DESIGN FOR SUSTAINABILITY: METHODS IN SEARCH FOR A BETTER HARMONY BETWEEN INDUSTRY AND NATURE

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ABSTRACT
The praxis of Industrial Design has traditionally been oriented to the performance of better products, low cost series, efficiency of production and high profits overall. However, the design process is not always focused on minimizing the negative effects of the production line on nature and human society. In this way, the concept of sustainability can be used as a policy guide to *achieve our needs without compromising the ability for future generations to achieve their own needs*. Sustainability can be defined as the tendency of ecosystems to dynamically balance their consumption patterns of matter and energy, and evolve to a point where life itself can continue. The main contribution of this paper is to present a theoretical model of eco-oriented design as a dashboard for designers and decision makers to follow in the search for a better harmony between the industrial plants and the limits of nature.

1. INTRODUCTION
According to Rose (2000), the Industrial Design can be defined as a set of decisions aimed to solve specific requirements of a product and/or a process (i.e. service), which are usually related to manufacturing, distributing, marketing, consuming and using an object. In this way, the design process has traditionally been oriented to the performance of better products, low cost series, efficiency of production and high profits overall. As a result, the goal of the designer's work is to define appropriate materials, improving projects and its phases and making the use of the products safer and better.

The main role of the designer is, so, to develop integrated solutions in order to achieve both creative and technical aspects of quality, focusing on ergonomics, usability, product's performance, material and energy optimization and improvements on the production itself, converging to a 'materialization of a proposal' (Puerto, 1999: 23). In this way, the designer can be placed as an interface between producers and consumers, technique and environment, culture and products or services. Consequently, the work of designers influences the whole life cycle of matters and, especially, the way people live.

Originally, the industrial design process was strongly oriented to the market needs, solving constructive problems, trying to achieve high profits and acceptance overall. However, a closer look at the end of production line, especially in industrial plants, gives us the idea of designers as mere "mass makers". A lack between theoretical foundations and current practices is clearly identified when the analyzed approach is based on new trends, such as eco-oriented design. This approach shows that the industrial design is not always focused on reduction, recycling and reuse of materials and energy in order to minimize the negative effects of the production on nature and human society. The relationship between natural systems and human beings, particularly represented by culture, technology and economy together, are recognized as very complex subjects of research and can not be easily reached within the traditional model of making goods and services (Allenby, 1999).

From the environment perspective, the design methodologies and rules have to be changed as soon as possible in order to achieve both society needs and preservation of nature. According to the United Nations Conference on Development and Environment, held in Rio de Janeiro, in 1992, it is necessary that a new model of development considers the conservation of nature and the rational reuse of natural resources as a main principle, trying to achieve the needs of the present without compromising the ability for future generations to achieve their own needs. This vision reveals the imperative necessity of redefinition in production models and more consciousness on impacts of the industrial processes, especially in the social, environmental and economical aspects. Besides, new trends and procedures have to be introduced in search for a dynamic balance between use and preservation of natural resources, i.e., sustainability. This concept comes into scene as a policy guide for designers and decision makers to follow in order to minimize the negative environmental and social impacts of industry and economic activities as a whole.

Sustainability can be defined as the tendency of ecosystems to dynamically balance their consumption patterns of matter and energy, and evolve to a point where life itself can continue. From this point of view, our methods in producing goods and services must consider the whole life cycle of products not only from "cradle to grave" but from "cradle to cradle". This means that methods of production should consider all impacts of the production line, from extraction of materials *in natura*, to the use of necessary mass and energy to produce, and the alternatives taken into account in order to minimize wastes during the distribution phase. At the end, the focus may be set on the use and discard of objects for disassemble, their recycling and adequating deposition back to nature. When possible, the materials may be put back to production line, starting a second product life cycle.

2. TRENDS IN SEARCH FOR SUSTAINABILITY

The means by which the human society can deliberately and rationally approach and maintain a

desirable carrying capacity, based on continued economic, cultural and technological evolution was defined by Graedel and Allenby (1995) as a new trend of research called Industrial Ecology. This method can be seen as a theoretical background to designers in search for sustainable practices. According to the authors, a full consideration of Industrial Ecology must include the scope of economic activity and consumer behavior, once they both impact natural systems in different scales. Within the industrial ecology, two important methodologies can be identified as evolutionary approaches for the design process:

a) Design for Environment; and
b) Design for Sustainability.

2.1 Design for Environment

The Design for Environment (DFE) methodology plays a very important role when associated to sustainable production models, considering the product development as an integrated system where every decision influences the whole process and results in different impacts on the environment. The DFE can be defined as a process of design that takes into account the environmental performance (i.e. producing without damaging) of products from the very beginning of the project, focusing on optimization of mass and energy flows during the life cycle of matters and especially characterizing an efficient use of materials, techniques and manufacturing procedures in order to achieve the goals of the market and at the same time minimizing the negative residues and damages on human society and nature as well. The DFE consists basically on technological innovations and methodological proceedings that are aimed to help the designers and decision makers to produce goods and services economically viable and ecologically friendly. The Figure 1 shows a theoretical model of DFE alternatives based on the life cycle analysis (LCA) methodology (Souza, 2002).

