Reflections on Design, Sustainability and Reverse Logistics: PET packaging recycling in Brazil

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1. Introduction

During the past decade the debate on the role of design and its contribution to problematic social contexts has increased round the world, constituting a field of inquiry of high importance to design knowledge. As a direct result of the design and production processes, packaging is seen as one of the biggest problems in industrial societies, being understood as a great villain for the environment, due to the fact that packaging represents the greater volume of the urban waste. In Brazil, this waste has been progressively recycled by specific industries, giving a better destination for those matters.

Historically, policies and strategies of companies have been exclusively focused on distribution and marketing, stimulating a permanent increase of consumption worldwide. The inverse flow, on the other hand, has not been part of any significant worry for managers and decision makers. This process creates an impasse when addressing responsibility to post use and disposal of discarded products. While in Europe some legislation takes into account the responsibility of producers during the whole life cycle of their products, in Brazilian context, society as a whole has been responsible and involved in social and political movements that assume the onus, and/or bonus, of taking care of urban residues. Particularly, the work of Non-Governmental Organizations (NGO's), some of them responding with a significant number of recycling processes, like associations constituted by recyclable collectors (i.e. people that make a living from the collection and selling of recyclable matters), has represented an alternative way of minimizing the impact of such waste as well as deprival people social inclusion.

What happens, for instance, with discarded PET (polyethylene terephthalate) packaging? The Brazilian organization CEMPRE[1] calls attention to the fact that 6 billion PET packs, generated by 15 million houses and 50 million people, are discarded every year in Brazil. Only the correct balancing of the reverse logistics and sustainable design practices of these matters can reintroduce them to a new life cycle in production systems.

This paper analyses the interactions among the people that take part of PET packaging recycling in Brazil, connecting the fields of Reverse Logistics, Sustainable

[1] Acronym in Portuguese for Business Agreement for Recycling (*Compromisso Empresarial para a Reciclagem).*

Product Design, and Social Inclusion. The main contribution of this research is to establish conceptual alternatives to develop products, presenting a discussion on the responsibility of designers and decision makers when performing products, according to the sustainability approach.

2. Environmental Responsibility: new challenges and strategies

Contrasting to the first legislation in the beginning of the 70's, which tended to be carried on governments the responsibility of environmental impacts caused by solid waste, one of the most recent and basic idea is charging the manufacturers, directly and indirectly the responsibility of the impact of their products on the environment, through laws regarding the recycling steps, or indirectly, prohibiting on disposing it in landfills, or even the use of some types of packaging to the proper reverse channel structure definition. These legislations are originated by the EPR (Extended Product Responsibility) philosophy.

One of the most significant normative tendencies of the European and other countries is to extend to the manufacturer the responsibility on the final phase of the lifecycle of the products. Environment protection theme and its relations with the solid waste disposing have been increasingly discussed mainly in the developed countries (Levy, 2000).

In the Brazilian scenario, solid waste generation and disposing still need a broad standardisation, that is to say one National Solid Waste Policy, defining rules concerning to, for example, the generation prevention, reutilisation, handling, packaging, collecting, recycling, transportation, treatment, reusing, and solid waste disposal. In 1998 was launched the official Brazilian Recycling Program (*Programa Brasileiro de Reciclagem*) by the Ministry of Industry, Commerce and Tourism (MICT) in order to elaborate national general proposals, and since then a large number of laws has been discussed in the different legislative levels in the country.

More and more effective attention to the final lifecycle processes of the products has been addressed by the companies' management, in order to mobilize all the technical and managerial knowledge available. However, the big challenges remain on readdressing the business strategies in order to consistently incorporate the recycling analyses to the productive chain. This means, the effective desire of changing the organisation's culture acquires central importance, bringing to the top the need of rethinking the beliefs, values, attitudes, and practices, previously managed by the short-term focus, by the emphasis on the unlimited production growth, and by the orientation only to the internal organisation processes.

3. Reverse Logistics: equalising the backward

Historically, the reverse logistics was strongly associated to the recycling activities and environmental aspects (Stock, 1992; Barry et al, 1993; Kopicki et al., 1993). In this paper, the reverse logistics concepts will be focused on examining the reverse flows, i.e., those flows on the opposite way from the direct chain, where the disposable products after consumption face the adding of different types of values through the reintegration of their components or materials to the productive and business cycles. The reverse logistics is considered by many managers as just a packaging recycling process, mostly seen as a big cost generator, originated from the reverse planning limitation (Cottrill, 2000).

Currently, the reverse logistics potential benefits can be put together in three distinct levels: (1) referring to the environmental demands, which have driven the companies to

worry about the final destination of the products and packaging (Hu et al, 2002); (2) economic efficiency, once reverse logistics allows financial gains generation through resource savings (Minahan, 1998); (3) constructing a good company image among its stockholders, besides increasing its brand prestige and its image on the market (Rogers et al., 1999).

