Chapter 22

How to Create a Business Relevant LCA

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Abstract

Facing issues related to innovative production and public requirement in sustainability, companies expect to develop an effective tool to integrate environmental aspects into their business strategies at product design stage. Although life cycle assessment is commonly used to evaluate the environmental impacts of products or services, it is time consuming, expensive and may produce irrelevant information for business decision making. Eco-design approach, as alternative, requires less efforts for data acquisition and evaluation, and utilises a wide range of indicators that meet business demand. This study develops a matrix-based tool to capture environmental information related to business according to industry engagement. This life cycle thinking-based approach focuses on more relevant environmental information, and provides effectively data to support business strategy. In addition, this approach is practical and flexible to be used at the early design stage where data capture is generally difficult. Finally, it helps the managers to identify data gaps, so that it stimulates further investments in searching more targeted data.

Keywords:

Business requirement

LCA

Eco-design

Data capture

22.1. Introduction

The combination of legislation, company values and consumer pressure is making sustainability increasingly important criteria for product design. Given that 80% environmental impact is determined in the formative design stages, [1, 2] it is especially important to include these aspects early on. From business point of view, sustainable development means adopting business strategies and activities that meet the current economic needs of the companies while maintaining and protecting the natural and human resources that will be used in the future [3]. On one side, the public require environmentally friendly products and services without negative impacts in the current and future world. On the other side, companies need to consider environmental impacts of their products as a competitive and innovative factor, as well as a social

and legislative responsibility. Despite a great awareness of sustainability, companies struggle to cost-effectively incorporate all three aspects (economy, environment and society) into their business management that traditionally focuses mainly on an economic perspective.

Environmental aspects of products and services are normally covered by undertaking a life cycle assessment (LCA), evaluating the environmental impacts through the entire product life cycle [4]. Critical environmental impacts can result from any of the stages of the life cycle, from extraction, through manufacture and product use phase, transportation and storage, to final disposal of product (from cradle to grave). Therefore, LCA provides for the managers of companies a wider vision of product innovation opportunities through a close cooperation with different stakeholders. Although many companies have

interest in using LCA for knowledge acquisition and marketing purpose, it currently cannot be used directly for marketing decisions. Firstly LCAs, especially detailed LCA which requires amounts of measured data or refined reviews from literatures, are time consuming, expensive and produce a wealth of environmental information that rarely provide an absolutely definitive answer, if the indicators have contradicting impact results (with all LCA studies, the answer normally starts with 'it depends'). Considering the cost and difficulty in capturing data, companies may not have motivation to carry out detailed LCA as one of the primary activities for business management. Secondly, the biggest complicating factor in using LCA during early product design is that much of the required information is not known, and thus many assumptions are made which increase the uncertainty of the results and decrease confidence [5, 6]. Thirdly, although life cycle cost assessment and social LCA have been development with more and more attention [7, 8], the traditional LCA methods only consider environmental impacts, but neither economic nor social impacts, which is too narrow to be used independently to determine sustainable perspective of a product/service [9, 10]. Hence the benefit of LCA for early design decisions is limited. The alternative to full an LCA is eco-design approach (also known as design for environment, or design for X). This is a streamlined assessment requiring less effort for data acquisition and evaluation, and utilising a wide range of indicators that are not commonly used in a traditional LCA. The process does, however, still employ the concept of life cycle thinking (LCT) [11, 12].

An eco-design approach considers systematically product performance with respect to environmental, health and safety, and social objectives throughout the entire product life cycle [13, 14]. A successful eco-design process should combine environmental performance with stakeholder requirements, so that the environmental issues become the drivers for product innovation, as well as marketing strategy, cost and competition. In contrast to traditional LCA, the choice of indicators and assessment for eco-design is performed in a way that is relevant to business topics, so that managers can readily monitor concerns and make improvements regarding their business purpose. In this paper, we demonstrate this business relevant life cycle approach, and show its application in collecting eco-data according to industrial requirements. Section 22.2 states the industry engagement to identify their business requirements. Section 22.3 introduces environmental indicators according to stakeholder requirements, and Section 22.4 describes a matrix-based tool to collect information used to evaluate environmental impacts that are mostly concerned by the industry. Finally, we discuss and conclude our study in Section 22.5.

