Journal of Cleaner Production 87 (2015) 452–462

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Eco-designing Product Service Systems by degrading functions while maintaining user satisfaction

C. Salazar, A. Lelah*, D. Brissaud

Laboratoire G-SCOP, Université de Grenoble – INP, 46Avenue Félix Viallet, 3800 Grenoble, France

ARTICLE INFO

Article history:
Received 4 October 2012
Received in revised form
16 May 2014
Accepted 13 October 2014
Available online 23 October 2014

Keywords:
PSS
Environmental performances
User satisfaction
Innovative eco-design
Functional analysis

ABSTRACT

Industrialising products and/or services, considering the current environmental situation, requires changing paradigms to be efficient. The paradigm of proposing product-service systems instead of selling products is one of them. Moving further, this article shows that it can sometimes be possible to consider product and/or service degradation in order to relieve environmental burdens, while still maintaining user satisfaction. In this new paradigm, degradation will concern certain technical performances of the system. To succeed, the approach must simultaneously consider users' expectations and environmental aspects. Environmental, economic and innovative approaches must be combined to adapt the products and services in an appropriate way. The product and service characteristics are negotiated with the users to cut down environmental impacts, while continuing to meet users' satisfaction. A case study of an eco-designed product-service system is presented.

1. Introduction

The international community promotes and claims sustainable development practice. Besides social and economic aspects, environmental issues are incorporated to reach Factor X impact reduction objectives (Reijnders, 1998). Customers are growing aware of the environment when buying products and services. Indeed, initiatives from international organisations such as the OCDE (2002), UNEP (2009) and other NGOs, concerning responsible consumption, are being developed. Transition to more environmental friendly economic growth requires broadening our vision of products and services in a system perspective. Designers have to improve, and even more often, propose innovative solutions to satisfy clients and abide by regulations and standards pushing environmental performances associated with products and services. Eco-design is encouraged through European regulations like EPR (Extended Producer Responsibility), REACh (Registration, Evaluation and Authorisation of Chemical substances), WEEE (Waste of Electrical and Electronic Equipment) and ErP (requirements for Energy-related Products).

During the last decade, eco-design has been principally based on standards, mainly from the ISO14000 series, concerning environmental impact assessment and eco-design. Development has been based on the use of different tools associated with the Life Cycle Assessment (LCA) method and design process as recommended by the ISO standards. It is necessary to move further into the designing process by integrating other concepts, such as Product Service Systems (PSS), and to consider a systemic view of products and services. Designers and developers must be prepared to change paradigms. This article proposes one such change where designers consider degrading product and service characteristics as a possible means to improve environmental performances and a trigger for innovative solution.

It would not be the first time that industry considers products or service degradation to meet customer or industrial needs. Although dealing with lifetime rather than customer value, Joseph and Tang proposed sacrificing quality at the initial stage of the product's use, to improve the reliability of the product and increase time-to-failure. The proposal was applied to a theoretical case concerning the diameter of the balls in roller-ball bearings (Joseph and Tang, 2008). Another example came from the ICT sector. Degrading transmission quality was necessary to boost the diffusion of video services. Formerly, video diffusion had been costly and mass diffusion technically unfeasible. To produce real-time video applications, such as video teleconferencing, it was necessary to transmit large quantities of data. To satisfy more clients, developers had to dramatically reduce the bandwidth of the video data. As a result, applications for viewing videos were rapidly available in high technology devices like computers and mobile phones. At the beginning the quality was degraded to meet needs. Later, designers

* Corresponding author. Tel.: +33 476574893.
E-mail address: alan.lelah@g-scop.grenoble-inp.fr (A. Lelah).

http://dx.doi.org/10.1016/j.jclepro.2014.10.031
0959-6526/

improved image quality, for example, by adapting perceptual video quality control mechanisms based on application-level perceptual video quality schemes (Lu et al., 2002). Today, technical performance degradation could become an innovative motor to reduce environmental impacts.

Bearing this in mind, this article integrates approaches that accelerate the process and help designers innovative in eco-design through degradation. Designers have to combine environmental aspects and knowledge of the customers to maintain acceptable performance of the offer. They should identify the system of products and services, and not just the product, to understand customer needs and expectations and their evolution over time; analyse their offers more deeply; concentrate on the final, delivered services; understand user perception of the overall system; evaluate true user expectations and be ready to negotiate product and service characteristics and performances with their clients. The principle proposed in this paper is close to value engineering (Miles, 1961). The problem at that time was post-war mass production at acceptable cost in a situation of insufficient extraction of raw materials, while today, satisfying customer demands of quality is more exigent and especially subject to greater environmental stress.

