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**ANALYSIS OF THE POST-CONSUMPTION REVERSE CHANNEL
OF THE PET BOTTLE IN BRAZIL**

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ABSTRACT

This paper intends to introduce and discuss the challenges that exist in operating the post-consumption reverse channel for PET bottles in Brazil using theoretical concepts to discuss the possibilities of reverse logistics in the PET bottle recycling chain. The importance of this study consists of raising important information about the sector and the opportunities for taking advantage of this waste through recycling, and the interests and difficulties found in their reverse flow. The successful structuring of the PET bottle reverse channel is found by involving the multiple players involved, whether of the public or private initiative, in order to achieve the desired result in the Brazilian environmental scenario.

Keywords: PET bottles, reverse channel, recycling

1 INTRODUCTION

Over recent decades, demographic growth, unprecedented industrialization and competitiveness for new markets have forced companies to face the issue of the environmental impact caused by their production process and the generation of waste from their post-consumption products.

With this scenario in mind, companies develop an emerging concern with the generation of waste from their post-consumption products, whose return needs to be considered, thus providing a business opportunity through reverse logistics (RL).

For companies, RL should not be understood merely as a business perspective, but also as a sustainable procedure that reflects concern for the environment and society in general.

Existing, post-consumption RL initiatives, mainly in the beverage industry, which manages the return of its bottles, have proven to be examples for other segments like the automobile, steel and technology industries.

According to Costa and Valle (2006), the recycling of Polyethylene Terephthalate (PET) packaging is an example of a post-consumption reverse distribution channel, because used packages, when recycled, add value since the raw material that stems from this product can be used in the production of other products.

The PET package is a thermoplastic polymer that has transparency, shine and lightness as characteristics. The package is ideal for the beverage industry, which uses it for mineral water, vegetable oil, and cleaning, hygiene and beauty products. Another interesting characteristic is it does not release toxic substances, even when burned, and it is also 100% recyclable.

In Brazil, approximately 53% of post-consumption packages were actually recycled in 2007, totaling 230,000 tons of the 432,000 produced. The bottles are mainly recovered by garbage pickers, as well as factories and selective collection operations by cities (CEMPRE, 2008).

At a global level, Brazil is one of the largest consumers of PET bottles. According to Dias and Teodósio (2006), although it seems that the tendency for growth of the soft drink packaging market is reaching a limit, PET growth in the country increases faster than production, pulled by the use of the polymer in new food segments. The tendency for production of the polymer is growing; however the reverse flow and recycling installations need to be structured.

The low volume of PET recycling is attributed to its economic value per ton compared, for example, to aluminum packaging. Leite (2003) says the PET bottle recycling index is affected by logistics factors, such as: geographic dispersion of post-consumption bottles, the weight/occupied volume ratio and the fact it is an open cycle reverse channel.

The importance of RL is tied to economic, governmental, social and corporate responsibility reasons (COSTA; VALLE, 2006). Thus, all those directly or indirectly involved in the PET package production chain must be aware of the importance of preserving the environment and

the gains all those involved can obtain, whether economic, social or in terms of corporate image.

In order to minimize the inappropriate disposal of waste in the environment, CEMPRE (2008) registers recycling business in Brazil promoted by corporate associations or isolated companies that believe in this alternative as a means to reduce raw material or process costs, preserve natural resources and promote inclusion.

As seen above, the objective of this study is to describe the challenge in relation to processes, through the creation of conditions for collecting this product from the market by the producer and also in relation to more effective recycling actions by product consumers.

2 LITERATURE REVISION

2.1 Polyethylene Terephthalate (PET) Packaging

Polyethylene Terephthalate (PET) was developed in 1941 by English chemists Whinfield and Dickson. But the bottles produced with this polymer only began to be manufactured in the 1970s after careful review of safety and environmental aspects.

PET is part of a group of materials called plastics, produced in a chemical process called polymerization that joins monomers to form polymers (ABIQUIM, 2008).

Use of the PET bottle focuses on packaging food products, since it is a material that contains transparency, impermeability and lightness characteristics (Figure 01). According to data from the Brazilian Association of PET Package Manufacturers – ABIPET, use of this package for food products answers for approximately 90% of the market.



