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THE APPLICATION OF ECO-COMPASS METHOD IN SUSTAINABLE PRODUCT DEVELOPMENT

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Abstract. The paper addresses the applicability of Eco-compass for sustainable product development process. The author makes the attempt to answer three fundamental questions: How to improve new product development in the context of sustainable products? What are the capabilities and limitations of Eco-compass? How can Eco-compass help with sustainable product development optimization? In responding to these questions, at first sustainable product development is described. Particular emphasis is put on early phases of new product development: idea generation and design. Afterwards, the methodology of using Eco-compass to compare two products or assess various options of one product in terms of its impact on the environment is presented. Next, considering the fact that in the era of sustainability the model of new product development must imply the integration of economic, environmental and social aspects, the potential of Eco-compass to improve eco-efficiency of the product is elucidated. Finally, conclusions are drawn from this paper.

Key words: sustainable development, eco-efficiency, sustainable marketing, sustainable product development, Eco-compass

INTRODUCTION

Strategic importance of new products is constantly growing. New product development is generally accepted as one of tools for business strategy execution and an important source of competitive advantage of the company. Business strategies that include the introduction of new products into the market help companies to match better to market forces thus increasing the odds of thriving.

In the era of transition from conventional to more sustainable economy based on three main pillars – economic, environmental and social – companies must turn their attention to sustainable products. Although the development of sustainable products

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needs a long-term investment and strategic view, consideration of environmental and social aspects is necessary nowadays. Due to the fact that sustainability is a priority for many clients and institutions, companies should strategically plan and invest in sustainable products to gain competitive advantage [Kerga et al. 2011].

Sustainable new product development requires a change in approach to organization and management of the entire process of innovation, including top management commitment, life cycle management and marketing [Brzustewicz 2013b]. Moreover, successful integration of sustainability into new product development implies the implementation of new tools and methods such as Eco-compass to respond to the growing complexity of environmental requirements that sustainable products must encounter.

Given the fact that relatively few studies to date have concerned sustainable new product development as well as the application of Eco-compass in the process of sustainable product development, the aim of this article is to answer three fundamental questions: How to improve new product development in the context of sustainable products? What are the capabilities and limitations of Eco-compass? How can Eco-compass help with sustainable product development optimization?

In order to support the thesis that Eco-compass is of primary importance for product eco-efficiency, the method of critical analysis of literature was used. Moreover, all three methods of reasoning – induction, deduction and analogy were employed. The study of selected textbooks, articles and reports allowed the author to provide a better understanding of the Eco-compass importance in sustainable product development as well as specifying certain key concepts and relationships vital from the viewpoint of the thesis of the article.

SUSTAINABLE PRODUCT DEVELOPMENT

A review of the existing literature indicates a wide variety of the definitions of sustainable products. Although there is no single and generally applicable definition, the majority of the publications refers to ecological and social aspects of a sustainable product [Peattie 1995, Edwards 2009, Martin and Schouten 2012, Brzustewicz 2013a]. The ecological dimension of a sustainable product refers to its positive ecological attributes that indicate what the productis made of, how it functions, how it is packaged, distributed, used and disposed. Green attributes of a sustainable product make the product environmentally friendly along its entire lifecycle. The social dimension is mainly associated with the conditions in which the product is developed. Nowadays more and more customers pay attention not only to whether the product satisfies their needs, is healthy, safe and environmentally friendly, but also whether employees involved in its development are fairly rewarded, employee rights are respected and local communities are supported by the company.

In addition to ecological and social aspects K. Peattie [1995] emphasizes that sustainable products should satisfy consumer needs and be at least as competitive as conventional products to survive in the marketplace in the long run. According to the author, sustainable products can be defined as “offerings that satisfy customer needs and significantly improve the social and environmental performance along the whole life cycle in compari-

son to conventional or competing offers" [Peattie 1995]. S. Edwards [2009] suggests that developing sustainable products is not just about transitioning to more benign materials and products. From his point of view "sustainable products minimize environmental and social costs throughout the product lifecycle and aim to maximize environmental and social benefits to communities, while remaining economically viable" [Edwards 2009]. A similar view of sustainable products is proposed by P. Brzustewicz [2013], who conceptualizes sustainable products as goods of a completely new environmental and social attributes, that exert considerably less pressure on the environment and people along the life cycle – from extraction of raw materials through production and use to disposal – compared to conventional products.