22.2. Industry Engagement

A previous study [15] has engaged with business to determine what data are required by companies in the

electronic sector at the early design stage. The aim of that study was to understand what the key factors are that affect the decisions made by industrial companies relevant to their business strategies. Through the questionnaires and interviews with industry stakeholders, it was found that product performance and consumer demands were considered as the top factors that determine product decision making. With regard to environmental aspects, three categories were identified: climate change, energy consumption and water use. Human health and environmental toxicity were also assessed but were normally effectively dealt with via risk management, rather than through a LCA-type process.

Based on this feedback from industry stakeholders, it suggested that the future LCA to product evaluation should change from such traditional environmental assessment to one that should consider both product performance and customers' demands, with a limited but more focused set of environmental impact categories.

22.3. Business Relevant Indicators

In this paper, we define indicators used to evaluate the properties of materials and compare the performance of alternative materials in aerospace industry from environmental point of view. These indicators (plus an additional category – reduction in greenhouse gases) were developed by the ADS (Aerospace, Defence, Security and Space) Design for Environment working group [16]:

1. Easy access to resources – material criticality
2. Reducing energy consumption
3. Reducing waste generation
4. Efficient water use
5. Recyclability and reusability
6. Reducing greenhouse gases (GHG)

22.3.1 Easy Access to Resources – Material Criticality

A reliable, sustainable and undistorted access to certain key raw materials is of growing concern across the world [17]. It is thus important to identify the materials within the value chains where there are significant risks arising from two main dimensions: economic variance due to price volatility (temporal and spatial) and potential interruptions in supply chain [18], and a material is considered critical for businesses when it has high economic importance and high supply risk.

Apart from business risk, access to resources also relates to environmental issues, such as depletion of natural resources and irreversible damage to eco system through extraction activities. In addition, the extraction and processing activities are energy intensive and produce significant amounts of emissions, which can pollute air, soil and water.

Therefore, consistent data fed into criticality assessment is needed to manage material risks effectively and support

the development of effective policies and strategies for the benefit of economy and environment.

22.3.2 Reducing Energy Consumption

Energy consumption is defined as the amount of energy consumed during the life cycle of products. Increasing demand for energy requires energy efficiency at each life cycle stage. There is a need to safeguard business continuity from risks such as potential increasing energy costs, energy dependencies and interruptions in supply. In terms of environment, the emissions during energy use have both direct and indirect environmental impacts, such as climate change, resource depletion and damage to eco system.

Therefore, reducing energy consumption and promoting efficient use of energy are considered as key factors to achieve a sustainable business.

22.3.3 Reducing Waste Generation

Waste is defined as the amount of solid, liquid and gaseous residues, which are not retained as part of the final products, generated during the life cycle of products and services. Higher environmental standards and requirements for green products enforce business to develop cost-effective management of waste [19]. The generation of wastes represents both business and security risks due to significant cost and heavy regulations for waste management and disposal. So the more wastes are generated, the more companies have to pay for materials to use. Additionally, the companies have to pay to deal with wastes, and that cost will be higher if wastes are hazardous to natural environment or human health. So in terms of environment, hazardous waste emissions contribute to eco system damage and human health issues. Over release of wastes into the environment may lead to the degradation of natural environment and loss of resource for the future generation.

Therefore, reducing wastes enables to save production costs and decrease the environmental impacts as well as improve the efficiency of resources use. Moreover, the development of innovative transition from wastes to useful by-products has potential to create additional value to production system.

22.3.4 Efficient Water Use

Water use is defined as the abstraction, supply and consumption of water throughout the life cycle of product. Water is a vital resource to support industrial manufacture and human health. Increasing industry demand and growing population could affect the availability and supply cost of water for both current and future circumstances, which leads to a risk to business continuity. Water has local environmental impacts that are influenced by various factors, such as the sources of water, the rate of abstraction (over abstraction of water can result in shortage of water and local environmental degradation, which may lead to social conflict) and the treatment of water.

Therefore, companies have interest in developing an effective approach to manage water risk and account for water use towards resource-efficient economy.

22.3.5 Recyclability and Reusability

Recyclable and reusable materials or product components can be recovered at the end of life and re-enter into industrial flow to become parts of new product chains. Increasing demands for materials and large pressure on reducing the environmental impacts of raw material extraction have a long-term influence that can affect the stability of material supply, a key aspect of business continuity. Recovering materials and product components can help business to prevent loss of materials, reduce supply risks and minimise costs for production and disposal. In environmental terms, recycling and reusing materials can (in appropriate circumstances) reduce the environmental impacts associated with raw material extraction and waste treatment at the end of life.

Therefore, business needs to understand the recyclability and reusability potential of their currently used materials and components.

