USING LIFE CYCLE ENVIRONMENTAL COST ANALYSIS FOR ENVIRONMENTAL PRODUCT DECLARATION

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ABSTRACT

Providing objective, credible and quantitative description of the environmental properties of products is the primary function of any certified Environmental Product Declaration (EPD). This description should be viewed from a comprehensive life cycle perspective. Certified EPDs should be applicable to products within clearly defined product groups to ensure comparability in the assessments of their environmental properties. The quantitative information included in a certified EPD should be separated for the phases of Life Cycle Assessment (LCA). The phases describe the results of the LCA study from raw material to manufactured product at the industry, distribution to the market, product use and transport to disposal facility, recycling and waste handling.

Life Cycle Environmental Cost Analysis (LCECA) tool is used for interpreting the outcomes of a LCA in terms of environmental costs. The new category of eco-costs includes eight eco-costs namely, cost of effluent/waste treatment, cost of effluent/waste control, cost of waste disposal, cost of implementation of environmental management systems, cost of eco-taxes, cost of rehabilitation (in case of environmental accidents), cost savings of renewable energy utilization, and cost savings of recycling and reuse strategies. It estimates as well as correlates the effects of these costs in all the life cycle stages of a product. Subsequently, LCECA identifies the feasible alternatives for cost effective, eco-friendly products.

LCECA can be used to find out the eco-costs of the product in each of its life cycle phase pertaining to the environmental burdens caused throughout the product life cycle. This facilitates to find out the possibilities of alternatives ensuring more eco-friendliness and cost effectiveness of the product. Also product comparisons within the product groups are also be done with reference to the costs involved. Attaching this cost analysis will be a sign of Extended Producer

Responsibility (EPR), which has to be attributed with any manufacturer today. This paper evolves a methodology for the usage of LCECA in EPD development by the manufacturers.

Keywords: *Environmental Product Declaration (EPD), Life Cycle Assessment (LCA), Life Cycle Environmental Cost Analysis (LCECA), Eco-costs, Extended Producer Responsibility (EPR)*

Background

Characteristics of the environmental assessment of products

Assessing the many processes in a product system can be a major task requiring large quantities of data. However, this task should be achievable within a given time frame. Hence, the nature of the task differs from that for the previously known assessment of an individual emission. The task is not to know all details and assess each individual process and emission with great precision, but to create an overview of the whole product system: an overview, which has not previously existed.

The large number of processes excludes the possibility of knowing all localities and site-specific conditions concerning the emissions in a product system. In other words, variations in the emissions over time and their distributions are often unknown. In most cases, the need for large quantities of data means that the task of collecting data for all actual localities in the product system would be too great. Instead, generally available data for corresponding processes must be used to represent the actual processes.

Consequently, detailed information on time and place cannot be found in most cases. Therefore, the environmental assessment of products can usually exclude an analysis of exposure, as described previously for individual emissions of chemicals and mixtures. The starting point is therefore that the product system is taken as independent of local conditions.

Principle of environmental assessment

An analysis of the exposure of an environment and its biota to an emission is required in order to predict the emission's actual effects. When this is not possible, the environmental assessment of products is limited to a consideration of the potential impacts or effects. The principle of the environmental assessment of products can be summarized as:

Potential impact = [Quantity of substance] X [Substance's impact potential] (Wenzel et.al, 1997)

Hence, the assessment is a summation of all the environmental exchanges in the product system. Depending entirely on where and how an exchange actually occurs, the potential impact can trigger real effects to a greater or lesser degree.

This feature is the most significant characteristic of the environmental assessment methods. It is caused by the difficulty of generating data specific to a product in time and place, and it applies in general to all existing methods. Attention must be paid to this aspect so that results are not over-interpreted where in reality the conclusion is ambiguous.

However, this lack of accuracy in environmental assessment is not a negative limitation. On the contrary, the accuracy in most cases is correct relative to the task of the assessment, namely to provide an overview and aid to rank the solutions for a product which are very different in environmental terms.

Environmental Product Declaration (EPD)

Product Groups with clearly defined products can be given with certified environmental product declarations to ensure objectivity, comparability, and credibility in accessing their environmental properties. EPDs represent an open presentation of the quantitative environmental properties and neutral since no predetermined environmental performance levels are specified.

Swedish environmental management council (1999) guidelines specify that EPDs should be divided into three sections namely,

1. Description of the Manufacturer and of the product or service (a content declaration can be included)
2. Environmental Performance Declaration

3. Information from the company and the certification body

The Information in section 2 shall be certified through a third party review.