Figure 1 – PET Bottles

Source: ABIPET (2008)

The package's low industrial cost increases the amount disposed of in the environment. There is also a lack of logistics structuring for collecting the material since the manufacturer of these packages has no interest in recycling used material. Brazilian legislation still does not permit reusing these packages for foods. This differs from other countries, including the United States, which use a bottling technology called *bottle-to-bottle* that uses recycled PET as its raw material (EXAME MAGAZINE, 2007).

According to Dias and Teodósio (2006), although it seems that the tendency for growth of the soft drink packaging market is reaching a limit, PET growth in the country increases faster than production, pulled by the use of the polymer in new food segments. In other words, there is a growing trend in producing the polymer although the reverse flow and recycling installations need to be structured. The authors also point out that Brazil is one of the largest consumers of PET in bottles.

Focusing on the life of a generic product, Manzini and Vezzoli (2005) define a series of activities and processes, each of them absorbing a certain amount of matter and energy, operating a series of transformations and releasing several types of emissions. These processes are grouped in several phases of a product's life cycle, which are subdivided into:

- a) Pre-Production: phase in which the materials are introduced, that is, semi-elaborated raw materials used in the production of the components.

- b) Production: phase in which the materials are elaborated for use, involving the transformation of materials, assembly and finishing.
- c) Distribution: phase that involves packaging, transportation and storage.
- d) Use: phase in which the product meets its purpose, the reason it was produced, satisfying the needs of its users.
- e) Disposal: this is the moment the product is “eliminated”. A series of options opens up for final disposal in this phase. Reverse logistics handles the products at the end of the production cycle.

All of the aforementioned phases are part of PET bottle production and they interact, causing environmental impacts due to the extraction of natural resources, generation of waste, as well as appropriate disposal.

It becomes necessary for processes to study and create conditions for the producer to collect this post-consumption package as well as more effective separation actions for recycling on the part of product consumers.

2.2 Recycling

Manzini and Vezzoli (2005) say that to extend the life of materials means having them live longer than the products made of these same materials. In other words, the materials can be reprocessed to be transformed into secondary raw materials. When this reprocessing occurs, there is recycling, which can involve two different processes:

- **Closed loop recycling:** this is a system in which recovered materials are used in place of virgin materials, being used to make the same products or derived components. Theoretically, this model feeds itself for a certain period of time, without the need for new virgin materials to be added;
- **Open loop recycling:** in this case, the materials are sent to a system, where the product is different from the original. It normally occurs with post-consumption

materials. This process operates with a mix of diversified products and different producers.

The PET bottle is a post-consumption waste and its disposal is not regulated by any type of legislation in Brazil. In other words, existing actions regarding returning these products for a new production cycle are related to initiatives by recyclable material pickers who send these materials to scrap yards, which in turn send them to recycling companies.

According to CEMPRE (2008), PET package recycling is growing quickly in Brazil. The material's characteristics are lightness, resistance and transparency, ideal for satisfying the demand of domestic consumption. Market evolution and technological advances have driven new applications for recycled PET, from sewing yarns and threads to carpets, egg and fruit trays and even new bottles for non-food products, since food product applications are not permitted as of yet by the National Health Surveillance Agency - ANVISA. Besides removing plastic garbage from landfills, its recycling only requires 0.3% of the total energy necessary for producing the virgin resin. And it has the advantage of being able to be recycled several times without harming final product quality.

According to CEMPRE (2008), after it is collected, PET bottle recycling is subdivided into the following stages:

1st - Recovery: in this phase, packages that would be thrown in common garbage gain the status of raw material. Recovered packages are separated by color and pressed. Separation by color is necessary so the products that will result from the process have color uniformity, thus facilitating application in the market. Pressing, on the other hand, is important to make package transportation feasible since PET is very light.

2nd - Revalorization: the bottles are shredded (flaked), adding value in the market. The resulting product in this phase is the bottle flake. It can be produced in different ways, and the more refined flakes can be used directly as a raw material for manufacturing several products

recycled PET is used for in the transformation phase. However, it is also possible to further valorize the product by producing plastic pellets. The product thus becomes much more condensed, optimizing transportation and performance in transformation.

3rd - Transformation: in this phase, the flakes or pellets are transformed into a new product, closing the loop.

After the above described process, the transformers can use recycled PET to manufacture several products including new bottles for non-food products.

The great difficulty in maximizing recycling is related to the costs involved in the process, that is, it is necessary to take into account costs related to collecting, transporting and storing as well as the material's commercialization value (MANZINI and VEZZOLI, 2005).

