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Summary Paper | Substitution: a Problem with Current Life Cycle Assessment Standards

February 2012

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Introduction

The leading standards for attributional life cycle assessment[1], such as the PAS 2050 (BSI 2011) and the WBCSD/WRI product accounting standard (WBCSD/WRI 2011a) [2], allow the use of a method called "substitution" or "system expansion"[3]. This method is used to deal with situations in which a process has more than one useful output or function (e.g. when the process produces two or more co-products), and the emissions associated with just the product studied need to be separated out or identified. This summary paper briefly explains the "substitution" method and why it creates problems for attributional life cycle assessment.

The Substitution Method

The substitution method involves identifying the product or function that is replaced or "substituted" by the co-product/co-function of the main product which is being studied, and then quantifying the emissions which *would have* occurred if this product had been produced. The emissions which *would have* occurred are then credited to the main product which is being studied.

To give an example, broken down into simple steps[4]:

1. A production process creates 3kg CO_2e and produces 1 unit of product A (the main product studied), and 1 unit of co-product B.

[1] Attributional LCA is an inventory of the emissions and removals from the processes used in the life cycle of a product.
[2] The ISO standard for life cycle assessment (ISO 14044) is unclear on whether it allows substitution or not. If it *does* allow substitution then it is subject to the problems outlined in this paper and should be amended, and if it *does not* allow substitution then the text in ISO14044 should be changed to clearly state that this is the case.
[3] The term "system expansion" is sometimes also used to describe a different method in life cycle assessment, whereby the function studied is expanded to include more functions. It is because of this ambiguity that we have favoured the term "substitution" in this paper for discussing the substitution method. It should be noted that the PAS 2050 and the WBCSD/WRI product standard use the term "system expansion" to denote the substitution method.
[4] The substitution ratios are 1:1 in this example for the sake of simplicity, but the substitution method can work with any substitution ratios.

2. The production of co-product B means that product C is not produced (i.e. 1 unit of B "substitutes" 1 unit of C), and producing 1 unit of C *would have* emitted 4kg CO_2e.
3. Using the substitution method, the avoidance of 4kg CO_2e is credited to product A (for avoiding the production of C), so the overall result for product A is -1kg CO_2e (3kg CO_2e – 4kg CO_2e = -1kg CO_2e)[5].

This example is represented graphically in Figure 1 below.

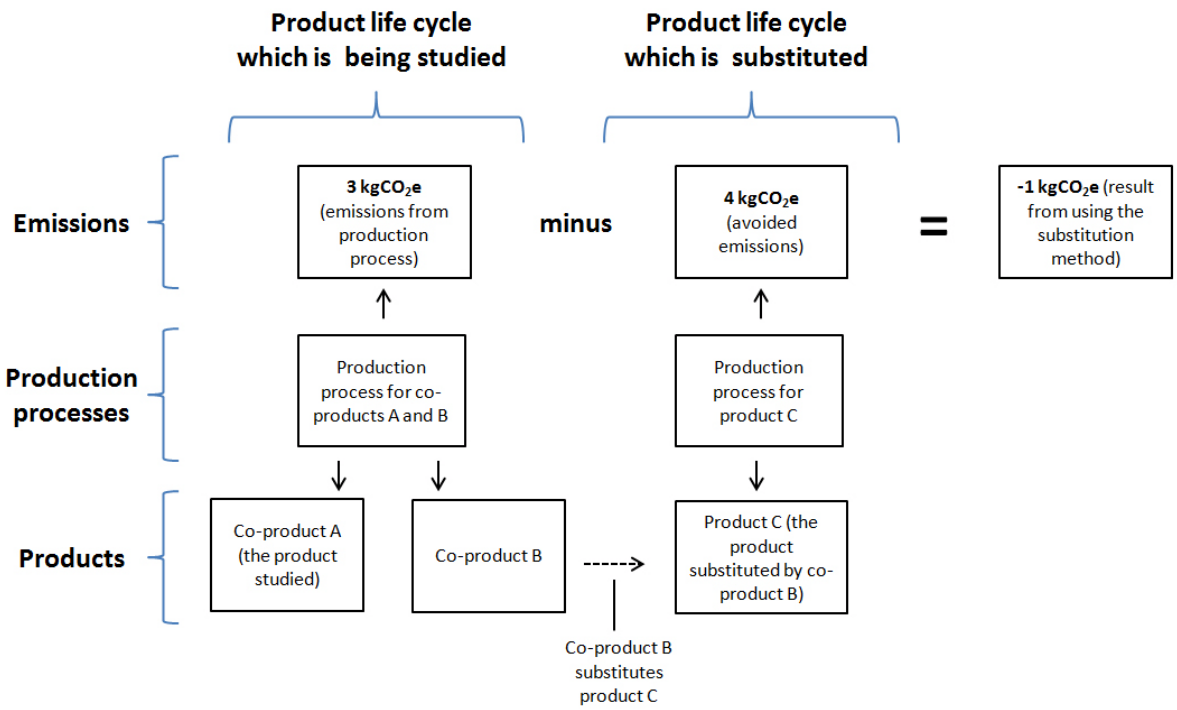

Figure 1. Example of the substitution method.

Problems with Using the Substitution Method

There are at least two problems with using the substitution method in attributional LCA:

1. **A conceptual problem.** Attributional LCA is an inventory of the emissions and removals from the processes used in the life cycle of a product (this can be distinguished from *consequential* LCA which measures the total change in emissions which result from a *change* in the level of demand for a product).

   The problem with using substitution in attributional LCA is that it introduces a value for emissions which *don't happen* (i.e. the emissions associated with the product which is substituted don't happen), and this means the result of the assessment will not be a true inventory of actual physical emissions and actual physical removals. It is not clear what the results of an attributional LCA which uses substitution *mean*, as they are neither a true inventory of actual physical emissions and actual physical removals, nor do they show the full

[5] The result from applying the substitution method is negative in this particular example. The method can also produce positive results if the avoided emissions are less than the emissions from the product system which is studied. It should be noted that both positive and negative results give rise to the problems outlined in this paper.

consequences of a change in the level of production (which is the purpose of consequential LCA). Substitution in attributional LCA creates a strange mixture of attributional and consequential analysis.

2. **An application problem.** Attributional LCA values can be used for consumption-based carbon accounting, and for reporting the emissions associated with procured goods and services in corporate greenhouse gas accounts. However, consumption-based accounting and corporate greenhouse gas accounting are both inventories of actual physical emissions and removals, and do not include values for avoided emissions. The WBCSD/WRI corporate value chain standard clearly states that "Any estimates of avoided emissions must be reported separately from a company's scope 1, scope 2, and scope 3 emissions, rather than included or deducted from the scope 3 inventory" (WBCSD/WRI 2011b, p107). If an attributional LCA has used the substitution method then the result will not be appropriate for use in consumption-based or corporate greenhouse gas accounts.

Conclusion

We recommend that the current attributional LCA standards, such as PAS 2050, the WBCSD/WRI product accounting standard, and ISO 14044, should be amended so that substitution is not permitted in attributional LCA. Multi-functionality should be dealt with by either expanding the function which is studied to include the multiple functions, or by allocating emissions based on attributes such as mass, energy content, or economic value.

For a more detailed discussion of these issues see: Brander M. & Wylie C. (2011): The use of substitution in attributional life cycle assessment, Greenhouse Gas Measurement and Management. http://dx.doi.org/10.1080/20430779.2011.637670

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