EPD information shall be divided into the phases of the Life cycle Assessment of the product. They are,

- Production phase-from raw material acquisition and energy generation to the manufactured product at the factory gate.
- Product use phase – distribution from factory gate and product use
- End of Life phase – transport to the disposal facilities and the recycling process

Description of The Manufacturer and of the product should contain mandatory information and voluntary information. The manufacturing specification consists mandatory information such as manufacturing company, manufacturing site and issuer / contact details, whereas voluntary information are ISO certifications, Environmental policy, manufacturer logo etc. Product specification includes mandatory information such as model, energy consumption, eco labels, noise level, net volume etc. Any special aspects and features of the product relevant to its environmental performance can be included in the voluntary information.

The functional unit is one product either a refrigerator or an air horn. System boundaries of the LCA study are to be defined. Details of production, use and end of life phases are given with respect to emissions, resources and energy consumption.

Details of the transports from the manufacturer to the user and from the customer to the disposal facility shall be included.

The units that are used may be kg for the emissions and material flows and kWh for electricity consumption. As far as possible, allocations should be avoided. The following are the requirements of the information that have to be included in the EPD,

- Resource use – Non renewable and Renewable – material resources (kg/ product)

- Non Specific Energy resources (kWh / product)
- Emissions (expressed in terms of potential environmental impact) - Green house, Ocean depleting, acidifying ozone creating gases, oxygen consuming substances
- Other information waste generation (classified into hazardous and other wastes).

The material declaration may include the total weight of the product and amount of the different materials used in the product. Also the information on non-presence of substances like heavy metals and halogenated compounds may be included. Recycling and disposal details are to be included in the recycling declaration. Finally, the information for the certifying body shall be attached.

Life Cycle Environmental Cost Analysis (LCECA)

The development of the LCECA model follows the guidelines from the LCCA methodology presented by Fabrycky and Blanchard (1991). A new generic cost structure has been additionally included with the CBS of the above-mentioned model. This new category of eco-costs includes:

- *Cost of effluent/waste control*, which is the expenditure incurred towards the in-process effluent control in suitable stages of a product life cycle. This includes the installation, operation and maintenance of effluent control systems throughout the process.

- *Cost of waste treatment*, which is the expenditure in treating the generated wastes at the end of each life cycle stage of a product. This includes the implementation, operation and servicing of the suitable environmental technology applied.

- *Cost of waste disposal*, which is the cost of either land filling or incinerating the treated scheduled waste. This includes the collection and transportation of the scheduled waste.

- *Cost of environmental management systems,* which consists of the expenditures on certification, training, scheduled tasks and monitoring of the established EMS.

- *Cost of eco-taxes,* which includes the eco-penalties, fines and any other legislative expenses at national and international levels, pertaining to a product during the possible stages of its life cycle.

- *Cost of rehabilitation* is the cost experienced in the case of environmental accidents, occupational health hazards and in turn the loss of manpower, etc.

- *Cost of energy,* which is a cumulative cost that, includes all sources of conventional and renewable energy.

- *Cost savings of recycling and reuse strategies*, which are revenues earned by implementing suitable strategies for recycling and reuse in every possible stage of a product life cycle.

The methodology of LCECA is given in Figure 1. As a first step, any product from a particular product family can be selected. Next, a disassembly of the product will be performed. For every part, a cost card will be prepared. This card consists of all the cost details pertaining to the part. Development of a suitable cost model and the identification of the feasible alternatives are performed simultaneously.

Various DfE checklists (Graedel and Allenby, 1996) are used to ensure the eco-friendly nature of the alternatives. These checklists have been prepared based on multiple environmental criteria such as disassembly, material recycling, product reuse, use of renewable energy, minimization of hazardous materials, increase in product durability, use of eco-friendly packaging, saving resources, eco-friendly disposal, etc., relevant to the life cycle design of a product. Based on life cycle impact assessments, suitable alternatives of materials, processes, transportation modes, energy sources, etc., are selected. The prime priorities for the selection are the eco-friendly nature and relatively cost effectiveness of a product apart from its functional requirements.

Costing for environment - Significance of using LCECA

By taking environmental performance of a product into consideration, there is a significant need for the development of an environmental costing methodology. This methodology may provide an environmental accountability for the product by including all of the environmental costs, either without obscuring them into overhead accounts or otherwise by mere oversight. Many environmental costs can be significantly eliminated or reduced as a result of managerial decisions, ranging from operational changes, investing in greener technologies, to redesigning the processes/products. In addition, these environmental costs could be offset by generating revenues through the sale of waste by-products, transferable pollution allowances, or licensing of clean technologies. Application of suitable scientific assessment tools will provide valuable input for these business decisions.