The analysis of the above definitions leads to a conclusion that sustainable products combine features of green (ecological) and ethical products. However, in addition to environmental and social attributes sustainable products have to meet customer needs and simultaneously be at least as competitive as conventional products.

From a firm's point of view every new product must go through a series of developmental stages. The existent literature contains a wide range of new product development models that differ from each other in terms of the number and the name of stages and other activities accompanying this process [Rutkowski 2007]. Today's models of new product development mainly belong to the methods of the second or third-generation [Cooper 1994]. The first generation process of new product development was sequential, i.e. going to the next phase depended on the fact if all activities in the previous phase had been completed. The second and third generation processes are integrated and are done simultaneously. Such processes also are divided into stages, but some activities which were traditionally done in the next stage, in the integrated process can begin before the previous stage is completed. Moreover, the entrance to each stage is preceded by a gate that is used to monitor the quality of the project and to make "go/kill" decisions. The number of the stages in new product development process largely depends on the industry in which the company operates and its strategic orientation.

Although many researchers [Cooper and Kleinschmidt 1986, Urban and Hauser 1993, Crawford and Di Benedetto 2003] have tried to develop the ideal scheme of new product development that covers all relevant stages and activities, the most widely known is Booz, Allen and Hamilton's model. According to the consulting company of Booz, Allen and Hamilton [1982], new product development process consists of seven sequential stages: new product strategy development, idea generation, screening and evaluation, business analysis, development, testing and commercialization.

Whereas sustainable products, like the traditional ones, must go through subsequent stages and gates to come on the market, the majority of the existing methods, techniques, tools and criteria for new product evaluation must be adapted to new conditions. New product development decisions that do not take into consideration environmental and social aspects result in unsustainable processes and unsustainable products. According to D.L. Varble [1972], "traditional economic criteria no longer appear to provide a sufficient basis for new product evaluation decisions. The implementation of a socially responsible attitude into new product development and evaluation is a task that is challenging business".

As conditions surrounding business have changed, the traditional approach to new product development must be revised. New product development requires more complex analysis and evaluation that include the potential impact of a new product on environment and society at each stage of the process. Additionally, sustainable model of new product development must reflect the life cycle thinking, including the physical product life cycle (Fig. 1). Such thinking, especially at the idea generation and design stage, helps understand environmental and social consequences of a new product.

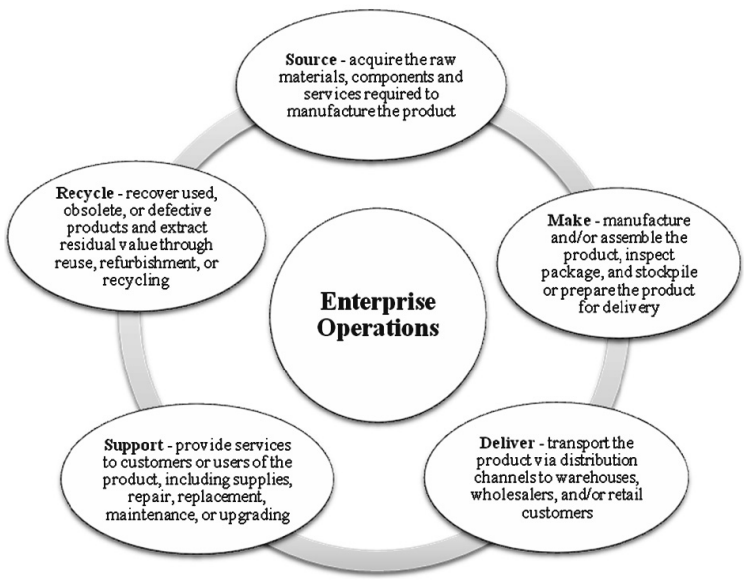

Fig. 1. The physical product life cycle
Source: Adapted from J. Fiksel [2009].