However, even when recycling is technically possible, the big challenge is to obtain the materials reverse flow through the distribution channels. As some authors pointed out, "specifically, recycling is primarily a distribution channel problem, because the biggest cost of waste recycling is the collection, selection and transportation" (Zikmund & Stanton, 1971:34).

Fuller (1978) believed that recycling after-consumption is properly seen as the reverse channels developing problem. This author argues that the initial collection, selection, and the material accumulation are just the first point of a big and continuous process, which must result in repetitive market transactions with industrial users.

The maintenance of the desirable round flow depends on four basic conditions: (1) an available technology to obtain an efficient processing of the materials to be recycled; (2) a substantial and continuous material quantities and secondary products must be available in the domestic solid waste; (3) a marketing channel profitable system linking secondary product suppliers and final users must be developed; and (4) a final product market must be developed. Besides, recycling materials match the industrial necessities in general. These markets require a stable material flow with recognized quality, big and on time quantities, and many buyers focused on a general category (ex. aluminium, plastic, etc) (Guiltinam & Nwokoye, 1974).

Carter & Ellram (1998) take reverse logistics as a hierarchical process. In this way, resource reduction refers to minimizing the use of used materials in products, such as the waste and the energy, through more environmental efficient products design (Carter & Ellram, 1998; Stock, 1992; Kopicki et al., 1993). As all other logistics decisions, this hierarchy must be considered within the context of the lifecycle analysis, where all relevant and measurable costs are considered (Kopicki et al., 1993). The authors stress the product reuse can reduce costs in buying, transportation and disposing; while the recycling of just one item reduces just the disposing cost. Although the recycling is just a desirable ecologically correct technique for waste disposing, it is good to remember that is not the final target when talking about sustainability.

4. Role of Life Cycle Design in developing sustainable alternatives

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". In this perspective, the Life Cycle Design (LCD) can be seen as an important tool to obtain higher environmental performances from products and services, i.e. producing without damaging.

This method focus 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, from the very beginning of the project, 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. Life Cycle Design 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 LCD alternatives based on the Life Cycle Assessment (LCA) methodology (Souza, 2002).

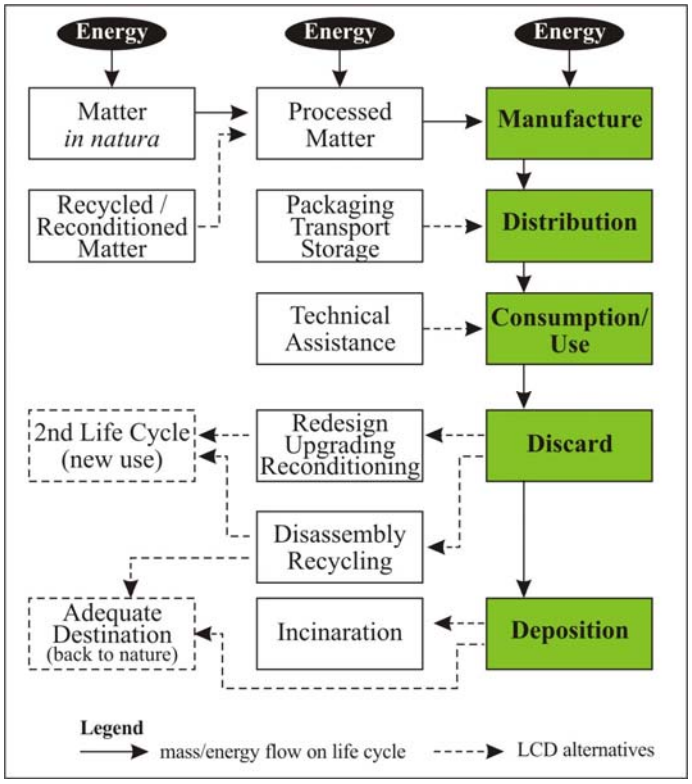


Figure 1 – Life Cycle Design theoretical model (modified – Souza, 2002).

According to Allenby (1999), there are three phases on the LCD 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 done, 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 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.

So, the sustainable product design is a process involving a large number of subjects, which goes further than packaging recycling. These subjects are connected to the product development what allows to overview the entire lifecycle. From this point on, it is possible to notice the complexity of the PET recycling chain in Brazil, marked by more and more intense social and legal pressures, and by many people's presence, with motivations, conceptions and different managerial capabilities.

5. Perspectives for PET recycling in Brazil

The packaging of PET was launched in Brazil in 1988. It not only brought great advantage to the consumer, but also brought the challenge of its recycling. Lately, the Brazilian production of PET has increased. Nowadays, Brazil is the third biggest consumer of PET in the world, for the production of 3.400 different brands of soft drinks in bottles. According to Tomra (2004), about 68% of all soft drinks produced in Brazil were packed in PET bottles.