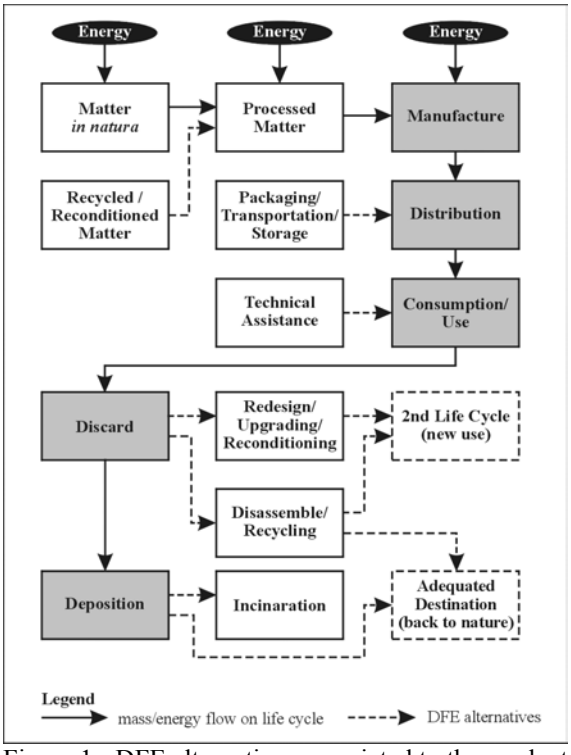

Figure 1 - DFE alternatives associated to the product life cycle analysis (Souza, 2002).

According to Allenby (1999), there are three phases on the DFE process: (1) inventory analysis, (2) impact analysis, and (3) improvement analysis. At first, the detailing of product needs and characteristics is done, identifying the environmental aspects that can make the product greener or not. During this phase, several tests must be done in order to verify mass and energy flows, material quality and production conformities that effectively contribute to a greater environmental performance. Second, the impact analysis process is proceeded, when the data are aggregated in eco-indicators (i.e. information systems with certain data that allow the decision makers to act in conformity with sustainable practices) that face the possible consequences of the process outside the industrial plant, especially those related to society and nature. At last, the improvement analysis process is done, when the designers and decision makers elect priorities and necessary changes in order to perform low costs, design innovation and eco-friendly improvements overall. The Figure 2 shows a check list of DFE presented by Souza (2002) based on preliminary studies of Tischner (1996).

Phase	Aspect of environmental performance
Production/ Manufacture	• Demand of material and energy to produce; • Diversity of materials in product design; • Intensity of residues/emissions from production; • Degree of loses during the manufacturing phase; • Demand of transportation; • Necessity of packaging; • Phisical impact of the industrial plant; • Degree of toxity in production line.
Consumption/ Use	• Demand of energy to use the product; • Weigh, size and demand of space; • Cleaning facilities; • Inovation/optimization in use; • Multifunctionality (e.g. different uses, combinations, modularity, etc); • Intensity of residues/emissions in use; • Lastingness, assurancy; • Monetary value, resistance, conservation; • Disassemble facilities, modularity.
Recycling/ Redesign/ Reuse	• Demand of materials and energy to reuse, upgrade and redesign; • Construtive complexity of the product; • Connections of materials (e.g. pasting, soldering, connecting systems, casting, etc.); • Disassemble facilities; • Facility in recognizing different materials; • Recriation / redesign facilities; • Reselling / redistributing facilities.
Discard	• Possibility of use as a new matter (i.e. 2nd life cycle; • Decomposition / biodegradation facilities; • Incinaration facilities; • Reduced degree of environmental impact during the decomposition phase.

Figure 2 - Check list of DFE (Souza, 2002 and Tischner, 1996).

2.2 Design for Sustainability

According to Manzini and Vezzoli (2002), the concept of Design for Sustainability (DFS) is strongly related to the capacity of promoting production systems that can respond to some social and environmental requirements in their products using as less natural resources as possible, in comparison to the current patterns. In these terms, the designers and decision makers have to coordinate every product, service and communication that can contribute to clarify the design

alternatives and technical solutions in order to attend social and cultural innovations. The method also considers the life cycle of matters and its impacts on human and natural systems, but assumes that new behavior patterns are taking place over the market in a point that consumers demand from producers much more conformity with environmentally sustainable, socially acceptable and culturally attractively ideas.

The DFS is aimed to offer efficiency to the design process, focusing on reduction of materials, choosing the right and eco-friendly source of energy, optimizing and giving more lastingness capacity for products and especially designing disassemble facilities from the very beginning of the project. Manzini and Vezzoli (2002) have presented four important phases to implement the DFS: (1) redesign, (2) upgrading, (3) new consumption patterns, and (4) sustainability.

