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ENVIRONMENTAL LIFE CYCLE COSTING AS A TOOL OF COST MANAGEMENT

Summary: Life cycle costing, in the conventional meaning or in cost management practice, is often suitable for neither an assessment of the economic implications of a product life cycle nor modern and adequate management. The LCC approaches need to address the complete life cycle and be expanded to direct connection to other sustainability aspects, such as environmental and social. The main question is how costs and environmental aspects can be combined in a consistent way and help managers to run businesses in the sustainable way. The answer is Environmental Life Cycle Costing. This article presents the main goals, scopes and framework of Environmental Life Cycle Costing and its role, position and relation to Life Cycle Management. The main target of the article is to find answers to the question about the place of ELCC in cost management.

Keywords: LCC, ELCC, cost management, environmental, costing.

1. Introduction

In practice, the project team has chance to use many of the physical and performance data during the product planning. In a situation in which an existing product has been offered for some period of time, it is likely that the data will not be fully collected in a fashion suitable for Life Cycle Costing. In a simple way, the management team should find answers to the following questions:

- What will be the product type?
- Where will it be offered?
- Are there any modifications available?
- What is the general construction?
- What is its general condition?
- When was it built?
- What running cost information is available at this moment and in the future?
- What is the condition of the individual elements of the product?

It should be emphasized that the major purpose is the desire for simplicity, which means clearl and also much detailed questions [Ciambrone 1997, pp. 6–9].

It is good to know that a lot of possible benefits will be lost if the product performance and costs of ownership are not monitored directly throughout product

life cycle. It is important to get feedback on the costs but, on the other hand, there has not been any standardized systematic approach to the collection of product cost data. There is a gap between design, occupation and the availability of reliable data on planning and running costs.

Life Cycle Management (LCM) in simple words is a derivative of LCC and Life Cycle Assessment. In a quite simple and clear way, it identifies those areas in which running costs detailed by Life Cycle Costing might be reduced by a change in operating, planning practice and sometimes the appropriate system.

However, the main aim of Life Cycle Assessment is to guarantee a complete and detailed identification of environmental effects of a product throughout its lifetime. Such an approach leads to the decrease of both issues (economic and social), which can significantly limit the usefulness of LCA technique in conjunction with fundamental premises of sustainable development. This paper presents basic assumptions and concepts of Environmental Life Cycle Costing (ELCC) in the light of recent tests and international research studies as well as analyses of professional literature. The main aim of the paper is to find an answer to the question whether ELCC might be used as a management tool. The author will apply research methods such as methods of deduction with practical assessment. There is few professional publications about Environmental Life Cycle Costing.

2. Introduction to Life Cycle Costing

Life Cycle Costing is an economic assessment of an item, system or facility over its life, expressed in terms of equivalent cycle costing. It is used to compare different options by identifying and assessing economic impacts over the life of each option. It has a unique opportunity to connect initial cost and ownership cost to optimize total cost. The background of LCC may be traced back to the Second World War, when it was created due to material and labor shortages. It is possible to identify two distinct options of Life Cycle Costing:

- estimating costs on a whole life cycle basis;
- monitoring the cost incurred throughout a product life cycle.

Life Cycle Costing takes into account investment costs and costs in the operation of all phases. Total costs can be considered from diverse points of view, for example, from the product supplier or the product user or from the point of view of society. Life Cycle Costing also could be seen as a way of thinking and not only as a costing tool because, in addition to the management of costs, it concentrates on the long-term performance of products by getting a variety of management accounting methods. To know the life cycle costs of a product is one of the basic requirements to consider. For example, in the construction industry LCC is applied to quantifying costs of whole buildings, systems and building components and materials. The technique can assist decision-making, for example, in building investment projects [Hoar 2007, pp. 92–93].

Due to the environmental load imposed by the low, there has been an urge to make the product offer more sustainable. LCA is adopted as a technique to assess the environmental performance of a product throughout its life cycle; LCC could be also used as an economic tool to make product sustainable. Moreover, Life Cycle Costing methodology is composed of three appraisal stages: strategic, system and detail. The strategic level is mostly for the initial appraisal phase in the pre-construction part. The system and detail levels are generally used in the design stage.