In order to integrate sustainability perspective in new product development, companies can use many solutions, methods, techniques and tools, such as:

- various checklist techniques that contains, except for economic aspects, environmental and social criteria;
- sustainable design strategies and life cycle assessment (LCA) method;
- life cycle costing (LCC) method for estimating socioenvironmental costs;
- sustainable production strategies, e.g. design for source reduction, design for servicization, design for recyclability or design for human capital;
- multifunctional teams;
- sustainable supply chain management;
- sustainable marketing orientation and marketing research at each stage of sustainable product development.

As the early stages of new product development are critical for the future impact of the product on environment and society, there is a great need for the new methods which can be used to create and select ideas for sustainable new products or assess the products

or various design options in terms of sustainability. Considering the fact that around 90% of the waste that can be attributed to many of products has been created before the consumer starts using a product [McAloone and Bey 2009], the methods such as Eco-compass seem essential to succeed in sustainable products development.

THE MAIN PRINCIPLES OF ECO-COMPASS METHOD

Eco-compass, which was developed at Dow Chemical Company, is a useful method that allows a comparison between two products or an assessment of various options of one product in terms of its impact on the environment. Eco-compass measures life cycle impact of a product or its conceptual design along six dimensions which cover all relevant environmental issues. These six "poles" are defined as follows [Yan et al. 2001–2002]:

- mass intensity measures the total amount of the material consumption and mass burdens related to the product over its full life cycle;
- energy intensity refers to the consumption of the energy connected with the product over its full life cycle;
- health and environmental potential risk reflects the change in the environmental burdens associated with the product over its life cycle;
- revalorization indicates the ease with which remanufacturing, reuse, and recycling of the product can be accomplished;
- resource conservation reflects the change in the conservation of materials and energy associated with the product over its full life cycle;
- service extension depicts the extent to which the product throughout its life cycle can be completed with service.

It is worth noting that two of these dimensions, namely health and environmental potential risk, and resource conservation largely refer to the environment, while four others: energy intensity, mass intensity, revalorization, and service extension reflect a process of integration environmental issues into business decisions.

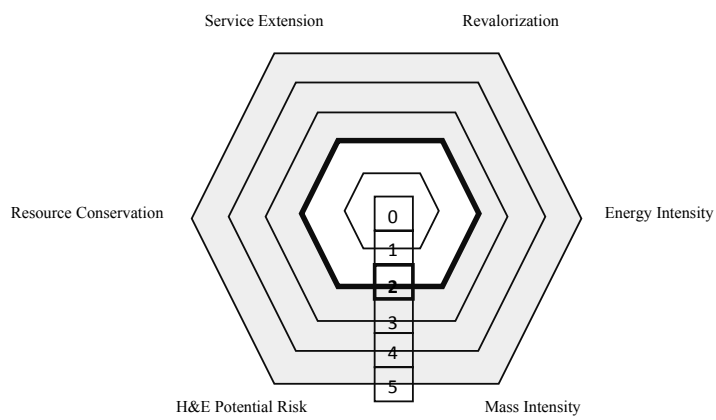

Fig. 2. Diagram of Eco-compass
Source: Yan et al. [2001–2002].

Each of these six dimensions is evaluated on 0–5 scale (Fig. 2). The base case (the product which is used as a reference point) always scores 2 in each dimension. The particular score depends on how different the compared product is from the base case in terms of each dimension. The values of the subsequent dimensions are interpreted as follows: 1 – at least half as good as the reference product; 3 – to two times better than the reference product; 4 – two to four times better than the reference product; 5 – at least four times better than the reference product [Kleiber 2011]. For example, when it is known that energy consumption associated with the new product at the stage of production amounts to 5 kWh per product and the base case uses only 15 kWh, the new product obtains three scores in the energy intensity dimension.

Eco-compass allows the visualization of data in the form of a spider web diagram. The closer the shape of the product is located to the outer part of the web, the better its environmental performance is. The creation of the spider diagram adapted to given product involves having environmental information. Companies can collect the data independently or use standards for environmentally preferable products wrought by national government agencies and independent third-party organizations. The useful sources of required indicators for Eco-compass, which allow the assessment of the environmental and social impact of technology, materials and processes, are LCA (life cycle assessment) databases.

