

STRENGTHENING EPD ROBUSTNESS - BEST PRACTICES FOR MODULE D

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Guidance Paper

Today, there is a strong focus on demonstrating commitment to reduce environmental impact and promote circular economy principles. Besides using low carbon primary metal, increasing the recycled content is an efficient way to reduce the environmental footprint at production stage.

Since the end-of-life recycling rate reflects more completely the circularity of a product over its whole life cycle, it is important to consider additional environmental benefits that end-of-life recycling offers, while securing no double counting with benefits offered by the recycled content at production stage.

This is what Module D of standard EN 15804 is doing. However, it is important to calculate it correctly and in a consistent way.

This guidance paper clarifies how Module D should be calculated, in relation to the net flow of secondary material generated from the product life cycle. It also highlights practices to be avoided to ensure the reliability and credibility of life cycle assessment results.

Overview

Transitioning to a more circular and less carbon-intensive building environment is imperative. Aluminium reuse and recycling do not only preserve significant abiotic resources but also save up to 95% of the energy and greenhouse gas compared to primary production. Given the current political emphasis on resource efficiency and the circular economy, it is vital to properly account for reuse and recycling aspects on the whole life cycle perspective and their potential contribution to environmental impact within Environmental Product Declarations (EPDs).

Although end-of-life recycling rates for aluminium building products typically exceed 90%, the average recycled content in these products remains much lower. This discrepancy is due to limited scrap availability, which constrains the supply of recycled aluminium and constitutes a bottleneck to achieve high recycled content. The amount of aluminium that can be recycled from building products today depends on the aluminium building market of several decades ago. Given the rapid increase in aluminium use over the years and the long service life of aluminium building products, today's quantity of aluminium scrap available is much lower than the present aluminium demand in the building sector. The difference requires the use of primary aluminium.

As a result, the reusability and recyclability of aluminium building products, reflected by the End-of-life recycling rate, are only partly integrated at the production stage by the recycled content. Hence, to tackle the whole life cycle perspective, the production stage needs to be complemented with the additional environmental benefits resulting from the end-of-life stage. This is what Module D in standards EN 15804 (product level) and EN 15978 (building level) is doing.

The EN 15804 standard outlines the core rules for developing Environmental Product Declarations (EPDs) in Europe. This standard employs a modular approach to cover the three product life cycle stages: production (Module A), use (Module B), and end-of-life (Module C). However, a cut-off rule is applied to Module C so that the environmental aspects resulting from reuse or recycling at end of life cannot be considered. To address this gap, Module D has been introduced. It calculates the additional environmental aspects resulting from recycling or reuse at the end of life through the substitution methodology.

Likewise, at the building level, Module D in EN 15978 complements Modules A to C by evaluating the additional recycling or reuse benefits throughout the building's life cycle by substitution. This information is crucial for supporting a sustainable circular economy in the building sector.

It is very important to note that, by considering only the net flow of secondary material generated by the product life cycle, i.e. by excluding the recycled or reused content, Module D avoids double counting.

Consistent calculation

To clarify this concept, the following example (illustrated in Fig. 1) explains the calculation principle, demonstrating how Module D can be properly calculated and how errors can be avoided. This simplified example only reports the calculation principle for the aluminium production and recycling, i.e. ingot production, but it does not consider all the downstream manufacturing processes. This example assumes the production of 1 kg of Aluminium sheet made of 40% recycled metal (i.e. 0,4 kg of scrap input to Module A) which is recycled at a rate of 90% at end of life (i.e. 0,9 kg of scrap output from Module C, assuming no losses along the recycling value chain).

Module D assesses the additional benefits derived from the net flow of scrap exiting the system, representing 50% (90% minus 40%) recycled metal, equivalent to 0,5 kg (0,9 kg minus 0,4 kg) of scrap that is not addressed by recycled content. These benefits are computed through substitution method, considering the environmental burdens of recycling/reuse for 0.5 kg of aluminium, offset and balanced by the savings in environmental burdens of the primary aluminium that is substituted.