3. The concept of Environmental Life Cycle Costing (ELCC)

Environmental Life Cycle Costing (ELCC) is, to use a simple definition, a listing of all the cost incurred during product cradle-to-grave cycle, as borne directly by one or several entities participating in the cycle (such as suppliers, producers, end-users, consumers as well as the entities involved in the end-of-life phase of the product under evaluation). A characteristic item of the ELCC model is the requirement that all the cost under study must refer to the actual monetary flow. The main reasoning behind the development and use of ELCC accounting is the observation that standard methods of product life cycle assessment, such as LCA, are often perceived as barriers to economic development. This is particularly evident in relation to modern technologies, characterized by a drastic reduction of life time cycle. The basic framework of Environmental Life Cycle Costing is shown in Figure 1 [from Hunkeler, Lichtenvort, Rebitzer 2008, p. 11].

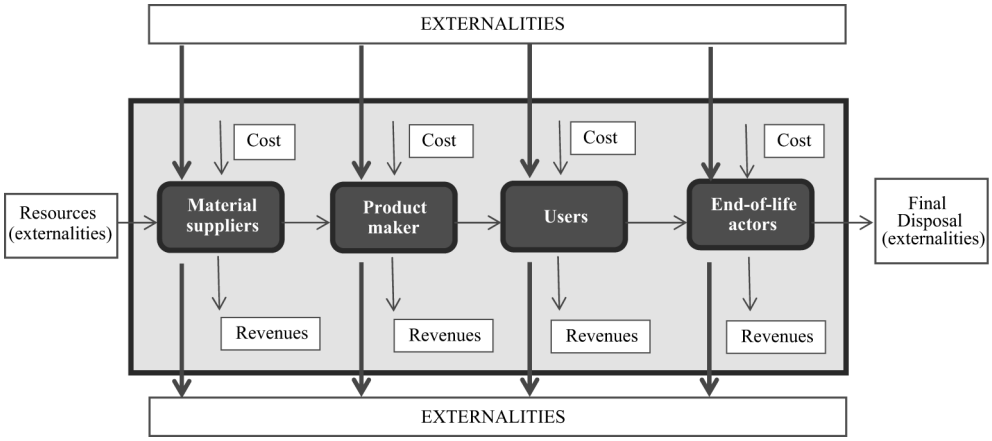

Fig. 1. Conceptual framework of Environmental Life Cycle Costing

Source: Hunkeler, Lichtenvort, Rebitzer [2008, p. 7].

The general structure of Environmental Life Cycle Costing is based on the physical life cycle of the product under evaluation. This approach requires a separate

assessment of five distinct life time stages, detailed and elaborated as required, namely: research and development, production, use and maintenance, and disposal/ recycling management.

Environmental Life Cycle Costing accounting, as contrasted to traditional Life Cycle Costing, supplements product cost analysis with the so-called environmental cost. The environmental cost represents economic cost incurred as a result of environmental use, such as eco-taxes, cost of waste emission and emission control, cost of eco-product marketing, etc. In the conceptual assumptions of Environmental Life Cycle Costing, these cost items should be inventoried and singled out in the profit-and-loss account. On the other hand, it includes in accounting and bookkeeping all the environmental cost supplemented by any external cost that may occur in the foreseeable future [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 9–16].

ELCC should not be employed as an independent technique but in connection with LCA environmental analysis, which is a globally normalized method for the evaluation of environmental impact of a product as well as the estimation of total consumption of resources within the complete product life cycle [Ciambrone 1997, pp. 6–9]. This includes raw material output, production and end-user operation, recycling, energy recovery and eventual neutralization of the remaining waste. The procedures of Environmental Life Cycle Costing accounting should supplement and support the standards (norms) of ISO 14040 and ISO 14044, which apply to life cycle. International ISO standards provide concrete and verified requests for conducting transparent and adequate calculations of such measures as a carbon trace [*Biuletyn*… 2009]. The main standards of the period, as applied to the issue of product life cycle, are:

