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CORRELATION BETWEEN ENVIRONMENTAL, ECONOMICAL AND SOCIAL ASPECTS IN LCM OF TECHNICAL OBJECTS

Krzysztof Koper

Faculty of Machines and Transport, Poznan University of Technology, Piotrowo St 3, 60-965 Poznan, Poland, e-mail: krzysztof.koper@put.poznan.pl

Abstract: *Life Cycle Management integrates categories of impact an object has on environmental, economical and social levels with phases of its life cycle in which certain categories of those impacts are dominant. This can be presented in a form of matrix of interlacing subcategories. After thorough analysis of an object through its life cycle, using complex tools like LCA, LCC and SLCA, decisions can be made concerning its development aimed at reducing impacts in these subcategories. The paper presents a new approach in measurement and evaluation of results in life cycle assessment of products. It also gives an insight for understanding why it is, or is not possible for an object to show improvements in all the categories and spheres simultaneously. Examples of positive and negative correlation are given to illustrate the problem of continuous development of a technical object in means of LCM philosophy.*

Keywords: LCM, evaluation, connection matrix, product development, technical object

INTRODUCTION

In this paper, Life Cycle Management is understood as a framework to analyze and manage the sustainability performance of goods and services, as presented in the UNEP-SETAC 2009 guidelines. LCM methodology is still far from being fully elaborated and there is no agreement on its common definition. It should not be confused with product management strategies like marketing-oriented Product Life Cycle Management (PLCM) or Product Lifecycle Management (PLM), which is based on description of the engineering aspects of a product. LCM concentrates mainly on environmental aspects of a product's life cycle, starting from its conception and project, manufacturing, use and disposal phases. This area is covered by Life Cycle Assessment (LCA), whose philosophy and methodology is firmly developed. Other widely accepted categories that are proposed for introduction in LCM are economical and social impacts. This trichotomy was agreed upon and presented in Life Cycle Management: A Business guide to sustainability in 2007. It resulted as a response to a wide critique delivered by scientists focused on practical introduction of life cycle thinking, like A. Brent (2005) In the mentioned

business guide, LCM is defined as a product management system aiming to minimize environmental and socio-economic burdens associated with an organization's product or product portfolio during its entire life cycle and value chain. The first can be covered by LCC (Life Cycle Costing) methodology. The latter, by SLCA (Social Life Cycle Assessment) idea, which, mainly due to quantification problems, is still at the beginning of its development. Guidelines for conducting SLCA proposed by UNEP-SETAC in 2009 suggest basing it on four specific phases of LCA (goal and scope, life cycle inventory, life cycle impact assessment, interpretation of results) but with different categories of impacts.

It should also be noted that according to some authors, for example H. Yamaguchi (2007), LCA constitutes a wider idea, consisting of environmental analysis (LCIA – Life Cycle Impact Analysis) and economical analysis – LCC.

LIFE CYCLE EVALUATION MODEL

Each of the three impacts can be seen, in less or more extent, in every part of an object's life cycle. Therefore, a matrix can be built, showing interlacing subcategories like e.g. "environmental impacts in disposal phase of an object", "economical consequences of manufacturing phase of a product" or "social burdens connected with the use of an object". The figure below (fig. 1) shows such matrix.

	Life cycle analysis methods (LCA, LCC, SLCA) →					
↓ Quality level description or measurement		Development	Manufacturing	Utilization	Disposal	*Result*
	Environmental	ENV/DEV	ENV/MAN	ENV/USE	ENV/DIS	*Env. Points*
	Economical	ECON/DEV	ECON/MAN	ECON/USE	ECON/DIS	*Money units*
	Social	SOC/DEV	SOC/MAN	SOC/USE	SOC/DIS	*Social Points*
	Result	*Quality Level*	*Quality Level*	*Quality Level*	*Quality Level*	

Fig.1: Life cycle phases/impacts matrix

As can be seen, each subcategory can be derived and discussed separately, based on partial environmental, economical and social life cycle analysis assigned to it. On a horizontal level, a full LCA, LCC or SLCA can be conducted for a complete life cycle of a product, giving results in values specific to it (environmental points, money value and social points). Due to the incompatibility of units, the same cannot be done on a vertical level. Instead,

different aspects of an object in a single phase of its life cycle form a quality level based on those three criteria, which can be presented either in a form of description or in a quantitative way based on chosen convention.

By partitioning the results into presented subcategories, the most vulnerable (in sense of high impact) areas of an objects' life cycle can be recommended for further decision making processes concerning product development. A comparison of different theoretical versions of a product (each evaluated in a full or partial analysis) can create a good basis. For example, an existing "zero" version of an object could be compared to the same object altered to decrease its environmental impact.

INTERDEPENDENCE OF IMPACT CATEGORIES

As there are many factors to be considered in the development process of a product, key role is intended for the attainment of as much data as possible concerning the categories in which an object is evaluated. For a proposed model, with LCM-based impact categories, life cycle analysis methods provide a complex set of data to be used in further activities. By looking at a single category of impact, decisions can be made concerning development of a product that will lower the general burdens in that category, and in every phase of object's life cycle. However, when taking into account two or three of categories simultaneously, such assumptions may fail. Simple positive and negative examples are given in figures below (fig. 2, fig. 3).

In context of a continuous (positive – lowering all the impacts) development of a product, after each alteration, a thorough analysis should be conducted to verify if results in certain categories did not deteriorate excessively because of improvements in others. This embodies a typical PDCA-based (Plan-Do-Check-Act) spiral of continuous development of incremental changes to an object's life cycle. In most cases it would probably mean that these changes will be smaller on each level of development, if they are not supported by new or innovative solutions in certain areas.

Proposed change: Redesigning the product, so that it contains more organic (plant-based) materials instead of petroleum-based resources		
Environmental impact	Economical impact	Social impact
Lowered: organic materials are renewable and can be disposed easily without harm to the natural environment, no pollution from petrol industry	*Lowered:* the cost of obtaining and modifying organic materials to the needs of manufacturing is low, easy disposal means cheap disposal	*Lowered:* more people find employment in agriculture (especially in developing countries), people are not subject to the drawbacks of petrol industry

Fig. 2: Positive correlation example

Proposed change: outsourcing the obligatory disposal of electronic equipment to a contractor operating in a country with very liberal environmental regulations		
Environmental impact	Economical impact	Social impact
Increased: landfilling or incinerating instead of recycling – means pollution and increased demand for natural resources in the future	*Lowered:* outsourcing the disposal lowers the total life cycle cost of a product from manufacturer's point of view	*Increased:* people employed as dismantlers lose their jobs, negative environmental impacts create a global problem, accusations of unethical conduct

Fig. 3: Negative correlation example

CONCLUSIONS

Today, Life Cycle Management, encompassing increased sustainability of an object in environmental, economical and social aspects goes along increased consumer awareness of these problems. As the product needs to be developed evenly in this multi-dimensional set of quality criteria, a stress has to be put on understanding the consequences of development undertakings on each branch of the product's sustainability. In an absence of innovations, object's life cycle can be managed only to a certain degree.

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