2.3 Logistics

According to Faria and Costa (2005), logistics, operating with diversity, whether of languages, cultures, legislations and climatic factors or the market base, when well managed, can become a strategic resource for gaining a competitive advantage, due to the possibility of offering a better level of service to the client or a reduction in logistics costs and improved company profitability, and must assume many requirements to produce the desired effect.

Business logistics studies how the administration can promote a better level of profitability in distribution services to clients and consumers through planning, organization and actual control for movement and storage activities that aim at facilitating product flow (BALLOU, 1993).

Christopher (1997) expresses the concept of business logistics as the process of strategically managing the acquisition, movement and storage of materials, parts and finished products (and the correlated information flows) through the organization and its marketing channels in order to maximize present and future profitability by filling orders at low costs.

According to the Council of Logistics Management (2008), logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third party logistics services providers. To varying degrees, the logistics function also includes sourcing and procurement, production planning and scheduling, packaging and assembly, and customer service. It is involved in all levels of planning and execution-strategic, operational and tactical. Logistics management is an integrating function, which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions including marketing, sales manufacturing, finance, and information technology.

2.4 Reverse Logistics

The Reverse Logistics Executive Council (2008) agrees that reverse logistics is the process of planning, implementing and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal.

Leite (2003) says reverse logistics is the area of business logistics that plans, operates and controls the flow and the corresponding logistics information, from the return of after-sales and post-consumption goods to the business or productive cycle through reverse distribution channels, adding value of several kinds: economic, ecological, legal, logistical, corporate image, among others.

Fuller and Allen (1995) say there are some factors that lead to the application of Reverse Logistics, including the following five factors:

Economic: related to production costs due to the need to adapt products and processes to avoid or reduce the impact on the environment;

Governmental: related to legislation and environmental policy;

Corporate Responsibility: related to manufacturers' commitment towards collecting their products at the end of their useful life;

Technological: related to the technological advances in recycling and product projects aimed at reuse after disposal by society;

Logistics: related to the logistics aspects of the reverse chain, such as product collection.

Rogers and Tibben-Lembke (1998) define reverse logistics as the process for planning, implementing and controlling efficiency and the effective cost of the raw material flow, in-process stock, finished products and information corresponding to the point of consumption to the point of origin aimed at recapturing the value or indicating the appropriate disposal as in Figure 2.

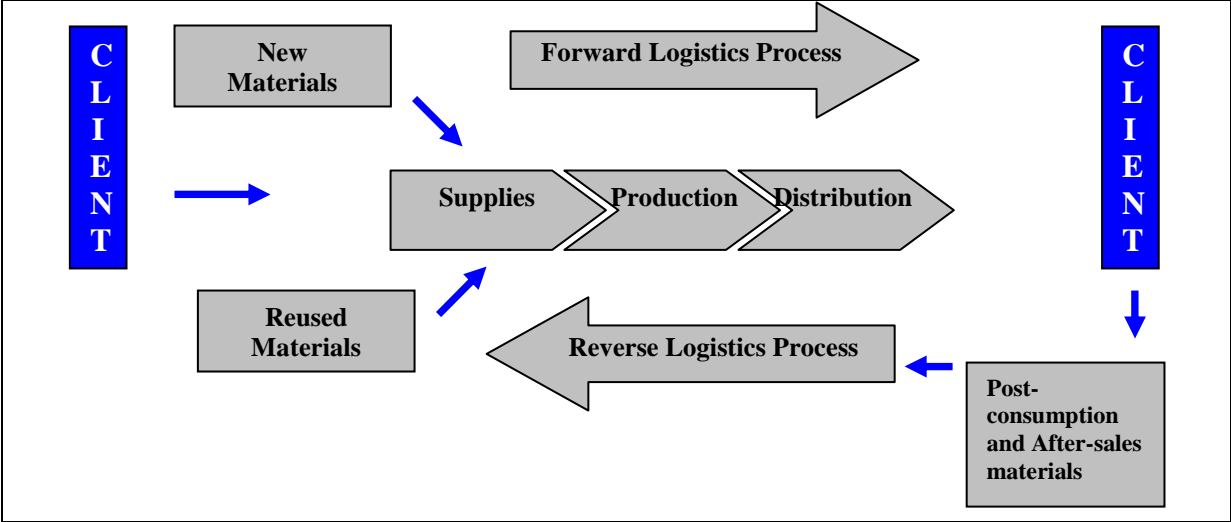


Figure 2 – Reverse Logistics Process

Source: Adapted from Roggers and Tibben-Lembke (1998)

According to Lacerda (2002), the reverse logistics process generates reused materials that return to the traditional supply process (Figure 3).

