Packaging and Sustainability
Challenges and directions in the context of the Circular Economy

CETESB – Companhia Ambiental do Estado de São Paulo
(Environmental Company of the State of São Paulo)

ABRE – Associação Brasileira de Embalagem
(Brazilian Packing Association)

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Packaging and Sustainability

Challenges and Directions in the Context of the Circular Economy

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(Food Technology Institute – General Director: Luis Madi)
Message of CETESB

The laws that established the State and National Policies concerning Solid Waste have brought up important advances to environmental protection in the country. Fundamental issues such as the ban on garbage dumps, social inclusion of recyclable material collectors, and the reverse logistics have occupied the whole agenda of discussions in the sector, generating significant improvements in the selective collection, recycling and final disposal of waste. However, there is a long road ahead, especially in what regards the prevention and reduction of waste generation.

In this context, packages represent a recurring concern for society, since their presence is constantly confirmed among the municipal solid waste generated. Although the systems for waste re-appreciation are being improved, it is essential to move forward in reducing the generation of these post-consumer waste. This matter needs to be addressed at its source - the excess consumption that is typical of our life style - in order to enable the establishment of technical criteria for developing packages that fulfill their roles with minimal impact throughout the whole life cycle of the system that consists of packaging and product.

With a view to start this discussion and set out the guidelines to initiate an open dialogue with the productive sector, CETESB and ABRE established a partnership, of which this publication is the first concrete result. In order to motivate the industry to take action, the document addresses key aspects that must be observed in order to incorporate environmental requirements in the packaging development process, disseminating information and bringing basic reflections and guidelines that help each company to find its way on this journey, in a cycle of continuous improvement we look forward to cooperating with.

It is with all that in mind that we congratulate all the efforts made in this first step, with the certainty that we are contributing to build a better and cleaner future for the entire world.

Otávio Okano – President

Nelson Bugalho – Vice-President

CETESB – Companhia Ambiental do Estado de São Paulo
(Environmental Company of the State of São Paulo)
Message of ABRE

The Brazilian Packaging Association (ABRE), in compliance with its mission to promote the ongoing development of the Brazilian packaging industry, aimed through this document to open the frontiers of knowledge and understanding about the role of packaging in our society.

This work was accomplished by 6 hands - inspired by the Ellen MacArthur Foundation and bringing together the productive sector through ABRE's Committee of Environment and Sustainability, the Government represented by CETESB (with which we have signed a Technical-Scientific Cooperation Agreement), and the center for research and development through ITAL / CETEA. Its goal was to delivered to society, an in-depth analysis of the role of packaging in the context of sustainability, considering a conceptual and holistic advancement of resource management by our society, migrating from a linear model to a circular model.

The packaging is a tool available to society, which should be used whenever it brings any benefit. It should contribute with environmental, social, and economic gains for the chain in which it is inserted.

We see the concept of circular economy as a packaging innovation catalyst as it gives opportunity for the scientific analysis of the current systems of production, transportation, marketing, communication, consumption, disposal and waste management, actually appreciating each product and the resources used for their production, as well as recognizing reusable and recyclable solid waste as an economic good with social value.

And for this process to be effective and to help strengthening the compliance with PNRS’s premises - which favor no waste generation, reuse and revaluation - we transformed the concepts presented in this document in a dynamic working tool, thus promoting continuous reflection against the packaging development process and resource management in our country.

We would like to thank everyone who was involved in this project and dedicated his or her time and knowledge to the project’s development.

Gisela Schulzinger – President

ABRE – Associação Brasileira de Embalagem
(Brazilian Packing Association)
Message of WPO

As WPO World packaging Organization we can state, that packaging is an indispensible tool for every society on the planet.

And WPO believes that packaging contributes to sustainability. Packaging preserves the product and thus all the environmental efforts put into its production and delivery. But new challenges are on the way to change our lives – and that means also the way we pack things: Circular Economy will replace our linear concepts of running business on this only planet we have.

Talking about packaging in a Circular Economy has to focus on the fact, that the package does not exist by itself, it is an integral and necessary part to the availability of a product to society. In fulfilling its function, packages should allow environmental benefits outweigh the impacts of their production, use and final disposal.

It is great to see, than in Brazil a State Environmental Agency is working together with the Packaging industry to discuss this issues and set some action to the identify and disseminate good environmental packaging practices. So, as WPO, we just can be thankful for such initiatives towards a “Better Quality of Life, Through Better Packaging, For More People”.

Johannes Bergmaier

Vice President Sustainability & Food Safety
WPO – World Packaging Organisation
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1. Introduction

1.1 Aims and objectives of the document

The technical and scientific cooperation between the Brazilian Packaging Association (Associação Brasileira de Embalagem - ABRE) and the Environmental Company of the State of São Paulo (Companhia Ambiental do Estado de São Paulo - CETESB) has the mission of identifying and disseminating good environmental practices for non-durable and durable goods packaging designs aimed at supporting compliance with the National Policy of Solid Waste, as well as collaborating with the discussion of the role of packaging in the Circular Economy. This document provides a harmonized understanding of environmental issues related to the development of packaging, presenting guidelines for the packaging chain and public policy development. These guidelines are divided on the optimization of three large dimensions: (i) Packaging role, (ii) Packaging in the Circular Economy, and (iii) Packaging itself; each addressed in one of the following chapters and shown in Figure 1.

The key issues of this document are:

- Optimization of the product life cycle with minimal resource consumption and waste generation
- Appreciation of the packaging role throughout the product value chain
- Guidance for packaging specification and project to facilitate its re-appreciation and the effectiveness of its performance
- Efficiency in re-appreciating the packaging, taking into account the current and future systems and infrastructure for reuse, reconditioning, and recycling, thus promoting seamless transition to the model of Circular Economy
- Environmental education and communication to consumers regarding the use of products and proper disposal of packaging.
1.2 The holistic, systematic thinking about packing

Packaging does not exist by itself - it is an integral and necessary part of the product delivery to society. The packaging's production chain is integrated into the product value chain. In addition, it requires a return system (reverse logistics) to handle packaging after it fulfills its role of delivering the product to the consumer. Systematic thinking about packing involves considering the packaging life cycle from resource extraction to production, to manufacturing process, to use and even re-appreciation or final disposal.

The development of packaging should be holistic, since there are many factors involved from conservation needs / requirements and product protection, to resource consumption for production (such as raw materials, water, and energy), to issues related to emissions associated with industrial processes, distribution and the final disposal of packaging. There are varied economic and environmental interfaces inherent to packaging – and different categories of environmental impact must be considered in the development of a product-packaging system.

