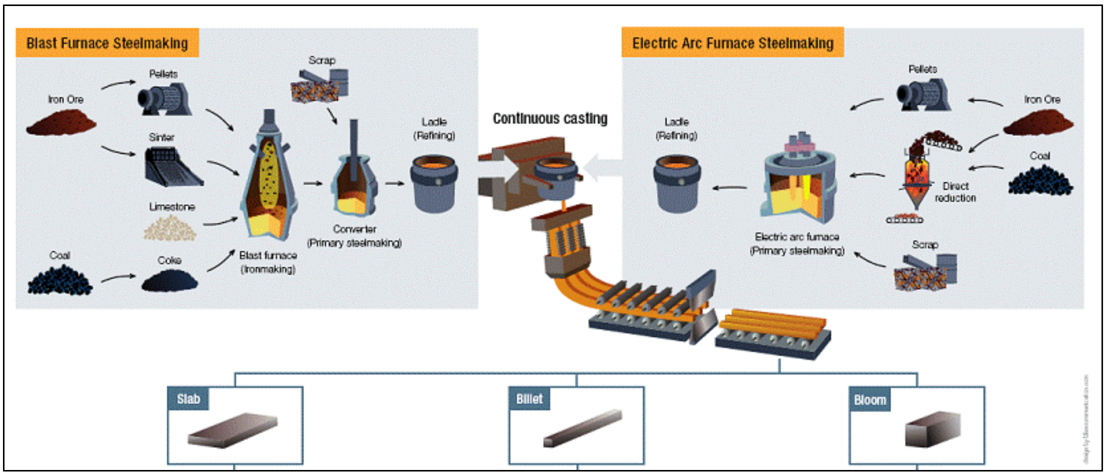

Figure 3: the two routes of steel production

7. CONCLUSIONS

With the current political focus on resource efficiency, the proper consideration of recycling aspects in LCA is becoming increasingly important. In this respect, two contrasting approaches are generally used: the recycled content approach [100:0] and the end of life recycling approach [0:100]. While ISO standards and ILCD handbook recommends using the second approach, at least for metal products, some national standards (e.g. NF P01-010) adopt the recycled content approach, i.e. apply a cut-off rule at the end of life stage, as chosen originally in EN15804. Hence, in order to reach a compromise solution, an independent module has been added to report the complementary environmental aspects related to the net flow of secondary materials and fuels exiting the product system. In this way, the recycling aspects of the product system are fully transparently reported and it is possible to generate full “cradle to grave” or “cradle to cradle” EPD by integrating module D into the assessment while avoiding any double crediting or counting issue. Ultimately, module D is intended to be used to promote the design for reuse, recycling and recovery of all building materials, including metals. At building level [28], module D becomes critical, not only in assessing materials flow on a full life cycle basis, but also in properly assessing the environmental aspects of energy being generated and exported by ‘active’ buildings.

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