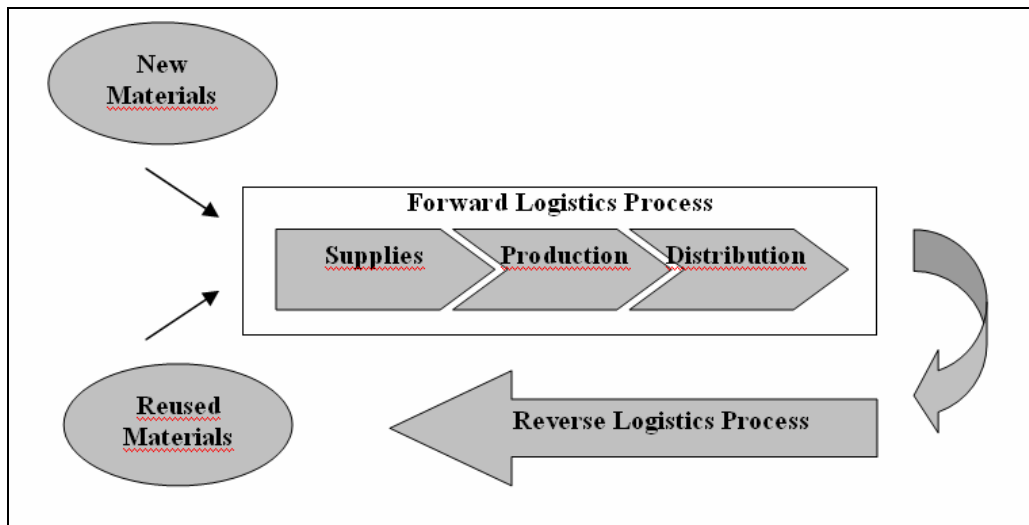


Figure 3 – Forward and Reverse Logistics Process

Source: Lacerda (2002)

Reverse logistics encompasses the movement of post-consumption (at the end of their useful life and industrial residues) and after-sales (returned due to commercial errors, problems and guarantees, among others) materials, from disposal on the part of the final consumer to their reintegration to the business cycle, without causing greater environmental impacts.

In the case of the PET bottle, recycling is for producing polyester fibers for the textile industry, manufacturing broom and brush strings and bristles, producing films and sheets for shower boxes, thermoformers, vacuum formers, traffic signs and signing in general, adding value to business. Through reverse logistics or post-consumption logistics, the product life cycle no longer finishes when reaching the final consumer. We can therefore say that recycling is the reverse channel of reverse logistics since it adds value to the product after use. After-sales goods return for different reasons and they mainly use their own direct distribution channels, whereas post-consumption goods have their own organization that will give origin to the reverse supply chain (LEITE, 2003). Figure 4 describes, specifically in the PET bottle sector, how recycled materials do not return for manufacturing similar products, thus characterizing an “open loop” reverse channel.