- ISO 14040: 1997 *Environmental management – Life cycle assessment – Principles and framework* (PN-EN ISO 14040:2000) [http://www.iso.org/iso/catalogue_detail.htm?csnumber=23151];
- ISO 14041:1998 *Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis* (PN-EN ISO 14041:2002) [http://www.iso.org/iso/catalogue_detail.htm?csnumber=23152];
- ISO 14042:2000 *Environmental management – Life cycle assessment – Life cycle impact assessment* (PN-EN ISO 14042:2002) [http://www.iso.org/iso/catalogue_detail.htm?csnumber=23153];
- ISO 14043:2000 *Environmental management – Life cycle assessment – Life cycle interpretation* (PN-EN ISO 14043:2002) [http://www.iso.org/iso/catalogue_detail.htm?csnumber=23154] .

In 2006, ISO board formulated a number of new standards. Polish translations provided by PKN included:

- ISO 14040: 2006 *Environmental management – Life cycle assessment – Principles and framework* (PN-EN ISO 14040:2009) [http://www.iso.org/iso/catalogue_detail?csnumber=37456];

- ISO 14044: 2006 *Environmental management – Life cycle assessment – Requirement and guidelines* (PN-EN ISO 14044:2009); [http://www.iso.org/iso/catalogue_detail?csnumber=38498].

The following stages may prove useful for the purpose of the realization of LCA technique supplemented by ELCC accounting. It must be underlined that the stages of construction and implementation may vary depending on the characteristics of end users. A basic outline of the stages involved could have the following list [Hunkeler, Lichtenvort, Rebitzer 2008, p. 12]:

1. goal and scope definition,
2. data collection,
3. data interpretation and identification of key points,
4. susceptibility analysis,
5. conclusions.

According to M. Rosund, the process of preparing the cost accounting of Environmental Life Cycle Costing could be proposed as follows [Kowalski, Kulczycka, Góralczyk 2007, p. 169]:

1. problem definition,
2. definition of cost elements,
3. system modeling,
4. data collection,
5. cost profile modeling,
6. evaluation.

ELCC should be performed within the second stage of the LCA process, i.e., during input data inventorying as well as output data inventorying for individual processes and for selected functional units. Input data, which is a catalogue of materials and energy use, can be supplemented by cost data pertaining to each item. Output data, taking into account emission and waste production data, can be supplemented with corresponding cost of economic use of environment. In this way, both "input" and "output" may be presented in monetary terms [Hendrikson, Lave, Matthews 2006, p. 10].

Thus, Environmental Life Cycle Costing may be summarized as a sum of all the cost incurred during design, construction, production, transportation, operation and, eventually, storage, recycling and utilization of a product. In addition, implementation of ELCC accounting requires a pre-defined time-frame (product life-span) to be employed in the analysis. Such a time-frame should correspond with the estimated duration of environmental impact of the product under study. ELCC should account for investment risk by means of a predefined discount rate. International scientist suggest that the discount rates for each category of an environmental impact should be set, for example, 0.1% for natural resource depletion, 0.01% for climate changes and 0.001% for toxicity [Kowalski, Kulczycka, Góralczyk 2007, pp. 160–161].

4. The scope of Environmental Life Cycle Costing

The ELCC method scope differs widely from the premises of the LCA method since, by design, it applies not only to environmental impact but also to cost. Environmental Life Cycle Costing accounting should not be held as part of financial accounting methods. This method is part of cost management processes in the context of sustainable development, aimed at the estimation of the cost incurred within full life-span of the product under study. Moreover, the LCA method is not an accounting method but a management method aimed at estimating a total environmental impact of a product to be employed in the evaluation of alternative solutions [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 39–40].

The target and scope of ELCC should be emphasised in product research and implementation. It is important to establish the margins of both the system as a whole and its individual units addressed by cost analysis. The most fundamental activities as a part of ELCC include:

- determination of total cost incurred;
- evaluation of product competitiveness (determination of consumer cost);
- reporting, monitoring and evaluation of company internal cost;
- preparing a compromise on the managerial level in respect to product portfolio and their relationship with ELCC;
- recognition of potential alternatives with less environmental influence;
- identification of the compromise between business and environmental aspects;
- defining corporate social responsibility and social influence of the product;
- analysis of potential economic benefits for consumers, determining the environmental and social impact at EOL stage;
- defining correlations between internal and external cost;
- defining the optimal life cycle [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 12–13].