The first and the second phases are normally integrated and can be placed together, depending on the route planning of both production lines and social demands. The redesign phase is basically focused on technological innovations and does not demand changes in social and consumption patterns. The role of the designer is to define strategies in conformity to the LCA, design products that attend the concepts of reducing, reuse and recycle. The phase of upgrading is focused on information, once is based on services and goods that are clearly eco-oriented. This means that the new proposals of green products are already recognized as valid and accepted by market and society. Innovations here represent strong ecological criteria and may be done progressively, demanding some behavioral changes in consumption patterns. From this point on, the participation of the society is crucial, which plays a definitive role in the search for sustainability, once is still difficult nowadays to introduce ecologically friendly products in market. The next phase, as the title itself says, demands new consumption patterns to be consolidated. It is focused on behavior and proposes sustainable practices in terms of living, buying, reusing, recycling, etc. The environmental aspects are the centre of the design project and the decisions must include new alternatives of making products, new materials, new strategies and better results for both production and nature. Despite of the fact that changing is always difficult and takes time, this represents the higher step to achieve sustainability as a whole. The last phase is naturally to maintain new scenarios and sustainable life styles, which can only be possible within the cultural perspective of changing views. The Figure 3 expresses graphically the implementation phases of the Design for Sustainability process, based on preliminary studies of Manzini and Vezzoli (2002).

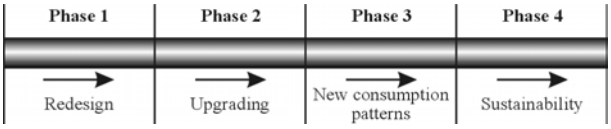

Figure 3 - Phases of implementation of the Design for Sustainability Proposal.

The perspective of sustainability discusses new concepts of development. Changes must immediately occur in order to stop depletion of natural systems and jeopardize life itself. According to Meadows *et al.* (1992), main considerations are necessary to be done on three strategic topics in order to achieve sustainable practices: (1) population, (2) search for well-being, and (3) technological eco-efficiency. At this point, sustainable solutions reflect in one hand social demands of goods and services, and on the other hand a technological response of innovation. Manzini and Vezzoli (2002) have presented a graphic model to better visualize the relationship between the Cultural Changes and the Technological Innovations, which are shown in Figure 4.

Eco-redesign is presented as solutions that are positive for the environment but not enough to be sustainable. The sustainability can only be achieved through new practices and trends that consider all aspects of natural and human systems themselves.

Figure 4 - Relationship between Cultural Changes and Technological Innovations in search for sustainability (Manzini and Vezzoli, 2002).

This idea signs some changes needed in order to achieve sustainability in different views, such as environment, society, ethics, culture, economy, etc. This strongly means changing the subject from technology through society and environment and vice versa. The Figure 5 shows an example of this trend focusing the changes of perspective needed in industrial process in order to achieve sustainable practices.

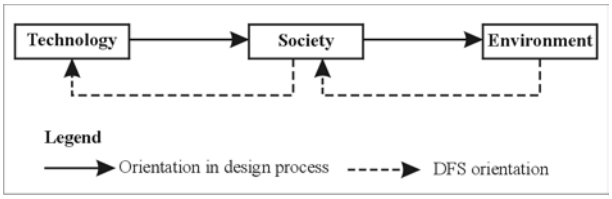

Figure 5 - Changes needed in search for sustainability.

According to the Environmental Protection Agency –EPA (2000), three main questions can be used as starting points when implementing an eco-oriented design programme: (1) in which ways does the company impact the environment?; (2) what exactly do these impacts represent to human society and nature?; and (3) how can the enterprise effectively improve its environmental performance?

These answers are normally used as part of a greater management strategy aimed to solve unconformities in production line and to work as a check list for designers and decision makers to follow in search for a better harmony between the industrial processes and the viability of life itself. In this context, DFE and DFS strategies are important tools to achieve sustainability, once both methodologies contribute to form a new pattern of industry with recycled materials, and a

rational and adequate use of energy to develop efficient products and eco-friendly as well.

3. CONCLUSIONS

This paper analyzes some concepts and methodologies such as Design for Environment and Design for Sustainability associated to the work of designers within the sustainable development context. The idea is to better understand the ways, in which designers should act in order to achieve sustainability in different views, such as environment, society, ethics, culture, economy, etc.

Using these views as a starting point, some reflections on eco-oriented design are presented. The main contribution of this paper is to present a theoretic model of eco-oriented design and to suggest design alternatives as a dashboard for designers and decision makers to follow in the search for a better harmony between the industrial process and the respect for nature and its limits.

Although several methodologies on designer's work have been published until now, more studies need to be carried out to consolidate eco-oriented design through the definition of a new behavioral pattern for designers, which is an open approach yet. The concepts presented in this paper are part of a greater project of research aimed to link design strategies (e.g. DFE and DFS) within the sustainable development context. The authors are opened to suggestions and comments that can contribute to achieve this common goal.

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