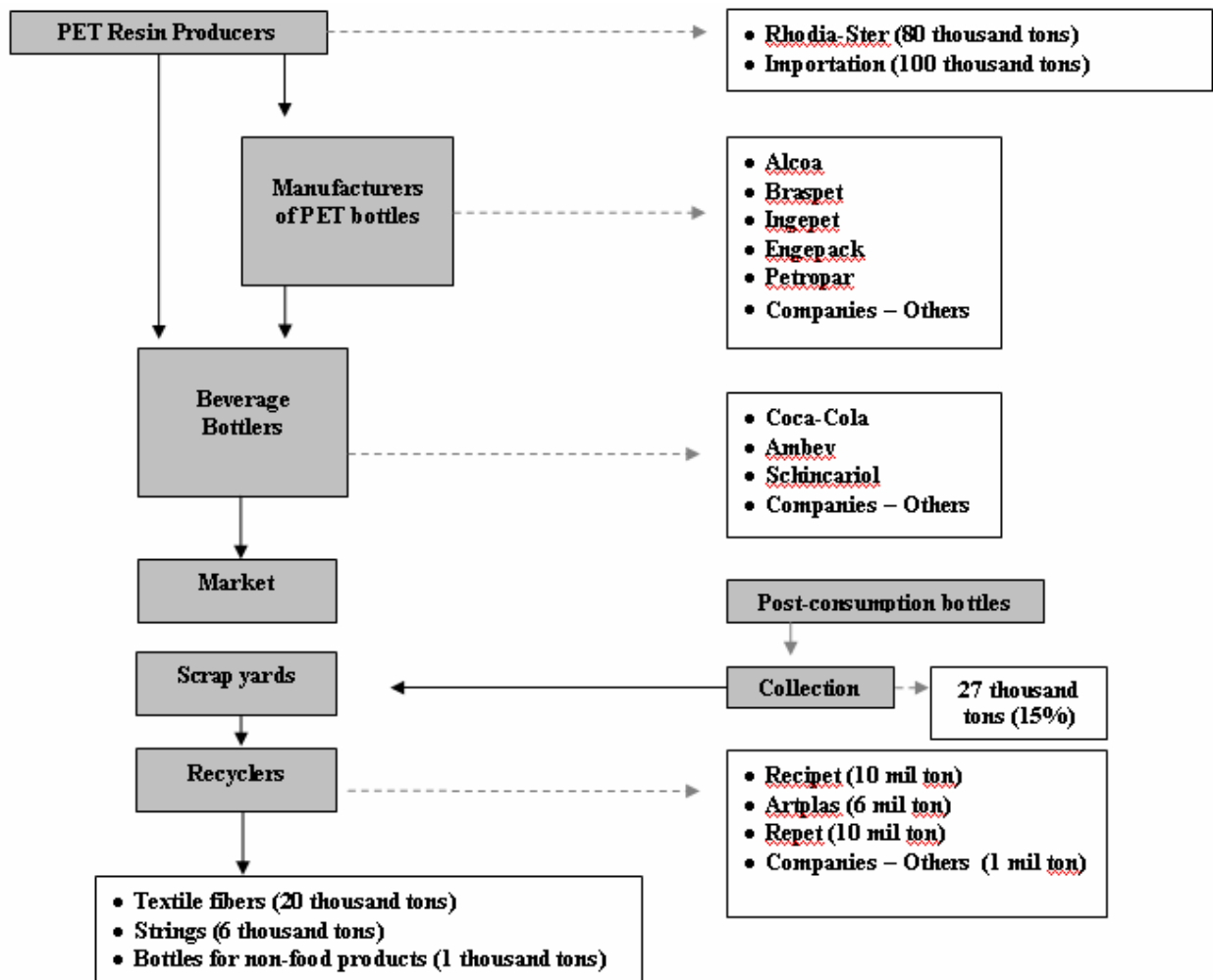


Figure 4 – PET bottle distribution chain

Source: adapted from Leite (2003)

Reverse logistics includes development processes for goods, inventories, resupply, repeats and excess inventories. It also includes recycling programs, hazardous materials programs, obsolete equipment disposal and recovery of resources.

According to Chopra and Meindel (2003), a supply chain is dynamic and involves a constant flow of product information and money between the different stages, such as: clients, retailers, wholesalers, distributors, manufacturers, part suppliers and raw materials. Every stage of the supply chain executes different processes and interacts with other stages in the chain. The series of organizations interrelate, creating value in the form of products and services, from raw material suppliers to the final consumer.

According to Leite et al. (2005), the organizational practices and procedures involved in the diverse phases of product returns, the relationship and information exchanged between companies in the chain and the resources employed in return operations, define the degree of reverse channel structuring.

There are four reverse logistics processes involving recycling: collection; the combined inspection, selection and screening process; reprocessing and redistribution (DIAS and TEODÓSIO, 2006).

The reverse logistics process must be sustainable, since it deals with much broader issues than mere returns. The materials involved in this process can be returned to the supplier, resold, reconditioned, recycled or simply disposed of and replaced.

2.5 Reverse Flow of Post-Consumption Goods

According to Brito and Dekker (2002), there are three important issues for analysis and structuring of reverse chains. The first issue is related to the reasons for which the packages are returned:

- In the manufacturer's perspective, there are three forces that can direct its actions, that is, economy, legislation and extended responsibility.
- In the consumer's perspective, the package must be disposed of at the end of its life. In general, it is difficult to involve consumers in returning products to the manufacturer since they require incentives for stimulating the consumer to return the post-consumption product to the manufacturer (BRITO and DEKKER, 2002).