Although it seems that the growth of the market of PET is in its limit, it is still increasing because PET is being used in new segments such as oil and water. Nowadays, four companies are producing PETs in Brazil, about 360 million ton per year. This production causes strong effects on the environment because they have a short life, from their production to their utilization until their disposal. The whole process takes just a few days.

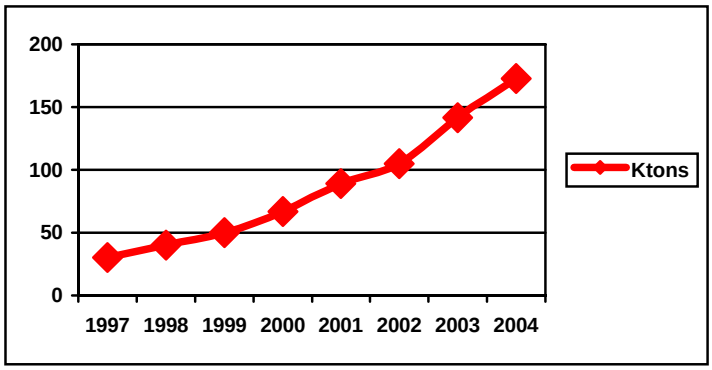
The technology development has increased the production of garbage from 0,5 kg to 1,2 kg per person every day (Leite, 2003). On the other hand, PET is 100% recyclable and it can be recycled many times. On the other hand, it becomes aggressive to the environment if it is mixed with common garbage. When it is left in landfills, the soil becomes impervious, reducing the gas and liquid circulation. PET should be the easiest plastic to recycle, but there are a lot of difficulties to collect the product with a great added value and low contamination.

Recent published data by ABIPET[2] shows the recycling of 48% of the total production of PET packaging in 2004, what means that 52% did not return to the industries, but yet, it lay on the beaches, streets and rivers. These not recycled ones, still in the "*one way*" concept, are part of the "*throwing away*" old economic paradigm. Besides that, the recycling level is increasing as shown in the Chart 1.

The recycling process should be improved, so that PETs would break technical and legal difficulties of utilization in different segments, especially in the direct contact with food, but it demands large investments in manufacturing. According to Plastivida (2005) there are 126 Brazilian recycling PET industries, but most of them are small, with minor investment and technology.

[2] Acronym in Portuguese for Brazilian PET Industry Associated (*Associação Brasileira da Indústria de PET*).

Chart 1: The evolution of PET recycling in Brazil (ABIPET, 2005).



The mechanical recycling of plastics is the most conventional way of regaining the added value of these materials in Brazil. The plastic garbage is grinded, washed, dried, and reprocessed, originating new products. But, in this process as a whole, the PET gets in contact with oxygen, water, light and heat, agents that attack plastic chemical bonds, degrading it and making its final properties worse. This recycling process is responsible for almost 100% of the PET recycling in the country, normally used in the synthetic fibres for padding, strings, carpets, cables, etc. The reverse chain object of this study has three very clear stages: (1) regaining: from the disposal until the PET bale composition; (2) revaluation: it ends with grinding it into flakes or processing it into grains; (3) transformation: the resulting recycled PET into new products.

5.1 Scrap Regaining: the collection and selection challenges

The increasing joblessness and homelessness in Brazil in the last 20 years has led to the development of a new strategy of income generation: to overcome poverty. Some urban / street residents have started up recycling activities, as their major means of subsistence. They mainly collect discarded mass produced objects and all kinds of recyclable materials. Collectors are engaged in the development of an environment-friendly economy as they clean the city. The materials they find are sorted and reintegrated into the productive cycle. Although they play an important role in the urban waste management, they receive no health care, housing, social security or education benefits. They are looked upon as dirty people, and even delinquents, rather than productive members of our society (Santos, 2005).

In 2003, 80% of the recycling activities were based on the work of collectors (Czapski, 2005). The reusing cycle begins with the collectors' hands, and many times passes through intermediate agents, and goes to the recycling factories and transformation industries. In a silent and slow way, they are becoming affiliated to organized associations, cooperatives, trying to have their rights recognized, imposing an alternative to the public collection service[3]. The purpose of creating collectors' cooperatives is to increase the value of the materials added by accumulating them and reducing the transportation costs to a profitable level. The scale is a fundamental element in order to make recycling feasible.

[3] In 2003, a Recyclable PET Industry was launched in Minas Gerais State, both created and managed by collectors cooperative.