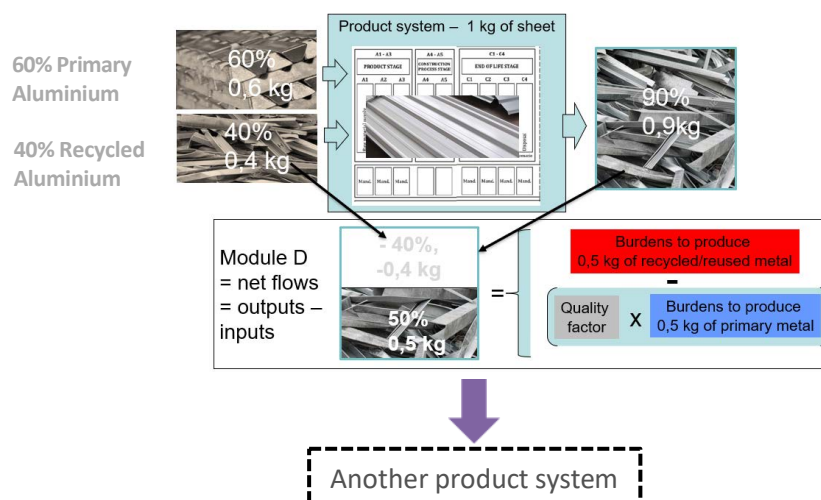


Fig.1. Module D calculation principle as per EN 15804

For simplicity reasons, such mass flow neglects the metal losses during the melting/recycling process

Example of **correct calculation** for the GHG emissions - simplified example for 1 kg of Aluminium product. To make it straightforward, the values were simplified in the next table, in the column “**Case 0**”.

Table. 1:

	EN15804/EN15978		Values	
Parameter name	Parameter	Module Relevance	Unit	Case 0 Correct calculation
Primary aluminium input	M_{Pr}	A	kg	0,6
Recycled aluminium inp %RC	M_{Recin}	A & D	kg	0,4
Total Aluminium input				1
Aluminium recycled at E of life – output	M_{RecEoL}	C3 & D	kg	0,9
Recycled aluminium considered in Module D	$M_{net=}$ $M_{RecEoL} - M_{Recin}$	D	kg	$= (0,9 - 0,4)$ $= 0,5$
Process Emissions				
Primary aluminium burden /kg Aluminium - Production	E_{pr}	A	kg CO _{2e} /kg Al	9,7*
Primary aluminium burde /kg Aluminium - EoL - substitution	E_{pr}^*	D	kg CO _{2e} /kg Al	9,7
Aluminium recycling burden/kg Aluminium	E_{rec}	A & D	CO _{2e} /kg Al	0,5**
Results				
Module A			kg CO _{2e}	6,02
Module D			kg CO _{2e}	-4,6

Sources: *[European Average](#) for primary aluminium used in Europe , **[European Average](#) for remelting aluminium in Europe, *** [Global average](#) for primary aluminium from International Aluminium institute

Module A calculation (production, excluding the conversion of the ingot into sheet and metal losses)

$$\text{Module A} = M_{Pr} * E_{Pr} + M_{recin} * E_{rec}$$

- A recycled content of 40% is used
- Module A: $0,6 * 9,7 \text{ kg CO}_2\text{e} + 0,4 * 0,5 \text{ kg CO}_2\text{e} = \mathbf{6,02 \text{ kg CO}_2\text{e}}$

Module D calculation (neglecting metal yield/losses of the recycling processes)

Module D = $M_{net} * (E_{rec} - E_{pr})$, where M_{net} is;

$$\text{Net recycled quantity } M_{net} \text{ (net flow)} = M_{RecEoL} - M_{recin} = 0,9 - 0,4 = 0,5 \text{ kg}$$

- A **net** flow of 0,5 kg of metal scrap enters Module D. Hence this flow shall be used to calculate Module D

$$\begin{aligned} \text{Module D} &= 0,5 \text{ kg} * [0,5 \text{ kg CO}_2\text{e} - 100\% * 9,7 \text{ kg CO}_2\text{e}] \\ &= 0,5 \text{ kg} * [- 9,2 \text{ kg CO}_2\text{e}] = \mathbf{- 4,6 \text{ kg CO}_2\text{e}} \end{aligned}$$

In such a case, 0,5 kg of metal scrap conveys a carbon saving of +4,6 kg CO₂e leaving the system, providing an environmental benefit of -4,6 kg CO₂e.

