Factor B in the Circular Footprint Formula

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1. Introduction

For material recycling to occur, waste material from a product life cycle must be made available for recycling and then used in the production of a new product. To stimulate recycling, when beneficial for the environment, life cycle assessment (LCA) results should give incentives for recycling both to products that can be recycled after use and to products that can be produced from recycled material. However, most established methods for modelling recycling in LCA risk giving little or even wrong incentives [1]. For example, a closed-loop or end-of-life approach gives the entire environmental benefit of the recycling to the product that is recycled after use. This means that producers do not get an incentive to use recycled material in their production. The cut-off approach in an Environmental Product Declaration (EPD), on the other hand, gives not credit for avoided virgin material production to products recycled after use. Most other methods, such as the Circular Footprint Formula (CFF) in a Product Environmental Footprint (PEF), also assign some of the environmental benefits of recycling to the product that uses recycled materials. This means that the incentive to send used products for recycling will be lower. If energy recovery also provides an environmental benefit, the LCA results may indicate that the waste should instead be sent to incineration – even when recycling is the environmentally better option for society. In a PEF, this risk is particularly great for textiles, because most of the environmental benefits of textiles recycling are assigned to the product that use the recycled material (see Figure 1).

Waste incineration with energy recovery yields an environmental benefit when heat and electrical energy from the waste incineration replace generation of heat and electricity that has a greater environmental impact. The CFF includes a Factor B, which can be used for assigning only part of the burdens and benefits of energy recovery to the waste treatment [2]. However, the default value for factor B is 0, which means that a net environmental benefit of energy recovery is fully credited to the products generating the waste. If factor B were given a higher value, the LCA results would give less incentive for energy recovery, and thus more often give an incentive for material recycling. This presentation proposes an approach for calculating factor B in CFF.

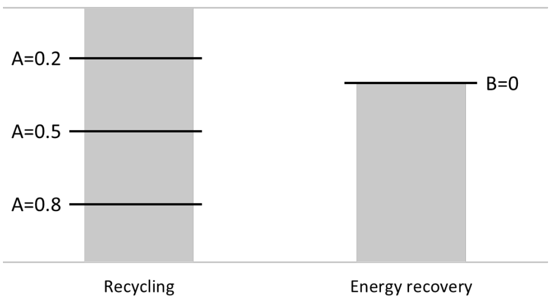

Figure 1: Qualitative illustration of the environmental benefits assigned to a product that is recycled or incinerated in a hypothetical case where both generate a net environmental benefit but material recycling is better for the environment than energy recovery. In CFF, the default value of Factor A is 0.2 for metals and several paper grades, 0.5 for plastics and 0.8 for textiles. The default value for factor B is 0.

2. Materials and methods

The PEF methodology models recycling as well as energy recovery with substitution [2]. For energy recovery, the CFF is

$$(1-B)R_3 \times \left(E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec}\right)$$

where R_3 is the share of material going to energy recovery, E_{ER} is the environmental impact of the energy-recovery process, and the avoided burdens are defined by the lower heating value of the material (*LHV*), the heat and electricity efficiency of the recovery ($X_{ER,heat}$ and $X_{ER,elec}$), and the impacts of the alternative production of heat and electricity ($E_{SE,heat}$ and $E_{SE,elec}$).

When applying substitution at a joint production process, Weidema (e.g., [3]) distinguishes between the co-product that determine the production volume of the process, and dependent co-products that are produced in volumes decided by the demand for the determining co-product. A consequential LCA of a determining product will include the joint production process and the avoided marginal supply of competing products substituted by dependent co-products. A CLCA of a dependent co-product will not include the joint production, since it is not affected by the demand for the product. Instead, it will include the affected, marginal supply of the competing product.

Using the default value B=0 is equivalent to assuming that the waste treatment service is the determining function of energy recovery, i.e. that the volume of waste incinerated is determined by the quantity of combustible waste. This assumption is often wrong. In many countries, combustible waste is deposited at landfills and the volume incinerated is much less than the volume of combustible waste. In some countries, for example Sweden, waste incinerators are constructed even though the existing capacity is more than enough to treat the domestic combustible waste that is not recycled. This is because it is profitable to treat waste from other countries. Hence, the concept of determining functions provides a basis for calculating a value of B that differs from zero.

3. Results and discussion

3.1. Approach for calculating B

The volume of waste incinerated is mainly determined by the waste-incineration capacity, because the incinerators are expensive to build but the running costs are low or even negative. In Sweden, at least, investments in waste incineration are determined by the expected profitability. Heat, electricity, and gate fees paid to deliver the waste all contribute to the profitability. Hence, waste incineration can be described as a process with multiple determining functions: waste treatment and energy recovery contribute to driving the process in proportion to their economic value. We propose that expected revenues from gate fees and energy are an appropriate basis for calculating Factor B:

$$B = V_E / (V_E + V_{GF})$$

where V_E and V_{GF} are the expected economic value of energy and gate fees, respectively.

3.2. Factor B in Sweden

In 2014, Waste Sweden [4] recommended economic allocation of emissions from waste incineration with 58.7% allocated to the energy and the remaining 41.3% to the waste treatment. Using the same values for calculating B we get B=0.587. Using three digits will indicate a precision that does not exist, however. The economic revenues will vary with time and between locations. In Gothenburg, for example, the energy generates only 30% of the revenues in a waste-management system dominated by incineration [5]. Factor B should ideally be calculated based on updated data on expected revenues in the relevant region. However, when such data are lacking, we propose that a default value B=0.6 can be used for Sweden, based on rounded figures from Waste Sweden.

4. References

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