1.3 Circular Economy

The concept of Circular Economy has multiple sources and therefore cannot be assigned to a single date or author. Its practical applications in modern economic systems and industrial processes have gained momentum since the late 1970s (Fundação Ellen MacArthur [Ellen MacArthur Foundation], UK, 2015).

The Ellen MacArthur Foundation was established in 2010 with the goal of accelerating the transition to a Circular Economy. Since its inception, the Foundation became one of the global thought leaders on this matter, thus inserting the Circular Economy concept in decision makers agendas throughout the global business scenario, governments, and academies (Ellen MacArthur Foundation, 2015).

The Circular Economy was born from the thought that it can be economically advantageous (cheaper) to reuse and recycle resources as many times as possible than to extract virgin materials - in contrast to the Linear Economy. The traditional model of Linear Economy is one that extracts resources, produces, uses the product and forwards it to final disposal, whereas the Circular Economy provides for the continued recovery and reintegration of resources and materials, as illustrated in Figure 2.

In the circular model, resources are kept in use for as long as possible so that maximum value is extracted while in use, while providing for recovery and regeneration of products and materials at the end of its shelf life (WRAP, 2015). It is a way of preserving natural resources in its optimal usefulness to society for as long as possible.

In place of extraction of natural resources, which are used just once and forwarded to final disposal (e.g. in landfills), this new vision invests in a different economic model. In a Circular Economy, reuse, recovery and recycling become the prevailing rule, thus promoting innovations in the markets of recycled materials, encouraging new business models, the Design for Environment among other initiatives (European Commission, 2015).

The development of a Circular Economy aims at the efficient use of materials and energy, ensuring an economic growth that is less dependent on natural resources, as well as reduction - or even elimination - of waste generation. However, promoting a trend of Circular Economy requires changes in public policies, business models, the economy as a whole, and the degree of awareness and participation of citizens.

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1 Some of the authors responsible for the concepts applied to Circular Economy: Walter Stahel, Michael Braungart, Bill McDonogh, Janine Benyus, Gunter Pauli, and John T. Lyle (Ellen MacArthur Foundation, 2015).

2 Design for Environment or Ecodesign is the integration of environmental aspects in the product development process, with the aim of reducing environmental impacts throughout the product life cycle (ISO / TR 14062, 2002).
The packaging development can have as inspiration the Circular Economy, while considering the entire life cycle of the product and packaging, as well as the different impact categories involved – thus the overall efficiency of the product-packaging system is evaluated.

### Outline of a Circular Economy

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Foster system effectiveness by revealing and designing out negative externalities.</td>
</tr>
</tbody>
</table>

#### ReSOLVE levers:
- **Regenerate**
- **Substitute materials**
- **Virtualise**
- **Restore**
- **Renewables flow management**
- **Stock management**


**Figure 2. Circular Economy**

3 We use the binomial product-packaging system because the packaging is inseparably connected to the product it contains. The accounting of the environmental performance of the packaging should take into account any potential impact (both positive and negative) on the product life cycle.
1.4 ‘The ‘National Waste Policy’ in the transition to a Circular Economy

To promote a trend of Circular Economy, all sectors of society must be aware and involved, which requires the development of solid public policies that encourage this spirit, as well as changes in business models. Some examples of instruments applicable to this concept include:

- Promotion Lines of research and development to enable, among others things, the diagnosis of potentialities and barriers to implementing the Circular Economy in production chains and consumption; and technologies to enable the Circular Economy such as recycling or recovery of materials
- Explore new business models guided by eco-efficiency and circularity
- Tax incentives for transition of business models such as the use of recycled raw materials
- Public procurement policy based on the purchase of goods produced focusing on the Circular Economy
- Educate people and raise their awareness to the Circular Economy
- Align programs and environmental plans (for example, the Action Plan for Sustainable Production and Consumption) to the concepts of Circular Economy

In Brazil, the implementation of the National Policy of Solid Waste (Politica Nacional de Resíduos Sólidos - PNRS) – established by means of the Federal Law No. 12.305 of August 2, 2010, is an instrument for the promotion of Circular Economy, once its principles include:

- Cooperation between the different spheres of government, the business sector and other segments of society
- Shared responsibility for the life cycle of products, including society as a whole – i.e. citizens, governments, private sector, and civil society – with individual responsibilities and linked to the eco-friendly management of the stages of the life cycle of solid waste
- Recognition of reusable and recyclable solid waste as an economic good with social value
- Established principles such as the polluter pays and the protector receives principles, eco-efficiency, and the sustainable development

Among the responsibilities set out in the PNRS, citizens are not only responsible for the correct routing of the waste they generate, but they also have the opportunity to make changes to exercise their role as consumers. The private sector, in turn, is responsible for creating means to reincorporate wastes in the production chains, including reverse logistics systems, but they may also exploit a fertile field of innovations in products and services or even new businesses that have the potential to bring environmental benefits. It is up to the federal, state and local governments to design and implement solid waste management plans, as well as other instruments provided for in the National Policy: For example, the development of improved management of solid waste, Design for Environment and the eco-efficient use of natural resources.

Specifically in relation to packaging, the PNRS reinforces, in its Article 32, that packaging should be manufactured in materials that facilitate reuse and / or recycling, where technically and economically feasible, and that they should be restricted in volume and weight to the size required for product protection. The following chapters address issues deemed fundamental issues for this discussion, in order to guide the packaging developers in complying with the new requirements brought up by the PNRS.

11.5 Benefits to society

In exercising its role of protecting the product until its consumption, packaging should allow environmental benefits superior to the impacts caused by their production, use and final disposal, which can be enabled by means of a suitable project. This project should take into account all aspects of the packaging life cycle - from the raw materials used in their manufacture, use and final disposal. Although packaging waste still represents a significant percentage in total urban solid waste, it is noticeable that the added value of this waste has great potential for a Circular Economy.
2. Optimization of the packaging role

Packaging accompany mankind since the day humans discovered the need to transport and protect goods [...] Some people have even pointed out nature itself as the first inventor of packaging, providing the pod to protect the beans and peas, the straw to involve the cob of corn, and the shell to protect the egg and walnuts, for instance. Mankind began to make use of plant leaves, leather, horn and bladder of animals, then humans discovered ceramics and glass, fabrics and wood, paper, cardboard and tin-plate, and finally reached the age of aluminum and plastic in its various forms (A História da Embalagem no Brasil [The History of Packaging in Brazil], Cavalcanti; Chagas, 2006).

Packaging has evolved meeting the demands that have arisen along with the development of society and the various consumer goods. Old qualities such as enabling protection and transportation remain essential, but are now complemented by other features also very important. Packaging plays a fundamental role in the urban-contemporary life style, and also allows the delivery of products in rural and hard to reach areas, protecting and promoting the product, informing consumers, facilitating the use, consumption and proper handling of goods, and optimizing transportation and logistics.