Environmental Life Cycle Costing, as shown earlier, refers to all the cost incurred. The total cost is part of the system defined within the LCA method. Following this way of thinking, the ELCC calculation may be formulated as follows. Naturally, this is a first expression like an entry point and could be modified in accordance with the requirements of a given entity.

$$ELCC = C_{IC} + C_{IN} + C_E + C_O + C_M + C_S + C_{ENV} + C_D,$$

where: C_{IC} – initial investment cost;
C_{IN} – installation cost;
C_E – energy cost;
C_O – operational cost;
C_M – cost of repairs and maintenance;
C_S – cost of stoppages and production losses;

C_{ENV} – additional environmental cost;
C_D – cost of recycling, discharge, rehabilitation [Kowalski, Kulczycka, Góralczyk 2007, p. 174].

5. The framework of Life Cycle Management system

To manage effectively a life cycle of a product, a firm can uncover a wealth of business, environmental and social value, then make a choice to engage in more sustainable activities and production patterns. Life Cycle Management is a framework for business planning and management. It useful to business by:

- analyzing and understanding the life cycle stages of the product;
- identifying potential economic, social, or environmental risks and opportunities at every stage;
- establishing proactive systems to pursue the opportunities and manage risks.

Life Cycle Management is not expensive to implement. Putting a life cycle thinking to management could help ensure that a business is either environmentally friendly or helps to identify opportunities to gain a stronger competitive advantage, reduce costs, improve strategic decision-making, design better products, improve relationships with key stakeholders [http://www.epa.vic.gov.au/Lifecycle/whatis.asp].

Life Cycle Management is all about making more informed and detailed business decisions, such as:

- products to be lunched,
- design of a product or service,
- sources of energy to use,
- management of manufacturing wastes,
- recycling considerations,
- preferred suppliers.

Life Cycle Management is a simply business management approach that can be used by all types of businesses (and other organizations) to make decisions in a more deliberate and systematic way and to improve their products and thus the sustainability performance of companies. It could be adopted by both large and small firms; its purpose is to ensure more sustainable value chain management. It can be used to target, organize, analyze and manage product-related information and activities through the life cycle. Life Cycle Management can be deployed as a part of a specific methodology, technique or "add on" environmental requirement. On the other hand, it is a systematic approach, mindset and culture that is embraced throughout the business, where decisions are made so that they can have an effect both on the input and outputs of product life cycle. Thanks to this, Life Cycle Management is becoming a systematic integration of product sustainability in company planning, product design and development, purchasing decisions and communication systems. Life Cycle Management is a quite new method that integrates different elements

of practices that have been used in businesses and brings clear business benefits to complement its environmental benefits. Companies are positioned to identify and realize cost savings through their product life cycle including all stages. These cost savings and environmental benefits can result from design or process changes that reduce material and energy consumption, emissions and waste. It can be helpful to reduce risk of future liabilities by assisting to minimize the environmental problems associated with product production, use, servicing and disposal. Life Cycle Management is about creating life cycle thinking and product sustainability operational for businesses that are striving towards reducing their footprints and minimizing their environmental and socio-economic problems while maximizing economic and social values [http://www.epa.vic.gov.au/Lifecycle/benefits.asp].

Leading companies which adopted life cycle management include:

- 3M – used life cycle management and related tools with the objective of preventing pollution and decreasing materials of concern;
- Eskom – used life cycle management to save money and to increase efficiency by reducing energy, reducing the use of materials and saving water and to support important investment decisions;
- Veolia Environnement – used life cycle management to deal with final customers and see sustainability as offering a competitive advantage.

6. Environmental Life Cycle Costing as a part of Life Cycle Management

The role of environmental support is to help different areas of the enterprises make improvements in their environmental performance. Environmental support may be needed in firms in the following spheres:

- different organizational procedures such as implementation of an environmental management system,
- environmental assessment studies such as life cycle assessment,
- life cycle cost analysis,
- environmental risk assessment,
- environmental and sustainability reports,
- monitoring, correcting and auditing environmental management system,
- environmental training of personnel,
- environmental life cycle costing.