In Section 2, this article proposes substitution of functions in products and/or services as a key to proceed to degradation. Section 3 uses environmental and economic tools to negotiate technical performance degradation of a product or service. In Section 4 a case study of electronic environmental sensors is presented. This case illustrates how developers combine different approaches to facilitate the eco-design process. Section 5 discusses the results and provides perspectives.

2. Innovative approaches to Product Service Systems

This section underlines how concern for environmental impacts of goods and services encourages the move from products to PSS while good eco-design imposes appropriate definitions of functional units that support innovative product-service combinations. Economically, efforts to optimise cost and materials lead to the consideration of customer needs and expectations. In particular, value engineering opens the way to introduce customer satisfaction and correctly substitute functions. In the context of PSS, functions are provided by combinations of products and services and so substituting functions means modifying these combinations and substituting products and services. The section suggests that creative thinking may guide substitution in solutions that, although they degrade technical features of the PSS, maintain overall performance and, particularly, user satisfaction.

2.1. Product Service Systems

In the market, customers can be offered several options (in this article the customer, client or consumer is a person who uses the product or service). They could simply buy a product, a pure service or get a combination of products and services. Changing paradigms requires moving the frontier between products and services (Sakao et al., 2006). For a long time, enterprises focused on mass production and selling physical products with environmental consequences related to material transformation (Maussang et al., 2009). Nevertheless, it was observed that the increase of the consumption of material goods does not necessarily lead to the increase of the quality of life (Tukker, 2005). Therefore, many developed countries have tried to decouple economic growth from environmental pressures. One way to achieve that was to switch from a product-based economy to a service-based economy by moving towards a new economical model (Maussang et al., 2009). Several concepts have emerged, for example, PSS (Tukker and Tischner, 2006), functional economy (Bourg and Buclet, 2005), total care products (Alonso-Rasgado et al., 2004), service engineering (Sakao et al., 2006) and extended products (Thoben et al., 2001).

According to Maussang, some companies switch to a 'partial' service economy in order to stand out from competitors and earn more money. Most of the time, support and maintenance services are added to physical products (extended warranty, availability of parts and so on). They provide new value to the products sold. However this is not a systemic change to the economic model because it often only brings incremental innovation to products and not a complete change in the manner to develop the system. In fact, the products and services are simply modified, based on existing ones (Maussang et al., 2009). In the future, designers will be asked not only to improve a product or service, but to move further and switch from the original product or service to other products, or services, or a combination of them, so as to minimise material flow and transformation. They may even propose new strategies using the initial products or services to satisfy the clients.

The PSS concept emerged from a new sales approach where the customer no longer pays to own the product but rather pays for a use, result or functionality provided by a system (Maussang et al., 2008). Tan et al. (2007) defined the PSS as "innovation strategies where instead of focusing on the value of selling physical products, one focuses on the value of the utility of products and services throughout the product's life period". It is necessary to consider the value provided by the PSS. The idea is to provide features or produce results with a PSS instead of a physical product alone (Maussang et al., 2009). What is more, Maussang suggested that from an external (customer) point of view, there would be no more borders between the products and the services of the system.

Car-sharing systems are a good example of PSS. Such systems have been set up by associations such the Citélib system in the Rhône-Alpes Region in France, or private companies such as the German systems 'Mietermobil' in Wolfsburg and 'Wonh mobil' in Hamburg (UNEP, 2011). Basically in these systems, owning a physical object (car) is replaced by the service of being given access to an individual transport system whenever required. The user easily picks up a car whenever necessary and generally pays per use. The PSS concept emphasises that users do not always need to possess objects. They can be satisfied simply by the service that the objects support and the results they obtain. This opens the possibility for designers to propose new solutions to clients with lower environmental impacts. This means that designers need to deepen their understanding of client expectations and satisfaction and adapt functionality of the offerings to changing customer expectations over time.

2.2. Identification of a functional unit to support eco-innovation

For 20 years, LCA has been widely used in environmental assessment and more recently in eco-design and eco-labelling processes. Amongst other advantages, it helps designers to cultivate life-cycle thinking and possibly avoid the transfer of environmental impacts from one impact category to another or from one life-cycle stage to another. LCA facilitates the reduction of environmental impacts by providing information, indicators and diagrams to establish environmental profiles of the products. It is useful for comparing, improving, innovating and eco-designing products and the associated production processes. Different approaches, based on LCA, have been used to support the eco-design of PSS (Lelah et al., 2011).

Eco-design relies on the Functional Unit (FU), defined by the ISO14040 standard. The purpose of the FU is to provide a reference to which the inventory data are related. The FU is a representation