An example of packaging relevance is the packaging for medicines, as shown in Figure 3. On the other hand, how much would grow the losses during transportation of fragile products such as eggs, or how would aerosol products such as cosmetics or insecticides be distributed to consumers without the use of packaging?

Once society needs products and services, packaging, as part of the product-packaging system, plays several roles, as shown in Table 1.

Table 1. Packaging roles (adapted from EUROPEN, 2009).

<table>
<thead>
<tr>
<th>Roles</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection</td>
<td>Prevents mechanical damage, product deterioration (barrier to gases, moisture, light, smells, etc.), external contamination, and tampering; and also increases the product shelf life.</td>
</tr>
<tr>
<td>Promotion</td>
<td>Provides pleasing aesthetics and sales appeal; presents and describes the product and its features; and is an instrument of advertising and marketing.</td>
</tr>
<tr>
<td>Information</td>
<td>Identifies the product; describes their way of preparation and use; lists ingredients; and provides nutritional information and instructions for storage, opening, security, and disposal regarding both the product and the packaging itself.</td>
</tr>
<tr>
<td>Logistics and handling</td>
<td>Enables efficient transportation of goods from producer to retailer, as well as appropriate display at the point of sale.</td>
</tr>
<tr>
<td>Convenience and individualization</td>
<td>Facilitates preparation, storage, portioning (individual purchase), and consumption.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Reduces product loss and can enable reuse of the packaging; assists and guides the product and packaging disposal; protects the product and allows for its proper storage, thus ensuring greater durability; enables efficient transportation; offers opportunities of using alternative and renewable raw materials and optimized designs, among others.</td>
</tr>
</tbody>
</table>
2.1 The role of packaging in the pursuit of a more sustainable development

Sustainable development is “the one that meets present needs without compromising the ability of future generations to meet their needs in the future.” (Brundtland Commission et al., 1987).

The meeting of human needs that involve consumption of products or services invariably constitutes environmental impacts. The discussion of the relationship between packaging and sustainability proposed in this document is restricted to understanding how packaging can participate in meeting the needs of society while causing minimal environmental impact.

Decisions related to the development of packaging (such as size, material, shape, etc.) and their interactions throughout the life cycle (product protection, consumption mode, disposal method, etc.) can minimize the environmental impacts caused by the packaging-product system, such as:

• Right level of protection

According to the Food and Agriculture Organization (FAO, 2011), one third of all the food produced globally is not actually consumed – it gets lost in the field, during the transportation and retailing stages, or wasted in homes and restaurants. Food loss and waste constitute significant economic and environmental impacts. In 2012, such losses were estimated at 936 billion dollars – a figure that is close to the GDPs (Gross Domestic Product) of countries like Indonesia or the Netherlands – and also represented the emission of 4.4 GtCO₂ equivalent in 2011, or 8% of total anthropogenic emissions of greenhouse gases. When compared to the total emissions of countries, food loss and waste would be in 3rd place, second only to the emissions of greenhouse gases from China and the United States, as shown in Chart 1 (FAO, 2015).

An optimized design of the packaging can ensure the desired protection to the product, without excessive material consumption, that is, offering the right level of protection. The packaging has the potential to play an important role in reducing losses as it provides adequate protection to the product, extending its shelf life.
Case: Packaging reducing the environmental impact of food production.

Considering the global average amount of water that is consumed and polluted at all stages of production and processing of lettuce (water footprint) as 237 liters / kg (WATER FOOTPRINT NETWORK, 2015) and knowing that the loss and waste ratio for this product in the post-harvest in Brazil is of 45% (SOARES, s.d.), we can conclude that for each kilogram of product wasted, besides the characteristic nutrients and fibers, we also lose approximately 107 liters of water. Applying this waste calculation to the estimated annual consumption of lettuce in the country, we find almost 19 billion gallons of wasted water due to post-harvest losses only in 2008. This volume of water would be able to supply a city of approximately 340,000 inhabitants for a whole year. Some of these losses could be avoided, for example, by employing most appropriate transport packaging, storage in appropriate conditions and use of suitable packaging (films) to reduce gas exchange and water loss, extending the preservation and shelf life of the lettuce.

<table>
<thead>
<tr>
<th>Brazilian population in 2008¹</th>
<th>Per capita consumption of lettuce in 2008² (kg / person / year)</th>
<th>Water footprint of lettuce³ (liters / kg)</th>
<th>Post-harvest loss ratio⁴ (%)</th>
<th>Total waste water in 2008 (liters)</th>
<th>Average water consumption per capita⁵ (liter / inhabitant / day)</th>
<th>Water consumption per liter / inhabitant / year</th>
<th>Number of inhabitants supplied for one year</th>
</tr>
</thead>
<tbody>
<tr>
<td>194.769.696</td>
<td>0,91</td>
<td>237</td>
<td>45</td>
<td>18.902.691.151</td>
<td>151,2</td>
<td>55.339</td>
<td>341.579</td>
</tr>
</tbody>
</table>

¹THE WORLD BANK (2015); ²SILVEIRA et al. (2011); ³WATER FOOTPRINT NETWORK (2015); ⁴SOARES (s.d.); ⁵SINIS (2010)
• Guidelines for consumer

The packaging is a good opportunity to disseminate conscious consumption. It can guide the purchase regarding the most appropriate portion / dose to the moment of consumption, avoiding household waste. It can also indicate how to prepare and how the product should be stored, inform how the product should be consumed to optimize its use (as in the case of concentrated products that require dilution before use), or even have dispensers that avoid product waste. Finally, packaging may also provide information to guide consumers as to the proper disposal of both product and packaging remains.

Case: Packaging reducing impacts through consumer advising.

In a hypothetical example, where consumers have the option of preparing their frozen food in the conventional oven (gas stove) or in the microwave oven, which of the two options would emit fewer greenhouse gases? Assuming, simplistically, that in the conventional oven heating would take about 1 hour to complete, and consume 0.225 kg of CLP / h¹ (liquefied petroleum gas), then we have the emission of 0.66 kg CO₂eq for food preparation. On the other hand, the preparation in a microwave oven with a power of 1,300 W, operating for 20 minutes, would emit 0.06 kg CO₂eq, that is, an emission more than 11 times lower than that of a conventional oven. This is taking into account only the emissions from the use of equipment and the CO₂ emission factors published by the Ministry of Science and Technology (Ministério da Ciência e Tecnologia) (BRAZIL, 2014) and the Brazilian GHG Protocol Program (Programa Brasileiro GHG Protocol) (2014).

The package labeling, containing such information, could guide the consumer as to the preparation options and their respective environmental impacts, thus contributing to environmental education, above all.