Calculation issues

In the context of life cycle assessment, it is important to understand the relationship between the results of Module A and Module D. Module A represents the environmental impacts of the production stage considering the specific contribution of reuse or recycling in the form of recycled content or reused parts in the products. In the previous example, there was a contribution of recycling at a level of 40%, i.e. the so-called recycled content, providing a result of **6,02 kg CO₂e**.

On the other hand, Module D accounts for the additional benefits resulting from recycling (or reuse) at the end-of-life stage. Since most aluminium building products are net generators of scrap from their life cycle, Module D reports negative values corresponding from the additional environmental savings resulting from the primary aluminium substituted. In the above example, a net production of 0,5 kg of recycled aluminium is generated from the product life cycle corresponding to a calculated saving of **-4,6 kgCO₂e**. Those additional GHG savings appear consistent and robust considering the product life cycle scenarios.

However, in practice, it happens that Module D can present higher values in absolute terms compared to Module A. In such a case, Module D may be considered as less consistent with the product life cycle scenario. Such issue may happen in two typical cases which are described below “**Case 1 and Case 2**”:

Table. 2:

	EN15804/EN15978		Values			
Parameter name	Parameter	Module Relevance	Unit	Case 0 Correct calculation	Case 1	Case 2
Primary aluminium input	M_{Pr}	A	kg	0,6	0,6	0,6
Recycled aluminium input = %RC	M_{Recin}	A & D	kg	0,4	0,4	0,4
Total Aluminium input				1	1	1
Aluminium recycled at End of life – output	M_{RecEoL}	C3 & D	kg	0,9	0,9	0,9
Recycled aluminium considered in Module D	$M_{net=}$ $M_{RecEoL} - M_{Recin}$	D	kg	$= (0,9 - 0,4)$ $= 0,5$	0,9	0,5
Process Emissions						
Primary aluminium burden /kg Aluminium - Production	E_{pr}	A	kg CO _{2e} /kg Al	9,7*	9,7	9,7
Primary aluminium burden /kg Aluminium - EoL - substitution	E_{pr}^*	D	kg CO _{2e} /kg Al	9,7	9,7	14.8**
Aluminium recycling burden/kg Aluminium	E_{rec}	A & D	kg CO _{2e} /kg Al	0,5**	0,5	0,5
Results						
Module A			kg CO _{2e}	6,02	6,02	6,02
Module D			kg CO _{2e}	-4,6	-8,28	-7,15

Sources: *[European Average](#) for primary aluminium used in Europe , **[European Average](#) for remelting aluminium in Europe, *** [Global average](#) for primary aluminium from International Aluminium institute

1) Case 1- wrong calculation of the net flow of scrap.

As described in section 6.4.3.3 of EN 15804:2019, Module D aims at assessing the benefits and loads resulting from the net flow of secondary fuels or materials exiting the product system. 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 aluminium sheet, the point of equivalence is the slab (rolling ingot). Hence, module D calculation needs to consider on one side the burdens of the recycling processes from the scrap up to the slab level while the benefits are calculated by the burdens of primary slab production which are effectively saved by substitution.

Calculation of the flow scrap is a key point, as wrong calculations may result in double counting of the benefits. This issue is illustrated in case 1, where the recycled quantity used to calculate Module D is the full exiting flow of 0,9 kg instead of the net flow of 0,5 kg. This calculation results in a Module D of – **8,28 kg CO_{2e}**, which is in absolute value much higher than Module A results, illustrating the double counting of the recycling credits and the illogical outcome of having negative values for the sum of Module A and Module D, as if the product would be a CO₂ sink.