Understanding as well as quantifying the environmental costs of processes and products can achieve more accurate costing and pricing of products. This can aid companies in the design of environmentally preferable processes, products and services. As a result, companies can have a competitive advantage for selling eco-friendly products at reasonable prices.

Better managing the environmental costs can attain improved environmental performance and significant benefits to human health as well as business success. Accounting for environmental costs and performance can also help a company in the development and operation of an overall environmental management system. Such a management system has become a necessity for international trade, as evidenced by the prevalence of ISO certifications.

Pollution prevention practices such as product/process design changes, material substitutions, etc., can reduce or avoid environmental costs. For example, increased environmental costs may result from the use of chemical A, but not from chemical B. This is true when A and B can be substitutable. Another example: some environmental compliance costs are required only when the use of a substance or the generation of a waste exceeds a defined threshold limit. A company that can reduce chemical use below this limit or employ substitutes for regulated chemicals can realize substantial cost savings from design, engineering, and operational decisions. Environmental costs that may include expenditures for raw materials and waste handling and storage, transportation and disposal, training, management overhead, and emergency response can be reduced by pollution prevention measures. Using pollution prevention approaches can also reduce the likelihood of incurring significant future environmental costs, such as remediation activities.

LCA provides a detailed inventory of raw materials, emissions, energy usage, etc. It quantifies the impacts caused at every stage of a product life cycle, which includes mainstream and lateral stream processes. As a pollution prevention tool, LCA can provide a similar set of information on the assessments of possible alternatives. However, LCA cannot provide costing details pertaining to pollution prevention measures. Decision makers with an introduction to suitable tools to expand upon traditional economic analysis of processes/products to identify their environmental costs, can achieve the benefits and cost savings of pollution prevention. There is a strong need for prescribing methods to improve the economic justification of pollution prevention tools such as LCA.

Using LCECA for EPD

Methodology

The methodology followed for using LCECA for EPD is shown in Figure 2. Data collection was carried out in two phases. Life cycle inventory data of the selected packaging material at the manufacturing phase of the life cycle had been collected with the help of standard LCI data sheets. Cost data pertaining to the eco-costs were collected using the cost data sheets, which were developed for this purpose. Since the data was collected from company records and daily ledgers, the quality of the data may be low. In addition, individual cost data had been derived from historic data available within the company.

The LCA had been streamlined by limiting as well as eliminating a few phases of the product life cycle. The SLCA was conducted to find the environmental impacts caused by the product in its manufacturing phase. Simultaneously, the cost data was fed into the LCECA model, which was computed using LIMDEP, a computational software tool. The results of SLCA gave the impact indicators of the manufacturing phase. The results from the computation of LCECA also provided the cost relationships of the eco-costs with the total cost of the product. As a cumulative result, the significance of every eco-cost can be found. The same methodology had been repeated for an alternative. BEA of the cost relationships of the alternatives provided the most feasible solution, which in turn led to the EPD of the product with an economic evaluation.

This methodology enabled an environmental assessment of products in the manufacturing, use and disposal phases of their life cycles. An economic evaluation was also carried out using the LCECA model for interpreting the environmental accountability achieved by this assessment. Product comparisons were done to select more eco-friendly and less costly products between two possible alternatives that are assessed.

Assumptions and references

The following are the assumptions and choices of reference made before performing the case studies to validate this LCECA model. They are listed below in two specific stage categories, namely LCA and LCECA.

LCA

1. *Goal definition*: This study aimed to find the environmental impacts of the selected product, namely an air horn and that of its alternative model.

2. *System boundaries*: The system boundaries were defined as 'gate-to-grave'. As the raw material enters the production floor, the boundary starts and LCA was conducted for the manufacturing, use and disposal phases of the product life cycle. As the finished product enters the disposal facility, the boundary ends.

3. *Functional unit*: The functional unit is one product of the refrigerator or of an air horn produced.

4. *Data quality*: Data from actual measurements, engineering estimates, theoretical or published values, specific manufacturer's or facility's data, and Industry average values were used. Both primary and secondary data were used.

5. *Usage of the study*: The study was targeted for internal use within a company and its parent company for product improvement and material selection.

6. *Alternatives considered*: One of the widely applied alternatives had been considered for this study.

7. *Supporting information*: Details of the processes, intermediate stages, intermediate products, prevailing environmental legislation, and ISO standards were collected and used as supporting information.