For the return to happen, it is necessary to consider all players involved in the process. An attempt is made to understand how reverse logistics works in practice. Those involved can be differentiated according to who returns, receives, collects and process the material. Any part of the chain can be responsible for returning, including consumers. Receivers can be found along the supply chain (suppliers, manufacturers, wholesalers and retailers). Then, there is the

group that collects. They can be independent intermediaries, like: specific recovery companies, reverse logistics service providers, municipal residue collection companies, public and private foundations created to help in recovery. Finally, the processors are responsible for transforming it into a new product that will return to the market (DIAS and TEODÓSIO, 2006).

3. USING RECYCLED PET

In face of the need to reduce residue at a global level, the use of recycled PET is an alternative to increase the useful life of landfills since it is material that takes a long time to degrade in the environment.

According to data from ABIPET (2008), the destination for most recycled PET is the textile industry, as seen in Table 1.

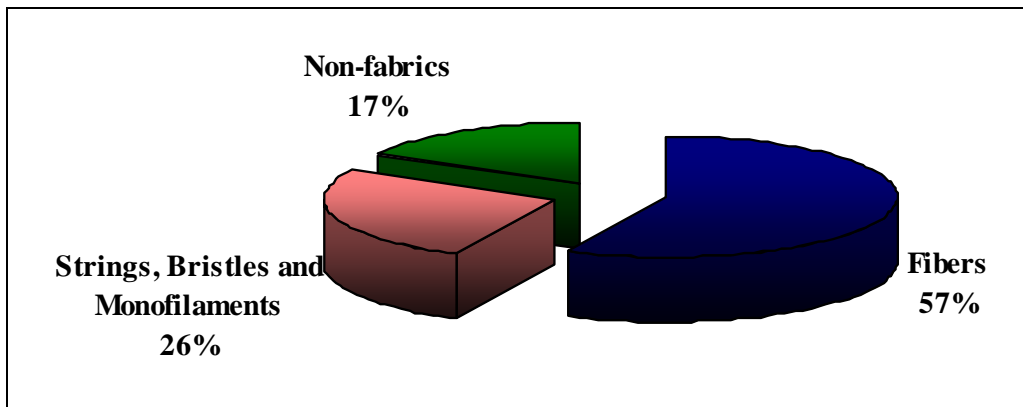
Table 1 – Destination of PET in Brazil from 2004 to 2007

	2004	2005	2006	2007
<i>Textiles</i>	49.4%	43.0%	40.0%	50.5%
<i>Sheet Extrusion</i>	-	-	16.0%	13.1%
<i>Thermoformers</i>	-	11.0%	15.0%	12.0%
<i>Chemical Resins</i>	6.7%	16.0%	7.0%	6.1%
<i>Exportation</i>	8.0%	12.0%	7.0%	5.8%
<i>Injection and Blow</i>	-	-	3.0%	4.1%
<i>Tapes</i>	5.1%	5.0%	3.0%	3.6%
<i>Engineering Plastics</i>	-	-	4.0%	3.2%
<i>Tubes</i>	6.2%	6.0%	2.0%	1.7%
<i>Laminates</i>	5.7%	4.0%	-	-
<i>Packaging</i>	5.3%	3.0%	-	-
<i>Others</i>	13.6%	-	3.0%	-

Source: ABIPET – PET Recycling Census in Brazil 2004-2007, (2008).

According to ABIPET data, the application in textile products is still the most important destination for recycled PET, and it has benefited from the heating up of the economy and exportation and tubes were uses that lost share compared to the year before.

