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CONCEPTUAL FOUNDATIONS FOR A SUSTAINABLE WASTE MANAGEMENT: LCA CAPACITY FOR THE DEVELOPMENT OF SUSTAINABLE PRODUCTS

> ... the Commission will address ways to improve the environmental performance of products throughout their life cycle... to prevent waste generation at source. This will comprise action ...for environmentally friendly products, enhancing 'green' demand...
>
> (Environment 2010, 2001, 10)

1. Definition of life cycle assessment (LCA)

The sixth EU environmental action programme introduced an integrated product policy approach based on life cycle assessment (LCA) to satisfy consumer demand with less resources and lower hazard and waste production, and to promote the greening of products and processes. This is to encourage managers, who are going to develop environmentally sound products, to consider the actual environmental impact that is caused by their products during their whole life cycle.

Since the 1960s, LCA has been a tool for assessing the environmental effects of products or processes over their entire life cycle. This is done by identifying and describing quantitatively and/or qualitatively the energy and material use and output of waste into the environment. All transportation involved in the life cycle is also considered. LCA assesses the environmental impacts of the economic system in the areas of ecological systems, human health and resource depletion.

LCA is a methodology to evaluate the environmental consequences of a product or activity holistically, throughout its life cycle from 'cradle to grave' (i.e. from raw material extraction and processing, through manufacture, distribution, use, re-use, recycling and final disposal). LCA is a standardized defined process of the International Standardization Organization – ISO 14040, 14041 series.

2. Stages of an LCA

According to the ISO 14040 standard [ISO, 1997] life cycle assessments include four components:

– Goal and scope definition: Definition of the objectives of the analysis, research boundaries and documentation requirements.

– Life cycle inventory analysis: Data collection considering the entire life cycle.

– Impact assessment: Classification and evaluation of the collected data.

– Interpretation and improvement analysis: Discussion of the results and assumptions (Figure 1).

The goal and scope of the study should be unambiguously and clearly described. The scope should cover the functional unit, system boundaries, allocation procedures, assumptions and limitations etc. The functional unit is defined as a "quantified performance of a product system for use as a reference unit in a life cycle assessment study" [ISO, 1997].

Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system [ISO, 1997]. Thus, inventory analysis aims to quantify all energy and raw material requirements, emissions into the air, discharges into water, solid waste and other emissions at each step of a production process. All the inputs

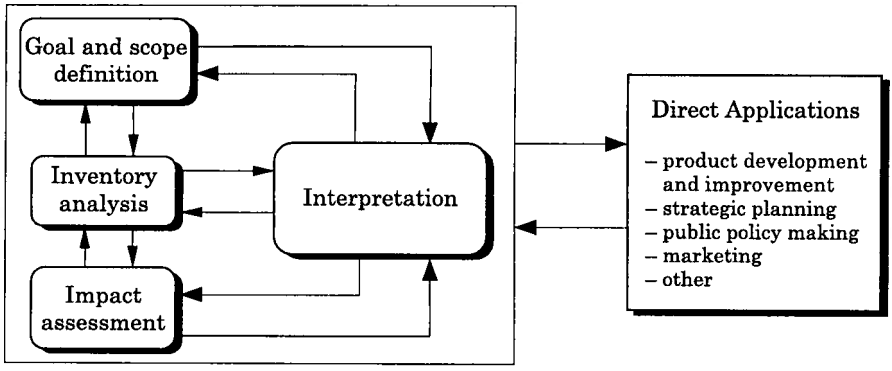

Fig. 1. The phases involved in LCA [adopted from ISO, 1997]

and outputs are normalized according to a functional unit, which is the basis for the calculations performed.

Table 1. Shows the data categories to be collected by inventory analysis

Input	Output
Materials	Product
Energy	Recycled Material Outputs
Water	Solid Waste
Air	Atmospheric Emissions
Transportation	Waterborne Emissions
	Discharged Water

The impact assessment phase of an LCA is aimed at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis and includes the phases shown in Figure 2 [ISO, 1997].

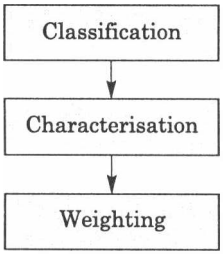

Fig. 2. The impact assessment process

Classification phase: inventory data are assigned to different impact categories based on the expected kind of potential impacts on the environment. The characterization phase involves modelling of the inventory data accounting for the relative contribution within each impact category. The weighting phase is an optional phase [ISO, 1999] where the results for each impact category are weighted into an overall quantitative statement of the potential environmental impact for the product system.

3. Problems in performing an LCA

Several problems may occur when an LCA is performed. These problems are related to the four stages of an LCA and shown in Figure 3.