In the case of bottles and other type of plastic packaging that take a lot of room (the low density with high volume and low weight), it's necessary to press and pack the scrap or to grind and commercialise the material. Grinding is the first step of the recycling industrial process, demanding resources and higher specialization than the pressing one. A good recommendation is to first withdraw taps and labels, and then the primary crease with the feet. In the PET case, the recyclers suggests 100 kg bales with no more than 2% of other plastics, and 100% free of PVC and other impurities, in order to maximize the commercial product price. Once again we face the importance of the design: in order to increase the recycling quantities, the plastics have to be pre-compacted when ruled out, by stepping the bottles or washing and squeezing them, facilitating their transportation.

The PET wrappings, when properly separated, provide the workers the second best income level of the scrap market. Its recycling operations, apart from avoiding plastic waste in the public landfill, needs only 30% of the total energy necessary to the virgin resin production, and may be recycled many times without losing the quality. In the sense of facilitating the plastic resin detachment, the companies and the recycling related organizations adopted a codification for the recycling plastic recipient system that consists of a symbol with three following arrows, marking the type of plastic used to manufacture the recipient.

5.2 Revaluing: the recycling link

The PET polymer is a kind of polyester, one of the most recycled plastic in the world, due to its extensive number of uses, from the textile fibres to the packaging. Most of the manufacturers produce flakes or fibres to many applications. The industry motto is that the fibre production does not need high intricate gumminess. After drying the flakes, the material can be grinded and transformed into grains to different uses. This is a critical step, once the grain production through the material fusion process cannot be contaminated and degraded, what leads to a drastic low intricate gumminess, and to the yellowness of the product, lowering the quality and reducing the possibility of many different applications.

The PET reverses chain benefited from the already developed collecting of paper and aluminium structures. The recycling companies are responsible for reprocessing the PET packaging, obtaining two different sub-products: flake and grains. The recyclers specialized in flake manufacturing are normally small companies, with just some of medium size. They process the scrap by separating it manually, grinding, washing with water, and drying the final amount. High quantities of collected plastic packaging are necessary, about 150 ton/month, in order to make the activity profitable.

The plastic recyclers in general face a wide range of bureaucratic obstacles due to the Brazilian state complexity (federal, state and city procedures), lack of specific garbage processing legislation, the federal taxation (IPI, industrialized products tax) on the plastic scrap (the only recyclable plastic scrap not free from it), and also the bi-taxation of the value added (ICMS) state tax. Furthermore, the access to the technology innovation channels is difficult. This situation reflects what is happening to the national industry, like low private investment tradition in research and development, difficulties to reach the correct information, and mainly the weak connection between the research centres and the manufacturers, in special the small and medium sized ones.

All these pointed difficulties do not contribute to the expansion of the market. Another obstacle is the mandatory classification of the different types of plastic (PVC, PET, PP, PEBD, etc.), what increases the selection costs. Despite these restrictions, the

expansion is pushed by the strong demand, caused by its costs or the ecological appeal. In the PET and PVC cases there are more incentives coming from the transformation industries. The market evolution and the technological improvements have been pushing the uses of recycled PET as for threads, strings, carpets, trays, and even new bottles. Only the ABIPET members are responsible for 80% of the total PET scrap consumption.

6. Final Considerations

Recycling in Brazil faces many dilemmas and despite of its fast growth in the last decade, it still needs to overcome some challenges in order to make a wider way towards more advanced levels into the sustainable design direction. The main difficulties related to the PET collection are about the colour and the type separation due to its multiple uses and applications, and also the contamination by other plastic materials, besides glue and dirtiness. Plus, there are intermediate human agents, called "sucateiros", who add troubles to the quality increasing of the productive process: the quality and the reliability of the handing over collection, and because of the low quality of the work force (collectors), which have many obstacles to get higher qualification. In addition there are few initiatives for the selective collection, taking into account the size of the urban universe in the country. Finally, it is urgent to review the public policies in the three government levels, such as taxation and urban waste management.

In order to reach the best results it is necessary to invest in pre and post recycling steps, that means, in the selective collection and on the recycled products market. Governments, universities, non-governmental organizations and companies working together may motivate the recycling development in the country.

Despite of these difficulties, the PET recycling has strong appeals in the ecological and economic senses, besides the social paper in Brazil. The collectors' capillarity as reverse packaging agents of the consumed products turns wider the scope and the feasibility of the recycled volumes. Their presence in the metropolis brings important contribution to the education and to the enlargement of the environmental consciousness.

This way, it's necessary to invest more money in the design of information and technology process: showing to big audiences the knowledge about material recycling, providing information about how to proceed for the correct packaging disposal - this is the main idea (i.e. developing technologies to create easier recycling materials, harmless and inert ones), protecting the environment as another important issue to take action in. It is also necessary to improve the recycling education process in Brazil, particularly the perspective related to domestic 3R practices, i.e. reduce, reuse and recycle.

On the other side, the scrap has a life cycle to achieve its valorisation in the productive chain of recycling and reusing. Job generation, income and resource savings' are the consequent phases of the non-wasteful logic.

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