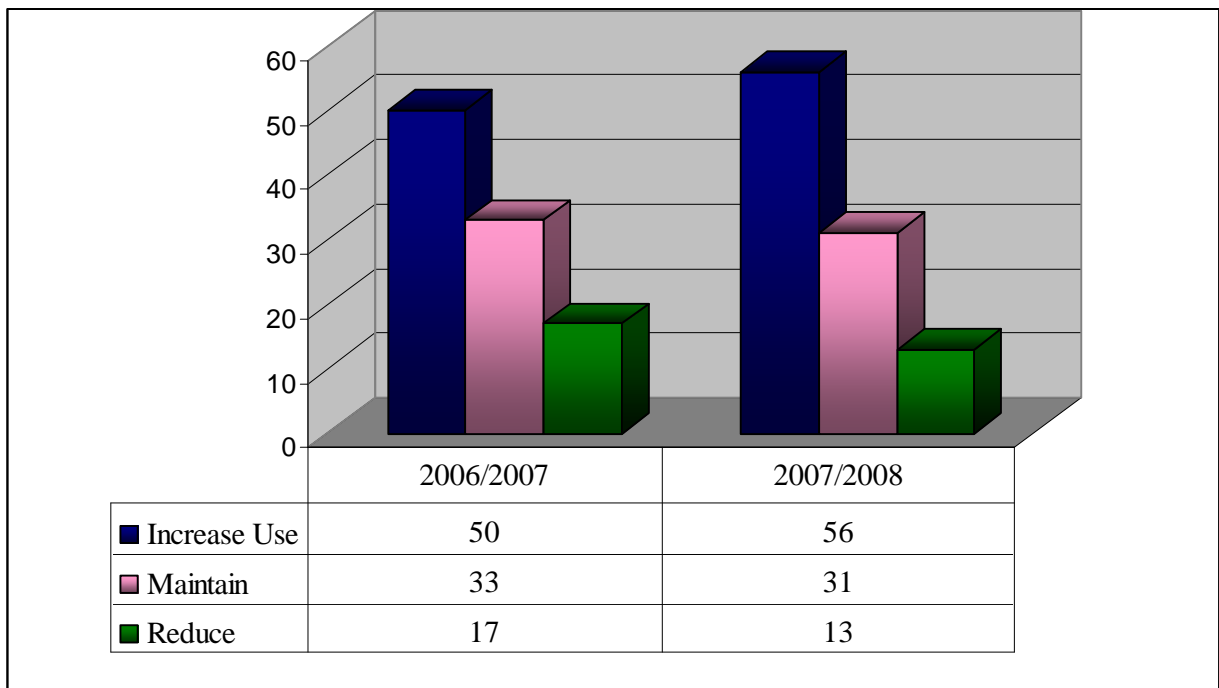
Considering only textile applications, which represent more than 50% of the total, graph 1 highlights the growth of applications in strings, bristles and monofilaments.



Graph 1- Recycled PET – Final Uses - Textiles – 2007

Source: ABIPET (2008)

The use of recycled PET has broad approval by users. So much so, the vast majority continues to make plans to increase or maintain resin consumption, as seen in graph 2.



Graph 2 – Intention with regard to the use of recycled PET

Source: ABIPET (2008)

Observe that comparing the censuses of 2006/2007 and 2007/2008, there was a 6% growth in relation to business owners who intend to increase the use of recycled PET, and also a 5% retraction in terms of those who intend to reduce the use of the material. This reveals growth in the tendency for using the material.

5. FINAL CONSIDERATIONS

According to data, it can be observed that effective actions are needed in the sense of increasing the return of PET for recycling since there is an interest on the part of those who use the material to increase consumption. The reasons for increasing the use of recycled PET include the reduction in the production cost in relation to virgin material and the reduction in extraction of natural resources.

According to Manzini and Vezzoli (2005) the recycling phase related to collecting and transportation must not be underestimated, whether in terms of reverse logistics planning, or in terms of the environmental impact. This phase is often the one that indeed jeopardizes recycling savings and environmental advantages.

In the case of PET bottles, this phase is fundamental, since there is no other type of legislation that obliges the manufacturer or the consumer to provide proper disposal to post-consumption material. More specifically, those most involved in the process, the consumer, must be made more aware.

There is also the need to structure reverse distribution channels since the restriction factors, according to Leite (2003), in terms of an increase in **PET bottle** recycling levels, are:

a) **Economic Factor:** represents an important influence since this material has high purchase and sales price sensitivity and faces the difficulty of competition from other materials in collection and along the reverse chain due to the fact that the values involved do not correctly remunerate the diverse links;

b) Legal Factor: refers to the prohibition of the use of recycled plastics in new bottles for food use, which eliminates a substantial portion of the market for recycled plastics;

c) Technology Factor: this is restricted to larger recycled quantities due to technical difficulties in the industrial recycling process of the constituent material, which demands greater investment and specific technology, which differentiates it from the other plastics;

d) Ecological Factor: although much talked about by the sector, this has not shown any important influence in recycled quantities. The product is presented as highly recyclable; however, there is a big problem regarding logistics organization in the sector in terms of the diverse links of the forward and reverse chain which have no interest in structuring for collecting post-consumption bottles.

The main concern is in creating consumption awareness in the sense of residue generated, and no less important, the need to involve business players as well as government authorities with the objective of helping in the process through public policies.

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