8. *Level of specificity*: This study was specifically designed for decision makers, such as top and middle level managers of the companies involved.

9. *Pre-requisites*: List of available data, possibly useful for this study.

10. *Units and methods*: SI units were used throughout the study and all the methods used were stipulated by ISO 14040 series of standards.

LCECA

1. *Nature*: This LCECA study is relative in nature, attempting the find the influences of the eco-costs on the total cost of a product. It helps in the decision-making based on environmental accountability.

2. *Specificity*: This study was a subjective one and it was specific to a particular geographic zone of operation, and particular part families.

3. *Data quality*: Secondary data with low or medium quality were mostly used because of the non-availability of the environmental data. Available historic company data were used after interpolations.

4. *Sample data*: Due to a poor level of environmental management awareness existing in this region and a lack of companies support to conduct these types of studies, sample data was used to validate this model.

5. *Iterative*: Every new application of this LCECA model is highly subjective and it needs suitable changes according to the applied conditions. Repeated iterations can make the model best suited for the situation.

Case Studies In Progress

In order to validate the proposed methodology of using LCECA for EPD, case studies were identified. Based on the availability of data, wide usage, willingness of the manufacturers and time constraints, air horns were selected for the case studies. One of the Indian multi-national corporations, which are producing quality air horns in the Asian region, has agreed to conduct these case studies. Two commonly used models were selected for this study. The manufacturing units are certified with ISO 14000, were recommended by the parent company for data collection and further studies.

Concluding Remarks

A methodology has been proposed for Environmental Product Declaration with eco-costs connected with the environmental performance of the products. Already proven assessment tool LCECA has been used for this purpose. Product comparisons with both environmental and economic assessments are made possible by this proposed methodology which makes EPDs justified in terms of eco-cost.

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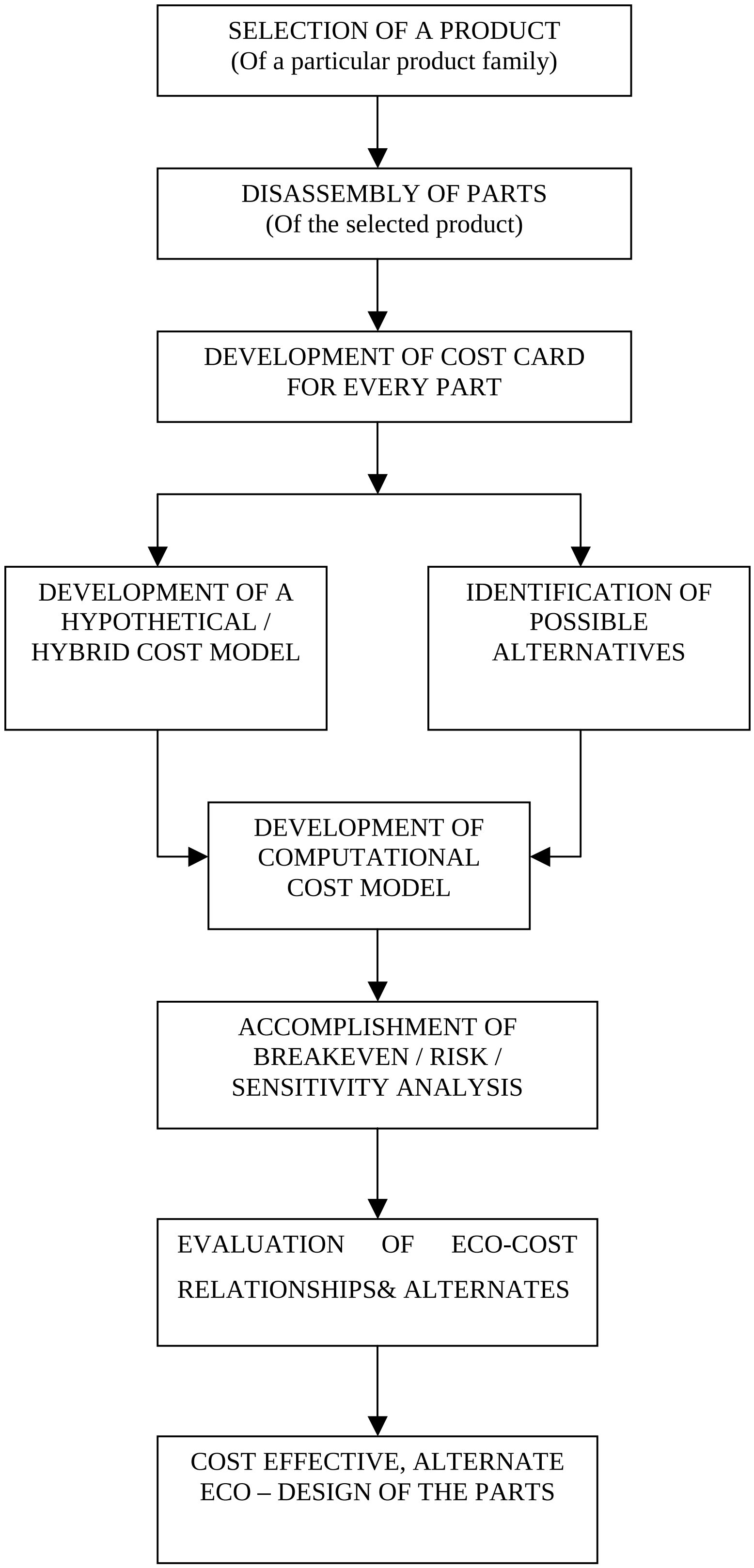