To avoid this mistake, considering/ only the net flow of secondary material to be addressed in Module D is essential, i.e. the secondary material exiting the system boundary at the end-of-life minus the entering secondary material already considered at the production stage.

1) Case 2 – Higher impact of primary aluminium production substituted at End-of-Life stage compared to the production stage

High negative values in Module D compared to the values of Module A can be obtained when, at the production stage, aluminium is mostly sourced from primary aluminium with a low environmental impact, while Module D is calculated based on a different type of primary aluminium dataset which has a much higher environmental impact. In such cases, the negative values reported in Module D may exceed, in absolute terms, the values reported in Module A.

In other words, this issue arises when the impacts/burdens of primary production, which are used to calculate the savings/avoided emissions at End-of-Life (EoL), are significantly higher than the emissions of primary production at the production stage. For instance, in “Case 2” as reported in Table 1, using the global average GHG emission of **14,8 CO₂e/kg ingot** as E_{pr}^* at EoL stage versus the European average of **9,7 kgCO₂e/kg ingot** at production stage. This approach results in “Module A” maintaining the same value of **6,02 kgCO₂e** as in Case 0, because nothing has changed at production stage. However, Module D would end up with a result of **-7,15 kgCO₂e**, instead of **-4,6 kgCO₂e** in Case 0.

So, in Case 2, Module D exceeds Module A in absolute terms. Such results do not appear consistent since the additional savings from the whole life cycle of the product appear higher than the impacts. To avoid this problem due to the inherent limitations of the substitution methodology, a rule should be implemented stating that the impact of primary production used at the end of life (E_{pr}^*) for calculating savings should always be lower than or equal to the impact of primary production used at the production stage ($E_{pr}^* \leq E_{pr}$).

The above proposed rule has already been proposed by the European Commission in the context of batteries for electric vehicles, the first product for which a European legislation will set the rules for carbon footprint calculation according to the Product Environmental Footprint methodology, which is also using the substitution methodology. The draft delegated acts of the [Batteries for electric vehicles - carbon footprint methodology \(Draft Annex page 23\)](#), states the following:

“ E_{pr}^ is the specific emissions and resources consumed arising from the acquisition and pre-processing of primary material assumed to be substituted by recyclable materials. E_{pr}^* shall be modelled based on the European average production or, when the European average production is not available, based on the global average production. However, E_{pr}^* shall be equal to E_{pr} when E_{pr} is lower than the applied average production”*

Similarly, European Aluminium recommends by default to use for the module D calculation, the LCI dataset corresponding to the primary aluminium used in Europe. However, if the impact of this dataset based on kgCO₂e is higher¹ than the primary aluminium used at the production stage, the later should be used instead. This calculation principle ensures that the overall life cycle assessment remains balanced and credible, better reflecting the environmental impacts and benefits. Therefore, applying systematically this principle will secure a more consistent and reliable assessment of environmental impacts across the product life cycle.

¹ Impact of datasets should be compared on basis of their single score calculated by the [PEF method](#)

Concluding Remarks

Ensuring the accuracy and credibility of Environmental Product Declarations (EPDs) and lifecycle assessments is vital for advancing a sustainable circular economy. Properly calculating Module D to make it consistent with the product life cycle is also crucial. Hence, this document provides guidance how such calculation should be done for aluminium products. It addresses on one side the aspects of the net flow calculation of scrap and on the other side, the choice of the primary aluminium dataset used for the substitution method.

Considering these two issues in the LCA modelling is essential for ensuring that Module D maintains its consistency and credibility to the overall life cycle assessment.

References

[Reconciling recycling at production stage and end of life stage in EN 15804: the case of metal construction products.](#)

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[Metals for Building, 2022. *Encouraging reusability and recyclability to reduce whole life-cycle greenhouse gas emissions and maximise circularity.* \[Online\]](#)

[Batteries for electric vehicles – carbon footprint methodology](#)

[Environmental Profile Report for the European Aluminium industry](#)

[PEF Method](#)