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 \emph{would have} occurred if this product had been produced. The emissions which \emph{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\(_2\)e and produces 1 unit of product A (the main product studied), and 1 unit of co-product B.
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 CO₂e.

3. Using the substitution method, the avoidance of 4kg CO₂e is credited to product A (for avoiding the production of C), so the overall result for product A is -1kg CO₂e (3kg CO₂e – 4kg CO₂e = -1kg CO₂e).^5

This example is represented graphically in Figure 1 below.

![Figure 1. Example of the substitution method.](image)

### 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

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^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.
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References

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