22.3.6 Reducing Greenhouse Gases

The GHG are the primary cause of global warming. Concern over climate change has promoted the development of policies to reduce GHG and encourage the creation of a low-carbon economy [20, 21]. At a company level, declaration of companies' GHG emissions at the product level is no commonplace and indeed expected.

22.4. Business Relevant LCA

To achieve an environment-friendly product or service, business should aim to provide an innovative product with that meets the required performance, as well as minimum negative impact on the environment over the entire product life cycle. To support this, a matrix-based tool to identify necessary key information for typical life cycle stages of manufactured product, in order to meet these six aspects above, is used. This approach aims to support business strategy with more relevant environmental information based on the perspective of LCT. Meanwhile, data collection will be more time- and cost-effective, since the effort only focuses on a limited set of categories in which the business has more interest. The categories used in this paper are derived for the specific case of the aerospace sector. It is likely that other industry sectors will define different key indicators.

This matrix has been generated by linking and cross-checking the identified business-relevant indicators with the five life cycle stages (Table 22.1). For each stage, general information has been included to describe the characteristics of materials extracted or used, such as mass or volume. The following sub-sections explicit how to use checklist to identify the key information for each life cycle stage.

22.4.1 Extraction of Raw Materials

In the first stage of product life cycle, information is most closely related to criticality of materials because of its direct effect on business continuity.

- Supply risk: as one of the important indicators to evaluate material criticality, the European Commission applies a method using four metrics to evaluate supply risk. Substitutability index measures the flexibility to change materials, recycling input rate indicates the recycle potential of materials which is also as key information for recyclability and reusability, world governance indicator considers political risk from the suppliers of unstable countries, and factor of concentration relates to the availability of natural sources [17, 18].
- Economic importance: the economic variance (price volatility) of raw materials has significant influence to the material criticality. Combined with supply risk, the European Commission defines a list of critical materials at EU level [17].
- Efficiency of material extraction is considered as key information. It links to the quantity of resources needed to meet manufacture demand. Therefore, improving extraction efficiency can reduce loss of natural resources extracted from the ores to save costs for materials used.
- As the three important environmental indicators, embodied energy consumption, GHG emissions and water usage cover the extraction process and its associated waste generation.
- Waste generation includes the type and quantity of wastes generated during the extraction, while its environmental information is already accounted previously.
- Legislative information: apart from the risk due to the criticality, other environmental or toxicity risks should be noticed according to local or global legislations and regulations. For example, the EU REACH Regulation identified substances of very high concern (SVHC) and put on the 'candidate list for authorization' [22]. The manufacturing companies should ask and record this information from their suppliers.

22.4.2 Manufacturing Process

The materials extracted are used through different production processes at this stage. Consumable materials are defined as materials used in production processes, but do not form any part of the final product. Additionally, wastes are generated.

- Efficiency of materials used: an effective use of materials can reduce the natural resource demand (e.g., materials, water) and waste generation, save energy consumption.

- The information of embodied energy consumption, GHG emissions, water usage and waste generation are collected and identified for each process of this stage.

22.4.3 Product Use Phase

The product use phase includes usability of the product, waste generation and processes or components used to repair and maintain the function of product during its use. The information of embodied energy consumption, GHG emissions, water usage and waste generation are collected and allocated to each part of the stage. Lifetime of use refers to the durability and recyclability of materials. The information of components used for repair service can also be linked to natural resource demand (access to resource) and reusability potential of product.

22.4.4 End of Life

The disposal of product at the end of its life has diverse destinations. Some parts of product can be recycled, remanufactured and reused back to the industrial flow. Otherwise, some parts of product can be treated in landfill or incinerated for energy recovery. According to different ways of treatment, the environmental data is collected, such as energy consumption and recovery, GHG emissions and water usage. The recycling/reuse rate is a key factor to evaluate the efficiency of recyclability or reusability. As mentioned in Section 22.22.4.1, the more materials are recycled for remanufacture, the less raw materials are needed from the extraction.

22.4.5 Distribution

This stage contains the transportation and packaging of both materials to manufacture and assembly facility and products to customers. The transport characteristics, including transport mode, distance and frequency, offer an opportunity to minimise environmental impacts and prevent hazardous risk. The mode and materials used for both product and transport packaging should be collected, which help the designers to reduce the packaging stages and minimise environmental impacts and risks due to the use of hazardous materials.

Once the checklist is completed and validated, a targeted investment in capturing data will be more efficient and inform further quantitative assessment when data is available. In addition, the checklist identifies the data gaps that will trigger uncertainty and sensitivity analysis to estimate their influences to final results.