¹LIQUIGÁS (2016)
• **Responsible communication**

Packaging is also a handy tool to communicate to consumers the gains in environmental efficiency of a product and its packaging. Environmental labeling is voluntary and there are precautions to be taken so that the information is verifiable, transparent and trustworthy. For this reason, some standards were established to guide this communication, as shown in Table 2.

**Table 2. Environmental labeling classification (adapted from Coltro, 2007).**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Award system - approval / disapproval</td>
<td>Statement in the form of text and / or logo</td>
<td>Product environmental statement, quantified information on the environmental profile of the product</td>
</tr>
<tr>
<td>License granted by a third party for use on the label (usually a logo or seal)</td>
<td>Improvements must be measurable</td>
<td>It can be presented in various ways: for example, text, graphics and illustration</td>
</tr>
<tr>
<td>Volunteer</td>
<td>Volunteer</td>
<td>Volunteer</td>
</tr>
<tr>
<td>Uses multiple criteria, based on impacts of the product life cycle</td>
<td>Typically based on one single criterion, but can also be based on multiple criteria</td>
<td>Multiple criteria based on evaluation study of the product life cycle</td>
</tr>
<tr>
<td>Set of product evaluation criteria determined by third party</td>
<td>Self-declaration, without the involvement of any third party</td>
<td>Set of quantitative environmental data verified by an independent third party</td>
</tr>
</tbody>
</table>

Examples:

- FSC
- "Made with a percentage of recycled material"

Incomplete, misleading or malicious statements may lead consumers to a less sustainable choice, or even to stop believing on substantiated information, discouraging engagement and change of attitude. Therefore, it is not correct to label products or packaging with vague messages such as “environmentally friendly,” “sustainable,” etc., with no possibility of proving or irrelevant aspects against the total impact of the chain. Any decision to communicate a sustainable benefit must be supported by the complete analysis of actual environmental benefits compared, for example, to the alternative previously offered to the consumer. The use of fake stamps or visual language that refers to existing certifications may confuse the consumer and should thus be avoided.
Studies carried out by Professor Kavita Miadaira Hamza, from the School of Economics, Business Administration and Accounting (Faculdade de Economia, Administração e Contabilidade) of the University of São Paulo (Universidade de São Paulo - USP), point out that, with respect to green labels, there is an overall lack of knowledge on the subject by Brazilian consumers, as well as the perception regarding the low use of such labels. On the other hand, people recognize the importance of the stamps and would like to see greater dissemination about them.

The consumers surveyed consider the stamps as a sign of higher credibility for the product. However, they still find it difficult to know exactly what the stamps mean. Some images / symbols in the packaging end up misleading consumers, who believe they are seals when, in fact, they are not.

To facilitate responsible communication, ABRE published in 2012 a booklet with important guidance regarding environmental self-declarations and the risks of Greenwashing.

An example of responsible communication is presented in the following chart.

Case: Packaging enabling responsible communication.

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4 Rotulagem Ambiental para Embalagens), among other publications of ABRE’s Environment and Sustainability Committee (Comitê Meio Ambiente e Sustentabilidade), are available in http://www.abre.org.br/comitesdetrabalho/meio-ambiente-e-sustentabilidade/cartilhas/

5 Greenwashing is the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service (THE SINS OF GREENWASHING, 2016).
• **Packaging Optimization**

The choices related to the development of the packaging itself also present opportunities for improvement. For example: The choice of raw materials and inputs with lower content of toxic and/or hazardous substances, the incorporation of post-consumer recycled material in the product or packaging, the type of decoration applied to packaging and effective specification reducing packaging weight without compromising the fulfillment of its roles, namely ensuring the required protection to the product. Other alternatives would be: promote improvements in production processes, with the application of concepts of Cleaner Production (P + L) by optimizing the use of resources (energy, water, raw materials, and inputs) and reducing emission levels; optimize logistics through a more efficient transportation chain; and facilitate reverse logistics through a suitable recycling project, among others.

**Case: Multiple packaging optimization gains.**

As a primary packaging reduction example we have the case of the Band-aid dressings, by Johnson and Johnson, during its participation in the End-to-End Sustainability Program (Programa Sustentabilidade de Ponta a Ponta) of Walmart Brazil (2009). This project was based on the development of a primary package of smaller volume to accommodate the same amount of dressings, bringing benefits such as reduction in the amount of packaging material and optimization of the production process and product transportation. The following reductions were quantified:

- 18% in the use of raw materials for packaging
- 11,600 km / year in transportation of containers of products in Brazil and Latin America
- Transportation of 3,228 pallets and 72 containers / year regarding the shipment of products to the US and Canada

This project also contemplates the use of 30% of post-consumer recycled raw materials on the product packaging and 40% in the shipping box, actions to reduce electricity consumption, recycling of silicon paper clippings, and better use of packaging materials during the production process.
2.2 The Life Cycle Thinking

To enable the optimization of the product-packaging system, it is necessary to understand its chain and identify its main impacts, which can be done through the Life Cycle Thinking.

The Life Cycle Thinking represents the basic concept of evaluation of the entire life cycle of the production system, from “cradle” to “grave.” It aims to prevent individual parts of the life cycle from being evaluated separately, in such a way that might result in the displacement of environmental impacts to other stages of the cycle, i.e., producing undesirable trade-offs. The application of the Life Cycle Thinking in the development of more sustainable products provides opportunities for improvements related to environmental performance of the product — from the extraction of natural resources, through processing, emissions reduction, packaging and transportation optimization, consumption, to final disposal.

The Life Cycle Thinking is a qualitative concept that is simpler than the Life Cycle Assessment (Avaliação do Ciclo de Vida - ACV). The ACV aims to quantitatively assess the main environmental impacts of a product system, as illustrated in Figure 4, which requires more time and resources. It is a technique used to evaluate the environmental performance of a product based on its function and including the identification and quantification of the energy and raw materials used in each stage of its production cycle (COLTRO, 2007).

![Figure 4. Stages of a Product Life Cycle.](image)

Although the use of the ACV methodology is important, it is not essential in all cases. The Life Cycle Thinking in itself brings opportunities to improve the environmental performance. In this case, the main ingredient is the curiosity to analyze the product and packaging chain stages, in order to understand the key inputs and outputs. This is often enough to guide the path to improvement, although some specific cases require a deeper, quantitative analysis.

A simple critical look at a production chain - for example, seeking points of waste in the chain of a delicate fruit such as the papaya, from the cutting and harvesting in the field, through cleaning, packaging and transportation - can point out improvement possibilities with large gains in product quality and reduction of environmental impacts.
3. Optimization of the packaging in the Circular Economy

The development of packaging can be inspired on the Circular Economy, taking advantage of potentials such as:

- Economic growth less dependent on natural resources
- Efficient use of materials and energy
- Reduction of waste generation
- Recovery and reintegration of resources and materials
- Systemic thinking, that is, to take into account how the parties influence each other within a whole, as well as the relations of the whole with the parties.