Environmental Life Cycle Costing presents simultaneously cost and life cycle impacts. Linking the environmental and cost impact for products can extract the entire subjective analysis. Environmental Life Cycle Costing is neither a financial accounting system nor a managerial accounting system converting indirect to direct costs. There is no typical, detailed calculation; therefore, it must be complemented with estimates procedures and techniques. Firms are compared with a very competitive

market, which pushes for increased efficiency and reduced costs. Environmental Life Cycle Costing can be used to extend managerial decision limits to include suppliers and customers and the time horizon in the future [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 12–13].

SETAC experts conclude that, "Environmental managers are interested in ELCC owing to a general consensus that present accounting practices do not fully capture the costs of many business decisions". It should be noted that there can be a significant effort in identifying, for example, various indirect or partially hidden costs and relationship costs to estimate the true cost. Environmental LCC tries to get any monetary flow anticipated in the decision-relevant future. On the other hand, it can be an effective instrument to identify additional business chances by expanding the scope of the financial analysis covering longer time horizons. Environmental Life Cycle Costing contains real costs to be internalized in the decision-relevant future due to its complementary with life cycle management [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 75–90].

7. Conclusion

This paper explored the use of a current Environmental Life Cycle Costing procedure as a part and tool of Life Cycle Management. A few years ago, environmental protection and management practices were mainly focused on addressing emissions and waste discharges to the environment from production processes. Nowadays, attention has shifted to product life cycles and their environmental impact. Thus, efforts are being made to optimize every step of product life cycles, from extraction of raw materials through processing, manufacturing and transportation to reuse, recycling and final disposal. Companies have started to view environmental performance as an important marketing aspect of a product. Life cycle assessment, environmental life cycle costing, environmental risk assessment, environmental performance indicators and environmental product declarations were therefore introduced to support industries in environmental management practices. LCA appraisal should be supplemented by cost analysis in the form of Environmental Life Cycle Costing. ELCC offers notable benefits in such applications as design of technological processes, making informed management decisions for a rational use of internal resources of economic entities and optimization of the compromise between environmental care, business and social aspects. ELCC-based information offers the prospect of making wise decisions in the context of sustainable development.

General conclusions which suit well with Life Cycle Management and Environmental Life Cycle Costing principles include the following information:

- it is a good communication tool both internally and externally;
- the sensitivity studies provide a means to integrate the ELCC into LCM;

- discount rates on the decision follows processes that would be applied in financial assessments;
- they also open the door to new ideas for providing the same products, but with reduced environmental impacts;
- they demonstrate a proactive approach to environmental management and sustainability [Hunkeler, Lichtenvort, Rebitzer 2008, pp. 75–90].

LCM results from a global trend to incorporate environmental considerations into purchasing decisions thanks to which ELCC is a part of cost management.

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RACHUNEK KOSZTÓW ELCC JAKO ELEMENT ZARZĄDZANIA KOSZTAMI

Streszczenie: Rachunek kosztów cyklu życia (*Environmental Life Cycle Costing*), zarówno w tradycyjnym rozumieniu, jak i w praktyce zarządzania kosztami, bardzo często nie jest odpowiednio dostosowany ani do zarządzania kosztami, ani do oceny ekonomicznego wpływu produktu na środowisko. Ekologiczne rozumienie stało się częścią składową obecnie stosowanych metod zarządczych przez przedsiębiorstwa. Uzyskuje się bazę informacyjną

o kosztach i przychodach powiązanych z wpływem danego produktu na środowisko. Rachunek kosztów ELCC staje się uzupełnieniem tradycyjnego rozumienia rachunku kosztów cyklu życia, a także wspomaga technika LCA. Definiuje się go jako łączny koszt ponoszony w całym cyklu życia wyrobu z uwzględnieniem kosztów środowiskowych. Artykuł prezentuje cele, założenia oraz ramy ELCC i jego rolę, pozycję i relację z zarządzaniem przez cykl życia. Głównym problemem postawionym w artykule jest odpowiedź na pytanie: czy rachunek ELCC jest elementem zarządzania kosztami?

Słowa kluczowe: LCC, ELCC, zarządzanie kosztami, środowisko, rachunek kosztów.