22.5. Discussion and Conclusion

The eco-design approach based on LCT integrates environmental consideration into the existing product design process. It corresponds to the expectation of business, which needs to develop useful and effective environmental indicators to support their business strategy. A systematic eco-design approach offers opportunity to optimise product performance over the

entire product life cycle, as well as any specific stage or aspect. For example, designers can focus on energy efficiency during the manufacture (i.e. design for energy efficiency) or using recycling materials to lower the raw material requirement (i.e. design for recycling). Our matrix-based tool offers flexibility to fit different eco-design strategies; the required information can be defined for different life cycle stages according to diverse business objectives.

Business expects to use some form of environmental assessment to improve product performance, with the aim of increasing market share. Although the interpretation of different environmental indicators of LCA can help business to learn more about their product or system at the environmental viewpoint, it is hard to draw an overall conclusion when several indicators give conflicting information. By contrast, the information provided by eco-design approach do relate well to business management that meets the needs of different stakeholders. Thus, business is encouraged to collect such information within and outside of an institution, which enhances the cooperation among the stakeholders. However, given that it is highly likely that the result is a multicriteria comparison between the products, designers should set priority orders of criteria including cost, social and environmental factors. When comparing products, the smaller set of indicators defined by the eco-design approach are much more specific and practical (may be less informative than detailed LCA) for preceding a new product design comparing with the older product.

Today, the companies are seeking for an effective way to integrate LCA into their business management, while the large cost for data acquisition and strict requirement of data reliability limit the adoption of LCA in business strategy. It seems that companies prefer to implement more simplified assessment based on LCT that can reduce costs and efforts for capturing data [9, 23-25]. Therefore, refining the data capture process is of critical importance in product innovation for sustainability, especially at the early design stage of industry where there are limits of data availability, transparency and reliability. This qualitative eco-design approach is much more readily used than a quantitative LCA and enables the designers to focus on more targeted information associated with business strategy of the company. The identification of key environmental information will trigger a detailed LCA, when it becomes necessary to quantify the environmental impacts.

This matrix-based tool is a preliminary framework for data capture, and an improved version should combine with data quality evaluation tools to carry out uncertainty analysis. This is because uncertainty about the quality of the information is useful for decision makers as well as information itself. Confidence in data can be defined and assigned quality scores associated with collected information. Such a scoring approach evaluates data

quality (generally, but not exclusively) based on expert judgement and will be determined differently in the different business areas and industry sectors. Therefore, this matrix-based approach offers a possibility to develop a mixed data capture and evaluation tool in the future, which will help the managers to manage environmental data and its associated uncertainty.

In conclusion, we demonstrate the role of eco-design approach in business strategy and how to integrate environmental information within other business-related aspects (e.g. cost and benefits, product performance and environmental risks). The matrix-based tool provides a cost-effective way to gather targeted information over the product life cycle, so that the communication among various stakeholders can be more appropriately involved in product development and business management. It is a practical and proactive approach for product innovation used at the early stage of product development where few data are available to carry out quantitative environmental assessment, such as detailed LCA. Moreover, data gaps can be identified through information capture process and new methods for filling data gaps should be developed.

Table 22.1: Example of information checklist for business-relevant LCA

Life cycle stage	Information requirement	Access to resource	Energy consumption	Water use	Recyclability / reusability	Waste management	Climate change
Extraction of raw materials	Supply risk	X			X		
• Material extracted	Economic importance	X					
• Wastes generated	Extraction efficiency	X	X				
	Embodied energy		X				
	GHG emissions						X
	Water usage			X			
	Waste generation					X	
	Legislative requirements	X					
Manufacture	Efficiency of materials used		X	X		X	
• Materials used	Embodied energy		X				
• Production process	GHG emissions						X
• Consumable materials	Water usage			X			
• Wastes generated	Waste generation					X	
Product use phase	Embodied energy		X				
• Usability of product	GHG emissions						X
• Wastes generated	Water usage			X			
• Repair and maintenance	Waste generation					X	
	Lifetime of use	X			X		
	Components for repair service	X			X		
End of life	Embodied energy and recovery		X				
• Recycle/reuse	GHG emissions						X
• Landfill	Water usage			X			
• Remanufacture	Recycling/reuse rate				X		
• Combustion							
Distribution	Transport characteristics		X				X
• Transport	Packaging mode		X		X	X	X
• Packaging	Packaging materials	X			X	X	

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