The concept of Circular Economy can be a catalyst of innovations in packaging, as it creates an opportunity for scientific analysis of the current systems. The innovations, however, must be based on the current assumptions regarding the recycling technologies available; potential economic barriers to their implementation; and the current systems of solid waste management, among other local features. The Circular Economy should be evaluated scientifically with the use of tools such as the Life Cycle Analysis and the Life Cycle Thinking, thus avoiding forced or unwanted circularity in the face of any existing economic and technological barriers.

3.1 Packaging promoting the transition to a more circular economy

There are several dimensions in which the packaging can contribute and participate in building a more circular economy, from design and production of the packaging and the optimization of its roles, to the re-appreciation of the post-consumer material. A fundamental dimension to the operation of a Circular Economy is the development of new business models guided by eco-efficiency and circularity, with the potential to leverage the markets of recycled and new materials. Figure 5 below illustrates these dimensions.

Figure 5. Breakdown of the dimensions of the packaging development focused on sustainability.
3.2 The harmonization and development of the selective collection system

The existence of an efficient selective collection system is a key point for the circularity of the economy. The *National Policy of Solid Waste* (*Política Nacional de Resíduos Sólidos*) defines selective collection as the collection of solid waste previously segregated according to its constitution and/or composition.

One of the important innovations of the *PNRS* in the meantime was the mandatory implementation of reverse logistics systems for various products and packaging. Reverse logistics is defined as an economic and social development tool characterized by a set of actions, procedures and means aimed at facilitating collection and recovery of solid waste to the business sector, for reuse in your own - or other's - production cycles, or another type of environmentally appropriate final disposal.

**Article 8 The instruments of the National Policy of Solid Waste (*Política Nacional de Resíduos Sólidos*) include, without limitation:**

III - Selective collection, reverse logistics systems and other tools related to the implementation of the shared responsibility for products life cycles [...]

The selective collection of solid waste is a collection system for recyclable materials such as paper, plastic, glass, metal and organic matter, previously separated at the source. These materials, after pre-processing – separation by type (screening), pressing, milling, and baling – are then sold to recycling companies or wholesalers, also known as “scrap dealers”, to be reincorporated in production processes. In Brazil we can find a few selective collection models (CEMPRE, 2014), including:

1. **Selective collection door to door**: Similar to the normal garbage collection procedure. Collector vehicles run through the residences in specific days and times (that must not coincide with the normal collection schedule), to collect the recyclable materials.

2. **Voluntary selective collection**: In some cases, containers or even small deposits are used, placed at predetermined fixed locations of the urban “mesh” know as Voluntary Delivery Points (Pontos de Entrega Voluntária - PEVs) or Voluntary Delivery Sites (Locais de Entrega Voluntária - LEVs), where citizens spontaneously deposit their recyclable materials.

3. **Reception stations**: These sites can also be called PEVs or LEVs, and its design may be similar to traditional drop-off systems. There are specific locations for the delivery of special waste such as lamps, tires, lubricating oils, etc.

4. **Waste pickers**: It is estimated that Brazil has currently about 800 thousand street scavengers (autonomous or members of cooperatives), responsible for the collection of various types of materials. You can find waste pickers working autonomously and also organized in cooperatives or associations, which can be involved in the screening steps, but also in the implementation of door-to-door collection and/or PEVs. The appreciation of the work carried out by waste pickers enables both economic and social benefits.

The integration of these models is essential to expand the area covered by selective collection, and must be harmonized with the screening systems available – manual or automated separation (separation by density, use of optical sorting system through infrared, ballistic separation, etc.). The active participation of the whole community is the basis for the success of recycling. Therefore, it is important to disclose and inform population about the dynamics of selective collection programs. That shall result in a gradual improvement on the quality and quantity of recycled material commercially available.

The investment in selective collection provides a number of advantages related to the so-called environmental costs (CEMPRE, 2014):

- Reduction of final disposal costs and increase in the life of landfills
- Reduction of costs with remediation of areas degraded by inappropriate waste disposal
- Environmental education and awareness to the population
- Improvement of environmental and public health conditions of the city
- The separation at the source of the different types of recyclable materials present in the trash promotes numerous gains that translate into cost savings in later stages. These costs are associated with screening, washing, drying and transportation, among others – for example, shorter washings cycles (less contamination of the material), reduced transportation of soiling aggregate to the material, etc.
• Best finishing quality and larger amount available to the market of recyclable materials
• Generation of direct and indirect jobs with the installation / expansion of recycling companies
• Social rescue of individuals through the creation of associations and cooperatives of waste pickers.

The development of packaging should consider the existing post-consumer chain in product consumption sites, both in terms of selective collection and recycling and upgrading technologies. The packaging choices must not jeopardize or compromise widely established re-appreciation chains. In turn, the design for disassembly and / or recycling may facilitate the re-appreciation of the post-consumer material. If the packaging structure is new and therefore still do not have an established re-appreciation chain, ways should be developed to encourage and promote its reuse through the development of new technologies.

Case: Developing recycling technologies.

The long life (or aseptic carton) packaging has in its structure the cardboard, polyethylene, and aluminum foil, which help preserve food properties and nutritional value for an extended shelf period, at room temperature, gaining benefits of distribution, safety, and consumption convenience.

After fulfilling its role of food protection, emerged the challenge to recycle this multilayer packaging, which led the Tetra Pak company to develop technologies capable of incorporating the material of their packaging in new production processes by separating the cellulose fibers of the aluminum / polyethylene structure.

The recycling of the fibers and the aluminum / polyethylene structure that make up the package starts in paper mills, on a machine called “hydrapulper”, similar to a giant blender. While stirring the material with water, the fibers are hydrated, i.e., they absorb water, separating from the layers of aluminum / polyethylene. After cleaning, the fibers may be used for the production of recycled paper, used in the manufacture of cardboard boxes, for instance.

The remaining material, compound by aluminum / polyethylene, may be forwarded to plastic processing plants, and recycled through processes such as heat injection or rotational molding, whereby it is used to produce plastic parts, such as shovel handles, pens, collectors, pallets, among other things.

The recycling for the production of plates and tiles comes from the grinding of the polyethylene / aluminum layers, which are then pressed with heating. These plates can be used for the production of furniture and tiles - products very well accepted in the domestic market.

**Tetra Pak’s packaging recycling process**
3.3 Symbology of selective disposal and packaging materials

The selective disposal symbol is directed to consumers, guiding them to the post-consumer disposal of packaging as dry waste, forwarding them to selective collection and the screening process. The application must be made once in the body of the package, next (side by side or one below the other) of the material identification symbols. In Brazil, this symbology is normalized as shown in Figure 6.