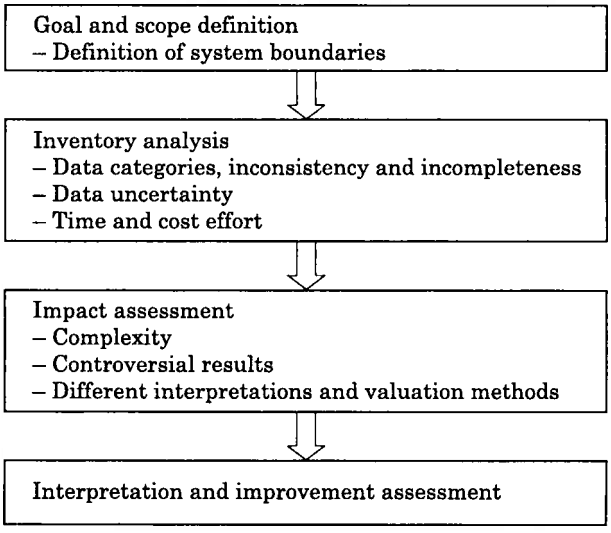

Fig. 3. The four stages of an LCA

The problems of the Life cycle inventory stage are considered at tree levels:

- Company.
- Data
- Methodology

3.1. Company

- Tremendous effort to perform LCA (time, cost, personnel).
- Risk of data outflow when using external consultants.
- Publication of production data.
- Risk of delivering proprietary data to customers: supplier becomes more vulnerable.
- Data availability from companies along the supply chain and throughout the life cycle is difficult.
- Much work has to be done manually.

3.2. Data

- Lack of consistency and incompleteness of life cycle inventory data.
- Difficulties in summarizing the results because of different data formats and sources.
- No transparency in measurement methods.

- Averaged data only available.
- Confidential data.
- No up-to-date data.
- Variation in raw material data, incomplete databases.
- Level of aggregation is too high.
- Data uncertainty.
- Allocation problems

3.3. Methodology

- System boundaries difficult to assign.
- Comparison of various LCA studies is problematical because of inconsistent data reporting, different data measurement methods and use of different sources.
- Possibility of different interpretation.
- Complexity of results. [Januschkowetz and Hendrickson, 2000]

The biggest problem in LCA is a lack of data and the complexity of data collection. Data in most LCA studies are taken from databases, which represent averaged, exemplary or aggregated data. Substitute processes have to be used, if the real processes are not known. No consistent collection along the supply chain is carried out. Mostly, the data are collected for single studies and not continuously. Including an LCA in up-to-date approaches or methods of environmental decision-making can solve these problems.

4. LCA and Cleaner Production

The uses of LCA are increasing. Thus, substantial effort has been focused on standardizing, simplifying and developing methods for LCA. LCA has been included in cleaner production (CP) methods. CP means continuous implementation of a complex preventive strategy in technological processes and products aimed at waste and human health risk reduction. Concerning technological processes, CP includes rational use of raw materials and energy, reduction of both toxicity and volume of all emissions and waste before they leave the technological process. Concerning products, the CP strategy is concentrated on the life-cycle assessment of a product: from raw material extraction to dumping of the used product or use for further processing [OECD, 1997].

In the CP strategy it is assumed that it is better rather to plan and implement actions with no or minor investments to improve environmental performance of the enterprise than invest money in expensive equipment at the 'end-of-the-pipeline'. Such examination usually allows

comprehending opportunities of significant cost savings, and also reduction of potential risk connected with the maintenance and storage of equipment, usage and disposal of raw material.

The main purpose of CP is considered to be reorganization of industry to achieve both ecological and economic effects by prevention of waste generation and pollution at he source. In other words, CP programs aim to increase the profitability of industry by means of water and energy savings, pollution and waste reduction with a simultaneous increase in product quality and occupational safety. To achieve these goals of cleaner production, LCA capacity is used for better understanding of the production process, finding a gap within the production line and collection of environmental data.

The CP method describes a feedback loop to implement activities securing continuous improvement. After implementing the options with the highest priority, the company is supposed to go back to the assessment phase and consider new options for implementation. The purpose of this important part of the method is to ensure the process of continuously improving process of CP.

5. LCA in Eco-labelling

Another mission for LCA is getting ideas for developing eco-label schemes with the aim of influencing consumer choice in favour of more environment-friendly products and the greening of public procurement. The sixth environmental action plan aims at a significant reduction in the quantity of waste going to final disposal by means of information, education and supplementary market-based instruments such as eco--labelling of environment-friendly products and processes.

Eco-labelling is a guide for consumers to make informed choices of products and services that cause less damage to the environment and supports environmental initiatives of companies.

– Eco-labelling makes a positive statement that identifies products and services as less harmful to the environment than similar products and services used for a specific function.

– Eco-labelling is fundamentally different from the setting of minimum product standards or requirements. The key difference is that eco-labelling is intended to reward environmental leadership.

– Information is given below about the eco-labelling in EU and Nordic countries. Eco-labelling programs are different, but their basis is the usage of life cycle assessment.

The "green" revolution in marketing began with non-food products. Products with "green" claims on their labels – like "recyclable,"

"degradable," "environmentally friendly," and "non-toxic" – began flooding the U.S. marketplace in the 1980s.

These green claims certainly haven't been confined to the U.S. Germany's "Blue Angel" label, launched in 1977 to denote "environmentally sound" products, pioneered the green labelling movement.

