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Networked Design Decisions in Balanced Life Cycles

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Abstract

Many decisions, both conscious and unconscious, have to be made during a product development process. In reaching a decision, it is essential to take the consequences of the different alternatives into consideration. To assess preconditions and consequences of decisions, an actor network can be used. An actor network is a combination of interrelated entities, representing multiple individuals and/or organizations. By adding characteristics to these actors and their relation, aspects like supply chain and life cycle issues can be addressed.

This publication describes the basic building blocks of an actor network from a generic and abstract viewpoint. From these essential building blocks, the construction of the overall actor network is described. Examples are used from the field of content-packaging combinations, as well as aspects from life cycle assessments to illustrate the intended fundamental functionality. In the bigger picture, the use of the actor network in the context of product-packaging combinations aims at achieving lasting balance in product-packaging networks.

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1. Introduction

Effectuating a visionary term like sustainability in product and packaging development trajectories remains a challenging and problematic endeavor. While sustainability is strongly rooted in well-nigh every mission statement and its hype is gradually replaced by 'new' trends such as 'circular economy', the successful integration of life cycle aspects in the everyday practice of product-packaging development is nowhere near complete. The (first) experiences from industry indicate that many problems still need to be overcome. In essence these problems can be traced back to a lack of knowledge and experience with life cycle engineering and a lack of data and tools that adequately adhere to everyday practice.

Many sustainability tools like guidelines, scorecards and principles are available and in use [1]. However, their corresponding scopes of application and the context of the outcomes is often overlooked, leading to misinterpretation and improper use of results [2].

As a development trajectory progresses, the efforts needed to change the product concept increases rapidly. Consequently, within the early stages of such trajectories, the potential to efficiently and effectively influence the future (environmental) impact of the product(s) is the highest [3]. Since many existing life cycle assessments tools need detailed product information, these tools can only be employed in later stages of the design and development process. Consequently, the possibilities to efficiently decrease the environmental impact at these later stages of the design and development process are limited.

Another problem of integrating sustainability is the relative high risk of sub-optimization, which seems to be caused by the misinterpreting of results acquired by the use of sustainability tools. To avoid sub-optimization, the consequences for the bigger picture, or the entire life cycle, need to be analyzed before making a decision. Deploying sustainability thus

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presupposes the consideration of the complete intended life cycle of the product within the development cycle. Consequently, aspects of the life cycle that might be unclear, unknown or even undeveloped have to be taken into account at an early stage. For example, a well-intended decision to reduce the overall weight of a packaging by changing its material might lead to product spoilage during transport while simultaneously interfering with the conventional recycling process. As a decision often affects the unknown areas or aspects of the product life cycle, the consequences are not foreseen. This leads to insufficient solutions in which the different processes within the intended life cycle are not attuned. For a decision support approach that addresses sustainability to succeed, it must fit in the approach of a 'standard' development process, because when push comes to shove, sustainability issues lose out on more direct issues like costs and consumer perception. Adequate decision support including the entire product life cycle is thus crucial in effectively integrating sustainability in product design and development.

From a life cycle engineering perspective, the functionality to map the consequences of a decision throughout the (envisioned) life cycle of a product, would be a prerequisite for the tool to develop. The various possible solutions, their corresponding consequences and the inherent differences between these solutions aid in assessing the impact of a decision. Consequently, enabling the comparison of different scenarios using the generally limited available information and time is the main functionality of the tool.

In the following paragraph the key problem areas of life cycle engineering within product development are elaborated followed by the approach for the decision support tool and a first translation of this approach into a prototype.

2. Requirements from a life cycle perspective

2.1 Model complex life cycles

In principle a design decision might have influence anywhere in a life cycle. For instance, using a bio-degradable polymer as a packaging foil might have great potential in reducing the overall impact of a packaging, but only when the entire life cycle of both the packaging and the content is considered. With certain bio-degradable polymers, the potential improvements can only be met if their disposal is strictly separated from conventional polymers, using the current disposal systems might cause a situation in which the bio-degradable packaging are incinerated instead of natural decomposition, nullifying the intended advantage.

Within such a development trajectory it is thus crucial to harmonize various parts of the life cycle, e.g. correctly informing the end-users and preventing the contamination of conventional polymer waste. Nevertheless, it can be very hard or even impossible to fathom the consequences of such scenarios. A clear depiction of those potentially complex life cycles is required.

A product life cycle consist of different processes which are executed by different actors. All these processes have their own life cycle as well. Furthermore, in every process of a product life cycle, symbiotic products are used that have their own life cycles and processes, and so on. Although many sustainability enhancing tools cut off these higher order life cycles, it would be valuable to take these life cycles into account because a decision can have major consequences for these sub processes. Consequently, an appropriate tool should simplify the representation of complex life cycles without losing too much information.

2.2 Adhere to various viewpoints

Many different stakeholders are involved in both the development cycle and the life cycle of a product. The inevitable differences in working methods, background, knowledge and organization are potential impediments in facilitating unequivocal decision support throughout those life cycles.

For instance, the level of detail in the various development trajectories can range from a coarsely-woven chain of decisions taken with 'seven-league strides', to a long-term engineering project of a specific compound used in a metal lid. In applying life cycle engineering, the relative importance of various aspects like social impacts or delivery times might also be different. Moreover, these aspects cannot always be determined on beforehand. Consequently, a tool supporting such a wide range of stakeholders and corresponding decision criteria should incorporate the needed flexibility.

With the inevitable differences also comes a different development "language". For the different actors involved in a product life cycle, the notion of the term product can differ. While a manufacturer of plated steel might consider the coils to be its final product, for the producer of the steel cans, these coils are a semi-manufactured article needed to produce their final product. These differences only grow when the relative 'distance' of two stakeholders in the life cycle grows. Furthermore, these differences might have drastic consequences when interpreted in the wrong way. Therefore, a tool fostering the decision support for such an amalgamation of different stakeholders needs to adhere to these differences.

2.3 Surmount the information paradox

During the early stages of a design and development process, information about the life cycle is often missing or uncertain. In applying life cycle engineering, the need for additional information often becomes paradoxical: the needed information simply cannot be known because the decision, for which the additional information was needed in the first place, has not yet been made. Seemingly simple answers are to either estimate the consequences or to substitute the missing information with similar information from another product or life cycle that is already known. While these principle solutions are powerful mechanisms in decision making, assessing the corresponding context of the substitute information and the uncertainty of the estimated consequences is a crucial but often overlooked element. Without it, a clear distinction between the for a development trajectory specific information and other, 'general' information cannot be made, obstructing the verification of that information and thus leading to an