The material identification symbology, in turn, presented in Figure 7, is intended to facilitate the screening process and is central to properly establish the reverse logistics. In the case of plastic packaging, the correct identification of materials facilitates their separation and enables the reduction of cross-contamination between different recycling chains, thus helping to reduce waste and increase the amount of products manufactures from recycled materials.

Figure 6. Symbol of selective disposal (ABNT NBR 16182:2013).

Figure 7. Material identification symbols that should be employed in paper, aluminum, steel, and glass packaging (ABNT NBR 16182:2013) and in plastic packaging (ABNT NBR 13230:2008).

All packaging must contain this technical identification, even when in practice some packaging are not sent for recycling because the region where the packaging was discarded has no technical or economically feasible process in place. Therefore, material identification symbology is neither considered an environmental labeling nor an assurance that the material will be recycled (ABRE, 2012).

In order to expand the adoption of appropriate symbology, in 2011 ABRE signed a industry pact with the Ministry of Environment (Ministério do Meio Ambiente) in Brazil under the Action Plan for Sustainable Production and Consumption (Plano de Ação para Produção e Consumo Sustentáveis), which provided for the inclusion of the selective disposal symbol on the packaging of a thousand products / year during the period from 2012 to 2014, as well as offered materials to support the adoption of material identification symbols – please visit ABRE’s website⁶. The evolution of the adoption of this symbology by those involved in the industry pact is presented in Chart 2.

Chart 2. Evolution of the adoption of the recycling symbol.

Registered products by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Registered Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1.031</td>
</tr>
<tr>
<td>2013</td>
<td>1.148</td>
</tr>
<tr>
<td>2014</td>
<td>2.265</td>
</tr>
</tbody>
</table>

⁶ Materials provided by ABRE regarding materials identification symbology are available in www.abre.org.br/descarteseletivo.
The dissemination and implementation of symbologies created to guide disposal and facilitate the identification and separation of materials were some of the actions that boosted the growth of recycling in Brazil. But there is still much work of education and disclosure to be done, since this symbolism must be understood and used by those responsible for the development of packaging, by consumers during waste disposal, and by the workers involved in the process of collection, sorting, and recycling of materials. When municipalities develop their waste management plans and selective collection programs, they must also be aware of this symbolism. This is an important step to leverage the circularity of packaging materials.

**Case: Inclusion of the symbol of selective disposal.**

- ABRE Award 2014 – Special Module – Sustainability
- Qualitá - Adherence to the Industry Pact of Recycling Symbology
- Silver Winner: GPA

In this particular project the use of a standardized symbology, agreed and present in Environmental Labelling Guidelines, is a way to guide society to properly dispose of their solid waste. In less than one year, 1,350 products were registered.
3.4 The different re-appreciation alternatives available

The material or energy re-appreciation of solid waste has a direct contribution to the conservation of natural resources, whether renewable or not, the preservation of ecosystems, and the efficiency of production processes, as it leads to the reduction of the environmental and economic costs associated with the life cycle of the products. Within the principles of Circular Economy, it is one of the most direct ways to promote more regenerative and restorative systems of production and consumption.

Considering the hierarchy of solid waste management, regulated by the National Policy of Solid Waste (Política Nacional de Resíduos Sólidos), the following order of priority should be observed: non-generation, reduction, reuse, recycling, solid waste treatment, and environmentally appropriate final disposal of waste (Article 9 of Law no. 12.305 / 2010). Figure 8 below illustrates the traditional view of this hierarchy.

In practice, this means that management systems should include options of prevention and re-appreciation of waste, in order to bring them back to the production cycle in the form of products (reuse), materials for the production cycles (mechanical and chemical recycling), organic compounds for agriculture (composting), and/or energy (anaerobic digestion and gasification, production of fuel derived from waste [CDRs], or incineration with energy recovery). The final disposal in landfills is intended only to tailings, according to PNRS, understood as those solid wastes for which all possibilities of treatment and recovery by technological processes available - and economically viable - have already been exhausted.

Thus, in compliance with current legislation, the development of packaging should seek, first, the reduction of waste generation, noting that this requires evaluation of the whole life cycle of the product-packaging system. This concern is reflected in the optimization of the dimension “impacts of the packaging itself”, to be treated in the next chapter.

Exhausted the waste generation reduction possibilities, next come the alternatives aiming at waste re-appreciation. According to the proposed hierarchy, the next concern is the possibility of reuse the waste, defined as the use of waste in production cycles without any biological, physical or chemical transformation. For many packages, this is already a standard practice (as in the case of many glass bottles and pallets, among other returnable alternatives).

The mechanical recycling, in turn, is a material recovery process for waste that aims at the production of new products by physical means (washing, crushing, melting, granulating, etc.). Mechanical recycling has broad application to cellulosic materials, metals, glasses, and for the processing of plastic products from a single polymer, such as PE, PP, PET, PS, etc. Multi-material structures, such as multilayer films, can also be recycled – however, they require technological solutions to promote compatibility between the components. Another option is the pre-separation of materials and recycling of components in specific chains, which happens in the case of re-appreciation of carton structures of the “long life” packaging, of which first the cellulosic material is removed (which represents about 75% of the structure in weight), followed by the recycling of the PE and aluminum layers.

Chemical recycling, in turn, is the name given to the advanced technological processes that convert materials (usually plastic) in basic raw materials (usually primary petrochemical molecules), which are used for the production of new goods – such as plastics and other petrochemical products (e.g. synthetic lubricants). The key advantage of
chemical recycling is the possibility of re-appreciating heterogeneous or contaminated plastic products, with very little pretreatment requirements.

A practical example of chemical recycling is the production of unsaturated resins from PET-PCR, used in the formulation of truck cabs, car bumpers, water tanks, swimming pools, motorcycles chests, plastic mass, road marking, etc. Alkyd resins are also produced, used in the composition of paints and varnishes for various purposes.

Chemical recycling products may also be useful as fuel. The technology consists of depolymerization processes that include pyrolysis, gasification, gas-liquid hydrogenation and catalytic cracking, among other (AL-SALEM, LETTIERI, BALEYENS, 2009).

For naturally biodegradable organic waste (including some packaging materials), another management alternative is the composting, in which organic compound is produced via controlled aerobic biodegradation. This alternative, however, requires careful segregation of what can be sent to composting, in order to preventing contamination and ensuring proper development of the process. The use of organic compounds in agriculture can reduce the need for fertilizers, thus reducing the environmental impacts of crop production. However, for that, the fertilizer must meet the purity and effectiveness requirements needed for the application, and also be approved by the relevant authorities.