According to UNEP [2011], LCA is a tool for the systematic evaluation of environmental performance of a product, process or a service through all stages of its life cycle. The importance of LCA results from the fact that it allows control environmental impact from raw material supply through to the point of use and disposal. Only with reliable LCA data environmental impact of processes, products or services can be measured. Data for the most popular materials and processes have been collected in advance and serve to calculate indicators from this [MHSPE 2000]. These numbers, which are available in some computer databases, such as Sima Pro, Gabi or Umberto, can be used as well by Eco-compass users to make comparative studies.

ECO-COMPASS AS A METHOD TO IMPROVE PRODUCT ECO-EFFICIENCY

As during the past few decades, the primary drivers of product value have shifted significantly, in the era of sustainability the model of new product development must imply the integration of economic, environmental and social aspects throughout the integrated product life cycle. The question that still remains open is what kind of targets should be set and actions should be taken to lead towards more sustainable products. Although there is still considerable confusion on this issue, WBCSD [2000] argues that every business should focus on the improvement of product eco-efficiency that means "creating more value with less impact or doing more with less".

According to WBCSD [2000], the creation of more value with less use of resources, waste and pollution can be achieved in seven various ways: by reducing material intensity, energy intensity, and dispersion of toxic substances, by enhancing recyclability, maximization of the use of renewables, extending product durability, and by increasing service intensity. In more recent time academic experts and practitioners extended the

term eco-efficiency to the synthesis of economic, environmental and social efficiency that refers among other things to employment practices, community relations, ethical sourcing and social impact of the product [Ranganathan 1998]. The attitude which does not embrace the society as the third pillar of eco-efficiency analysis is not a sufficient criterion for sustainability [Czymmek 2002]. The elements of sustainable efficiency analysis are depicted on Figure 3.

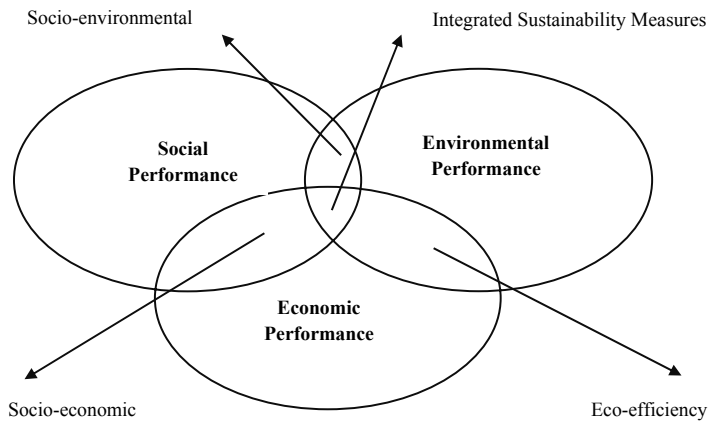

Fig. 3. Sustainability measurement schematic
Source: Ranganathan [1998].

As it was mentioned above, the early phases of new product development are of primary importance to its sustainability. The idea creation and evaluation are critical activities that have great influence on the later stages of the product innovation in terms of eco-efficiency [Tsai et al. 2011]. Selecting the right idea helps the team transform it into concepts of high environmental potential [Leroy et al. 2015]. In turn, the design phase is decisive for product eco-efficiency because as the product is designed, attributes are translated into specifications in attempt to achieve optimal form and function [Fuller 1999]. The power of design arises also from the fact that this initial phase of new product development plays a key role in its quality assurance in the next stages of life cycle (production, exploitation and liquidation) with reference to relation with the environment [Prabaharan 2012].

Sustainable features have positive influence on the demand for such products. The demand for socially responsible products, i.e. products with socially responsible characteristics (ethical products) and a price premium for primary product producers with respect to equivalent conventional products (fair trade products), has been growing steadily. According to The Ethical Consumer Markets Report [2014], the value of ethical spending in the United Kingdom grew by 9% in 2013, rising to 32.2 billion GBP. At the same time, the research results indicate that the rate of new product projects that are failures varies in the range of 38–45%, depending on the performance of the company [Edgett 2011]. It seems obvious that at the age of sustainability, ecological and social attributes of the product are one of the most important factors that influence its market success, which implies that it can radically improve the rate of successful products as well.

