

Life-Cycle Assessment and Material Balances - Different Approaches?

In recent years, the analysis of economic processes in terms of the materials being processed and the losses or emissions to the environment that occur during these processes is much practised. This has led to a rather extensive amount of closely related studies, methods, indicators and statements in this field, each with its own definitions and terminology. The result of this is a steadily growing confusion about what is meant by generally used terms as "life-cycle assessment", "material balances", "eco-balances", "input-output analysis" and so on. In some views, life-cycle assessment equals the study of material balances, while in other views these are basically different. The parties implicitly seem to argue here from different basic assumptions.

Let's take two relatively well-defined examples of such types of studies to clarify this point, the product Life-Cycle Assessment (LCA) [1], and the regional Materials Flux Analysis or Substance Flow Analysis (SFA) [2]. The goal of the product LCA is to specify the environmental impacts caused by a product from-cradle-to-grave. The goal of a regional SFA is to present an overview of the flows and stocks of certain substances or materials in a region for a specific year. Both types of analysis could be conducted through a materials balance approach. There are, however, differences in the systems definition:

	regional SFA	product LCA
geography	geographically demarcated area	unlimited
time	specific time period (e.g. 1 year)	unlimited
substances	specific (group of) substance(s)	all materials related to the life cycle
functions	all relevant functions	one narrowly defined function

The differences in the definition of the system lead to different modelling needs as well as differences in the conclusions that can be drawn for combating environmental problems. For example, accumulation and increasing ambient concentrations become apparent in a regional SFA, not in a product LCA.

Imports and exports and transboundary pollution are important categories in a regional SFA, but not distinct parameters in a product LCA. Product LCA aims at being comprehensive with regard to the environmental impacts of certain economic chains, a regional SFA specifies those only for the selected substance within the selected region.

These differences arise from a difference in the object of analysis. For a product LCA, the starting point is the functional unit, the fulfilment of a certain well defined economic function, and the potential contribution to certain environmental problems as a result of this. For a regional SFA, the annual economic activity within a region and its actually occurring environmental problems is the starting point.

In our view, there are two main angles from which to start in this field: the *functional* approach vs. the *regional* approach.

In the functional approach, the fulfilment of certain economic functions determines the system. If we want to specify the impacts of the fulfilment of a function, it almost automatically follows that no temporal or geographic demarcations can be made, not even when looking at function fulfilment for the population of a specific region, because in almost all cases some parts of the economic chain will be located elsewhere and in other time periods. To be location and time specific for all parts of the life cycle is virtually impossible. The product LCA methodology therefore has taken the approach of specifying *potential* impacts, without pretending to comment on what really happens on specific locations on a specific moment in time. The development of a location specific product LCA, which is attempted in various places, presents great difficulties because it can only be successful if brought in line with the basically non-regional functional approach.

The regional approach starts from the region itself, the environmental problems occurring there, and the need for solving those by a regional government. The starting point then is, what actually happens within the region: a specification in space and time. Parts of the life cycle are specified insofar as they are located within the region during a specific period of time, even if this means that production, consumption and waste disposal are partly disconnected.

(Continued on page 4)

(Continued from page 3)

Relations to other regions are specified as imports and exports only. Attempts to squeeze "ecological rucksacks" [3] or suchlike concepts into a regional analysis, adding the parts of the life cycle located outside the region to the system sustained by a fundamentally functional argument of "regional function fulfilment", are bound to fail unless the regional angle is abandoned, and the analysis gives up the pretence of specifying environmental impacts for a given region in a given year.

This does not mean that it is impossible or useless to quantify a concept such as an ecological rucksack, or to start a functional approach from a certain region. On the contrary, quotes such as "The Netherlands needs three times its size to fulfil its consumptive needs", or "Europe's economic materials use adds 40% to the global nitrogen cycle" are valuable and powerful statements. Between the two extreme examples, regional SFA and product LCA, many other types of analyses could be discovered. A few, quickly and loosely presented possibilities could be:

- a "substance LCA": for example, specifying the copper life cycle and its environmental impacts regardless of its location (closely linked to the study of global biogeochemical cycles);
- a "regional function LCA": specifying functions at a regional level, and performing for example a life-cycle assessment of a regions food provision including its stages elsewhere, but excluding the parts located within the region for the benefit of other regions;
- an "expanded SFA": starting from, for example, a regional chlorine production, and including in the systems all parts of the chain benefiting from this production, thereby expanding the region accordingly.

All these types of analysis, and others that could be thought of, have different combinations of choices for time, location and materials. All may be useful in their own way for a specific purpose.

From this, several conclusions can be drawn.

In the first place, LCA and SFA have a different scope, but nevertheless appear to be members of one family. We propose to call this family "integrated chain analysis", as its members start from a cradle-to-grave approach.

In the second place, integrated chain analysis is not an instrument itself, but a family name under which a number of instruments can be categorised. It is therefore important to choose the appropriate angle for a study, and not to try to expand one approach until it becomes all-encompassing. Wriggling "rucksacks" into a regional SFA, or location specific effects into product LCA are examples of such expansion urges. A sharp goal definition should determine the choice for a functional or a regional approach, and also the system boundaries with regard to space, time and materials.

A third conclusion might be, that it could be worthwhile to explore the possibilities and limitations of this family to some extent, and to see if we can identify more family members that may be developed into useful investigation tools.

References:

- [1] Heijungs, R. et al: Environmental life cycle assessment of products. Centre of Environmental Science, Leiden University, 1992.
- [2] As used in Van der Voet, E. et al: Cadmium in the European Community - a policy-oriented analysis. Waste Management & Research, in press.
- [3] "Ecological rucksack": an appealing concept developed to describe the parts of a life cycle taking place abroad for the benefit of a specific region. See for example: Bringezu, S.: Towards increasing economies? Fresenius Envir Bull 2:437-442, 1993.

Authors: Ester van der Voet and Reinout Heijungs, Centre of Environmental Science, Leiden University, P.O. Box 9518, 2300 RA Leiden, The Netherlands.

SETAC-EUROPE LCA NEWS

This bi-monthly newsletter is sent to all SETAC-Europe members. Non-members can send name, address and affiliation to SETAC-Europe, Av. E. Mounier 83, box 1, 1200 Brussels, Belgium. Tel +32-2-772.72.81; fax +32-2-770.53.86 in order to be added to the mailing list.

Copy can be sent to the same address before the 15th of each even month for publication in the next odd month.

Technical articles are welcome but every effort should be made not to exceed one page. Please provide copy on a diskette in one of the following formats: WordPerfect 5.1 / Word for Windows 2.0.