All of the European countries had specific eco-labels or phrases such as environmentally friendly", "100 percent recycled", "dolphin safe" or "ozone friendly" on their supermarket items. To avoid a proliferation of separate national schemes, the European Commission approved a voluntary "ecolabel", which resembles a flower stem bearing a large "E" surrounded by 12 stars, to help European consumers identify "green" products. Award of the label signals that the item meets 'rigorous environmental criteria and proper fitness for use', but it does not necessarily mean that a product contains any recycled content.

Products featuring the Eco-label should become more widespread as manufacturers apply to be allowed to use the label on products, which comply with appropriate criteria. These criteria are based on a detailed life cycle analysis. The items currently covered are tissue products (toilet rolls and kitchen paper), paper, washing machines, refrigerators, laundry detergents, paints and varnishes, light bulbs, and T-shirts/bed linen.

The Swan (Svanen) is the official Nordic eco-label. Products which are marked with Svanen must fulfil special criteria, which ensure that these products result in less environmental problems than other products for the same purpose.

Eco-label criteria for paper allow greater protection of the environment. Paper consumption represents millions tons per year, and its production, in spite of recent significant improvements, still involves considerable impact for the environment.

The environmental impact of products during their whole life cycle can be divided into three main areas: 1) management and logging of forests, 2) production of pulp, 3) production of the paper itself. There are also environmental impacts associated with the transportation of raw materials and products and the processing of waste after the product has performed its function. The Eco-label aims to help purchasers choose paper that has the least environmental impact in these areas.

All the European Eco-label award criteria go through a revision process every three years to take into account scientific and technological progress. A product's whole lifecycle, from raw material to waste, is studied, as well as the previous criteria aimed at reducing the discharges of various toxic or polluting substances into water, the consumption of energy and related emissions into the air, and a commitment to sustainable forest management is required.

European environmental criteria for paper production are:

1. Emission into water and the air are considered in relation to organic chemicals into water (COD), chlorinated organics (AOX), carbon dioxide (CO_2), sulphur dioxide (as S).

2. Forest management – implementation of principles and measures aimed at ensuring sustainable forest management.

3. Minimization of solid waste: all products of pulp, paper and converted tissue products should have a system for the handling of waste and residual products arising from their production plants. The system should include at least the following points:

- Procedures for separating and using recyclable materials from the waste stream.
- Procedures for recovering materials for other uses.
- Procedures for the handling of hazardous waste.

4. The product should be fit for use.

The new EU Eco-label criteria in addition tackle in more depth the issues of global warming and ozone depletion, with limits on the emissions of CO_2 and NO_x, as well as limiting the use of chemicals that are hazardous to the aquatic environment.

Paper is qualified as a sustainable product, because the production process ensures a reduction in water pollution, global warming, waste and acidification during the whole life cycle and promote the safeguarding of forests.

The Nordic eco-labelling scheme of packaging paper is based on LCA and requires low waste generation, low resource consumption and low environmental impact on forests including:

1. God material properties.
2. Timber from sustainable forests.
3. Sorting off waste at source.
4. Recycling of waste with energy content.
5. The reuse of environmentally friendly chemicals.
6. Low emissions of oxygen consuming substances, chlorinated residual products and phosphor into water.
7. Low emissions of sulphur, nitric oxides and carbon dioxide into the air.

In addition to the existing European and Nordic eco-labelling schemes that define all the procedures and documents, the International Organization of Certification introduced the ISO 14041 standard "environmental management – life cycle assessment – goal and scope definition and inventory analysis". This standard deals with two phases of LCA, goal and scope definition and life cycle inventory analysis and may be used to assist organizations in obtaining a systematic view of the production process, establish a baseline of continued environmental performance

improvement and to provide data for further eco-labelling. A company's choice in favour of the way to environmental performance improvement is determined by the company's purposes, whether they are export-oriented or sell their products on the domestic market. Eco-labelling is influencing, encouraging the greening of public procurement and undoubtedly leading to waste reduction. Therefore, it might be considered as a real and up-to-date tool for waste management.

Literature

Amundsen, A., *Joint Management of Energy and Environment in Industry*. Ph.D. thesis, 1999.

Asham, C., *Life Cycle Assessment – framework and methodology*. Saint-Petersburg, Russia, 2001.

Environment 2010: *Our future, our choice – the sixth environment action programme*. Luxembourg: Office for Official Publications of the European Communities, 2001.

http://europa.eu.int/ecolabel

ISO 14001 – Guideline, International Standard ISO 14001, ISO 14001:1996 (E) Environmental Management Systems – Specification with Guidance for Use. Geneva: ISO/IEC, 1996.

ISO 14024 – *Environmental Labels and Declarations – Guiding Principles*. Geneva: ISO/IEC, 1996.

Januschkowetz, A., Hendrickson, C.T., "Use of Enterprise Resource Planning Systems for the Life Cycle Assessment and Product Stewardship: State of the Art and Current Deficiencies", the Helsinki Symposium on Industrial Ecology and Material Flows, Helsinki, 2000.

Nordic Ecolabeling of Packaging paper, Criteria document, Version 1.4, 10 December 1998 – 9 December 2002.

OECD, Manual for Cleaner Production Program in Central and Eastern Europe. Paris, 1997.