Finally, energy recovery can be conducted by various technological routes, generally grouped in the English term “waste to energy” or “energy from waste”. The biodegradable organic waste, for example, can be treated by anaerobic degradation processes, such as methanization, wherein the organic matter is degraded in closed biodigestors to produce methane, which is harnessed to generate energy by combustion (ABNT, 2008a. LIxo..., 2010). Another option, applied to a wider range of waste, is the production of fuel derived from waste (CDR), where the treatment generates a product intended to replace traditional fuels in power generation units - mainly industrial boilers and furnaces.

However, the most common alternative to energy recycling, at least in Europe, is the incineration with energy recovery, which consists of burning - under controlled conditions - waste with high calorific value, using the energy contained in the waste to generate electricity and / or steam or hot water, replacing traditional energy sources.

The incineration with energy recovery should be carried out in industrial plants with high technology, that have efficient systems for the treatment of gas and wastewater, and that can ensure the proper disposal of ashes, among other requirements established by environmental agencies in specific legislation. In the integrated management of solid waste, this is the last alternative before final disposal in landfills, and must be associated with early adoption of generation reduction policies and especially selective collection, sorting and recycling of the recyclable fraction of all waste.
4. Optimization of the packaging: materials and processes

The National Policy of Solid Waste (Política Nacional de Resíduos Sólidos) proves to be aligned with the concepts of circularity contained in its Article 32, since at the same time it recognizes the importance and role of packaging to protect the product, it also guides for an efficient project that promotes reuse and recycling.

Article 32. Packages must be made of materials that facilitate reuse or recycling.
Paragraph 1 - It is up to the respective individuals responsible to ensure that the packaging is:
I - Restricted in volume and weight to the dimensions required to protect the content and marketing of the product
II - Designed in order to be reused in a technically feasible manner, consistent with the requirements applicable to the product it contains
III - Recycled, in case reuse is not possible
Paragraph 2 - The regulation shall provide for cases that, due to technical or economic reasons, are not feasible to implement the provisions of caput. (BRAZIL. Law no. 12.305, 2010, Art. 32)

As discussed in Chapter 2, in addition to the key role of delivering the product to the consumer in perfect condition, the packaging also plays many other roles, such as promotion, information and convenience, in addition to avoiding losses and consequent generation of waste and allowing for efficient handling of business, also contributing to the sustainability, to the extent it is (ABRE, 2013):

- Designed holistically with the product, in order to improve the environmental performance of the product-packaging system
- Produced from materials obtained from responsible sources
- Able to meet market criteria in terms of cost and performance
- Manufactured using cleaner production technologies
- Promoter and booster of reverse logistics and recycling systems, for example, by the incorporation of post-consumer recycled raw materials
- Efficiently recoverable after use, by reuse and recycling
- Originated, manufactured, transported, and recycled using renewable energy, where possible.

Thus, a well-designed packaging shall meet the product requirements and, at the same time, minimize the economic, social and environmental impacts of both the product and itself. The packaging must also remain attractive, keeping its commercial function as a marketing tool, and promoting the product and communication with consumers.

In order to promote self assessment of environmental sustainability indicators for the packaging chain, ABRE (2011) created a booklet called Guidelines for the productive chain of packaging and consumer goods (Diretrizes para a cadeia produtiva de embalagens e bens de consumo). The main contribution of this paper is to give developers a spreadsheet with environmental indicators for packaging, indicating for each one the purpose of its application, how it can be measured (metric) and links of the chain that are involved in its implementation. The main opportunities presented include:

- Optimizing the use of raw materials without loss of quality and / or functionality
- Minimizing water use per unit produced
- Improvements in energy efficiency and use of renewable energy
- Minimizing emissions of effluents, atmospheric gases and solid waste
- Searching forms of compensation for emissions of greenhouse gases

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- Reducing and/or eliminating the use of toxic and/or dangerous substances
- Reducing the forwarding of solid waste to landfills by creating recycling opportunities
- Scaling packaging to optimize the capacity of the transportation means (increasing the number of units per trip)
- Maximizing product protection by preventing its loss
- Optimizing the proportion of the amount of product packaged per packaging
- Maximizing total consumption of the packaged product
- Extending the shelf life of the pre-consumer product
- Disseminate and guide sustainable consumption and proper disposal of waste
- Searching compatible components (cover, bottle, labels, and multilayer) in the recycling process
- Designing the packaging foreseeing the form of separation of its components
- Prioritize the use of materials that are subject to post-consumer mechanical recycling, considering existing conditions
- Encouraging the design of packaging with a high reusability potential
- Incorporating post-consumer recycled raw materials in production processes, where permitted by law

4.1 The significance of different materials

The packaging perform a number of different tasks, the main ones being: protect the contents against contamination or mechanical damage, facilitate transportation and storage, and standardize the amount of content. By enabling the creation and standardization of trademarks, the packaging provides product visibility and promotes large-scale distribution. Special packaging with dosing caps, sprays and other convenience features make using the product easier. Furthermore, the packaging works as a symbol for its contents and people’s lifestyles. However, as well as a packaging can strongly impart the satisfaction that a product offers to consumers, it may also become powerful symbols of materials waste after the product is consumed (ROBERTSON, 2013).

Proper selection of materials is a key point for the packaging to fulfill its roles in the best possible way. There is no material universally “better” or “worse”. Selection is linked to factors such as the intrinsic characteristics of the product, desired shelf life, material costs, the conservation process (in the case of food) and the conditions to which the final product will be submitted, such as transportation and distribution, storage and marketing areas, aiming to always keep ultimate quality. According to Oliveira (2006), packaging is usually considered a support for the conservation methods, because, in addition to maintaining the physical form of the product, the packaging also protects it from external factors such as microbiological recontamination, attack by insects and rodents, as well as exchanges with the external environment such as moisture loss or gain, and permeation of oxygen and organic vapors. The selection of the type of packaging depends on variables such as presentation, potential development of micro-organisms, desired shelf life, and audience.

For the primary packaging (those that are in direct contact with the product) to fulfill their main roles it is usually essential to have a packaging system in which the secondary packaging contains one or more items wrapped in the primary packaging, and the secondary packaging is responsible for the physical and mechanical protection of the primary package during transportation and distribution, and may also be responsible for communication, particularly when it contains only one item wrapped in the primary package, as is the case of breakfast cereal boxes. The tertiary packaging groups several primary or secondary packaging to transportation, such as the corrugated cardboard box.

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8 Processos de conservação de alimentos são processos que previnem ou retardam alterações na qualidade do produto, seja pela inibição do crescimento microbiano, inativação da ação de enzimas indesejáveis ou controle de processos químicos e bioquímicos indesejáveis, que reduzem a vida útil do produto alimentício (OLIVEIRA, 2006)
or the heat shrinkable film containing beverage cans. The selection of this kind of packaging depends on the nature of the primary packaging, i.e., rigid, semi-rigid or flexible (AKL, 2016).