Figure 1. LCECA methodology (Senthil et.al, 2002)

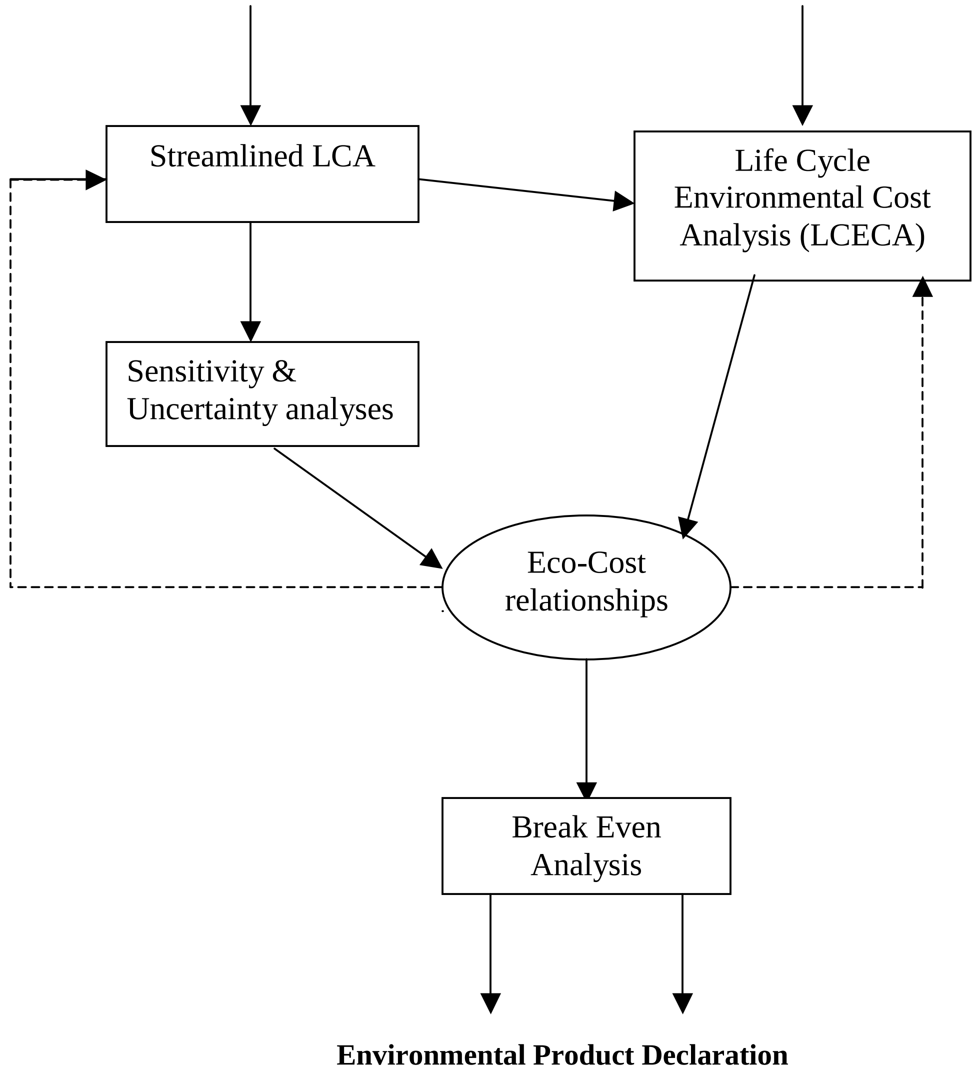

Fig. 2 Methodology of using LCECA for EPD