Design teams must be able to assess if certain design options will lead towards eco--efficiency and success on the market. Eco-compass, as a tool based on the indicators of eco-efficiency, provides decision makers with sufficient information about the product's environmental impact. Step by step, by applying the proposed Eco-compass, designers can select the optimal product design and its associated production, usage, and recovery processes [Yan et al. 2001–2002].

Although Eco-compass presents some gaps in the idea generation stage [Tyl et al. 2010], it seems that as a method for comparing different variants of the product can be also useful in the process of collecting ideas for new products. A new product optimization with Eco-compass is based on creativity regarding to potential ways for enhancing product eco-efficiency. Considering new areas, where the product could be improved, and solutions concerning such aspects as material replacement or reducing wastes, design teams can create a large number of valuable ideas for sustainable new products.

Dow Chemical is an example of a company that has had great achievements within the domain of eco-efficiency. As the company where Eco-compass has been developed and used, Dow has considerably improved its key indicators in human health, environment and sustainable chemistry dimensions. In the years 2005–2014 company reused 344 million GBP of by-product in manufacturing process, saved 110 trillion BTUs of annual absolute energy, reduced VOC, NO_x and priority compounds emissions more than by 30%, injuries more than by 1,300, spills by 9,000 and process safety incidents by 340 [Dow 2015]. Moreover, Dow delivered in 2014 22.4% (13 billion USD) of sales from products that are highly advantaged by sustainable chemistry [Dow 2015]. Given the fact that Dow's sales have steadily increased in all operating segments (net sales for 2014 exceeded 58 billion USD), this case demonstrates that being a leader in eco-efficiency is not only environmentally benign but also economically beneficial.

CONCLUSIONS

As consumer consciousness and demand for safe, healthy and green products increases, companies must integrate sustainability into new product development to gain competitive advantage. Although there is no single and generally applicable definition, sustainable products can be defined as goods that satisfy consumer needs, exert considerably less pressure on the environment and people along the life cycle, and are at least as competitive as conventional products.

New product development decisions that do not take into consideration environmental and social aspects result in unsustainable processes and unsustainable products. Sustainable products, like the traditional ones, must go through subsequent stages and gates to come on the market but most existing methods and tools for new product evaluation must be adapted to new conditions. Considering the fact that the early phases of new product development are of primary importance to its sustainability, design teams must be able to assess if certain design options will lead towards eco-efficiency and success on the market. In such a context Eco-compass as a method based on the indicators of eco-efficiency can provide decision makers with sufficient information about the product's environmental impact.

Although Eco-compass presents some gaps in the idea generation stage, it seems that this method can be also useful in the process of collecting ideas for new products. Despite

some limitations, the main advantage of Eco-compassis its qualitative and graphical character. Comparing new alternative against the current situation from an environmental perspective is relatively simple, on condition that all inputs and outputs of each process at various life cycle stages were identified correctly. Knowledge of the particular data enables teams to score the product in comparison to the base case in all six dimensions and thereby select the most optimal option in terms of eco-efficiency.

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WYKORZYSTANIE METODY ECO-COMPASS W PROCESIE ROZWOJU PRODUKTU ZRÓWNOWAŻONEGO

Streszczenie. W artykule podjęto rozważania nad problemem zastosowania metody Eco-compass w procesie rozwoju produktów zrównoważonych. Biorąc pod uwagę, że poruszane zagadnienia zostały do tej pory tylko częściowo opisane w literaturze, celem opracowania jest odpowiedź na trzy fundamentalne pytania z punktu widzenia rozwoju produktów zrównoważonych. Jak dostosować proces rozwoju nowego produktu do wyzwań związanych z rozwojem zrównoważonym? Jakie są możliwości i ograniczenia metody Eco-compass? W jaki sposób Eco-compass można wykorzystać do poprawy procesu rozwoju produktów zrównoważonych? Udzielenie odpowiedzi na powyższe pytania wymagało między innymi wyjaśnienia pojęć produktu zrównoważonego i procesu jego rozwoju, zaprezentowania głównych zasad metody Eco-Compass oraz ukazania jej potencjału odnośnie poprawy eko efektywności produktów.

Słowa kluczowe: rozwój zrównoważony, ekoefektywność, marketing zrównoważony, rozwój produktu zrównoważonego, Eco-compass

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