The greater the complexity of the packaging and the use of multiple materials, the more complex tend to be its process of re-appreciation. The re-appreciation technologies have evolved; however, the economic and infrastructure feasibilities are subject to local characteristics.

4.2 The limits of optimization

The industry has the responsibility of analyzing and improving the environmental performance of its packaging at all relevant stages of the life cycle. But this impact analysis should consider the product life cycle itself, including the study of the impact of product losses resulting from inadequate use of packaging, as well as the impact of excess use of packaging (ABRE, 2013).

Chart 3 shows that the environmental consequences related to product losses caused by excessive reduction of packaging can be much larger than those of the incremental excess of packaging provided to ensure adequate protection (ABRE, 2013).

Chart 3. Packforsk model to minimize the environmental impact of the product-packaging system (ERLÖV, et al., 2000)

Thus, the correct specification of the packaging (optimal point in the chart), which do not overestimate or underestimate it, is the balance between the amount of material used in packaging and the protection level required by the product.

The analysis of the environmental impacts of the product should consider both the packaging and the product life cycle. Therefore, the study of the product-packaging system must assess the environmental impacts resulting from the loss of product resulting from insufficient use of packaging, and the (unnecessary) impact of using excess packaging.

The simplification brought up by the analysis of only one or a few characteristics of the packaging - such as recyclable, compostable or change of raw material - may result in a false sense that sustainability can be promoted by individual attitudes or characteristics. The view of the chain as a whole supports the development of packaging driven by the sustainability of the product-packaging system, and prevents the increase of environmental impacts in other stages of the life cycle.

The main purpose of developing packaging aimed at sustainability is to make product and packaging chains as efficient as possible.
Case: The limits of package reduction.

The Packforsk Report (ERLOV, et al., 2000) presents some case studies to support its model, such as the environmental impacts of bread, ketchup, milk and yogurt, when compared to those of their packaging and the losses of such foods. The study unit in the case of bread was 700 g of white bread produced in Sweden, wrapped in polypropylene film (5.28 g) using a polystyrene clip of 0.31 g. Data on loss and waste were obtained from studies in shops and interviews with bread makers and consumers. The packaging represents only 3% of the total energy expenditure of the bread; losses and waste accounted for 18% of energy consumption; and, finally, the production and consumption of the bread accounted for 79%. Therefore, in principle, even with the increase of the package weight / product weight ratio, the total environmental impacts could decrease (to some extent) if the bread losses and waste lessened with the increment of the packaging. This has been proven and can be seen in the table and chart below.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Bread weight per packaging (g)</th>
<th>Packaging weight (g / kg of product)</th>
<th>Energy consumption of the packaging (MJ / kg)</th>
<th>Energy consumption of losses and waste (MJ / kg of product)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700</td>
<td>7.9</td>
<td>0.7</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>50% at 35050% at 700</td>
<td>9.1</td>
<td>0.8</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>10.3</td>
<td>0.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The graphic blue line represents the energy consumption of production, distribution and storage of the bread (26.6 MJ / kg), while the orange curve represents the energy expenditure of the bread in different packaging sizes. The optimal packaging is that in the lower part of the curve, i.e., with a packaging weight / kg of product ratio of 9.1. To the left of this optimal point, the package is insufficient, resulting in increased loss of bread, and, consequently, greater energy consumption. To the right of this point, packaging is excessive and, although robust, it does not result in less product loss – therefore, there is a slight unnecessary increase in energy expenditure due to excess packaging material.
4.3 The role of technology and innovation

According to Sarantópoulos and Rego (2012), meeting consumer expectations in the search for safety, quality, convenience and welfare, demanded many financial investments and dedication of scientists and technologists to the development of packaging - such as carton and plastic aseptic packaging, sterilizable plastic packaging, repointing and easy-opening systems, packaging for microwave ovens, and high barrier plastic packaging, among others. These innovations resulted from integrated actions of development of product / process / packaging equipment / packaging material / distribution system. Considering future scenarios, innovations will be associated to active and intelligent packaging, the use of nanotechnological materials aimed at greater preservation of products and the use of biopolymers.

Packaging evolves to meet the evolution of products, as well as new needs and habits of society. Packaging keeps the compass to ensure the delivery and use of products and services in the most profitable way possible, and it is able to boost modern economies, facilitating production flow and avoiding the waste of essential products, such as food.

Weight (thickness) reduction technologies without affecting the packaging roles.

The technological development in production of raw materials and manufacturing processes of packaging has allowed a significant reduction of weight / thickness, while maintaining the desired performance.
Weight (thickness) reduction technologies without affecting the packaging roles.

**Abigráf**

Weight reduction in paper card

- **350 g**
- **325 g**
- **300 g**
- **275 g**
- **250 g**
- **225 g**

**Abipet**

Weight of the pet packaging for carbonated - Brazil (g)

- **2002**
- **2012**

<table>
<thead>
<tr>
<th>Container Size</th>
<th>2002</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 ml</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>500 ml</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>600 ml</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>1.000 ml</td>
<td>40</td>
<td>33,6</td>
</tr>
<tr>
<td>1.500 ml</td>
<td>52</td>
<td>38,6</td>
</tr>
<tr>
<td>2.000 ml</td>
<td>56</td>
<td>42,6</td>
</tr>
<tr>
<td>2.250 ml</td>
<td>60</td>
<td>50,6</td>
</tr>
<tr>
<td>2.500 ml</td>
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<td>52,6</td>
</tr>
<tr>
<td>3.000 ml</td>
<td>64</td>
<td>56,6</td>
</tr>
</tbody>
</table>

**Abividro**

Glass weight reduction – drinks

- **Beer 300**
- **Beer 300 Standard**
- **Vermouth 900**
- **ICE 275**
- **GIN 970**
- **VODKA 910**
5. Recommendations

Aiming to consolidate the reflections of this document and support those involved in the ongoing search for sustainability in the packaging sector, following are brought together some recommendations for:

- The development of packaging meeting the product needs with minimal environmental impact caused by the product-packaging system; and
- Promote post-consumer management to maximize re-appreciation.

There are many factors involved in choosing the ideal packaging: from product conservation and protection needs / requirements, to consumption of water and energy for the production of packaging, to issues related to emissions associated with industrial processes, distribution and disposal of packaging. The product-packaging system is closely related, as the choices made during packaging development will affect the system as a whole.

Before any decision, it is important to know the chain of the product-packaging system - from obtaining raw materials to the post-consumer stage, including its re-appreciation phase.
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Expedient

Packaging and Sustainability: Challenges and Directions in the Context of the Circular Economy

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