# Closed-loop supply chain: green practices in the home appliance industry

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**Abstract**
This paper aims to analyze which green practices are being used for a multinational firm in the Brazilian home appliances sector. The research results demonstrate that the waste management practice is the most used one. On the other hand, green purchasing and life cycle analysis practices are less widespread.

**Keywords:** Closed-loop supply chain, green supply chain management, home appliance industry.

## Green practices in supply chain management

The exacerbated environmental degradation, increase consumer awareness on the need for products that do not affect the environment, the increasing regulatory activity and the new economic structure are some of the reasons for the growth of the need to implement environmental management systems in organizations (Oliveira and Pinheiro, 2009).

It is in this context of gradual demand for sustainability in interorganizational ties arise, since the 1990s, terms that integrate environmental and / or social concerns regarding the supply chain, but with different scopes, such as: management of green supply chain (green supply chain management, GSCM) (Vachon and Klassen, 2006; Srivastava, 2007; Zhu et al, 2008;. Sarkis et al, 2012).; closed-loop supply chain (closed-loop supply chains, CLSC) (Beamon, 1999; Tsoulfas and Pappis, 2006) and management of sustainable supply chain (sustainable supply chain management, SCCM) (Seuring and Muller, 2008).

The stimuli directed to the green supply chain management have prompted organizations to adopt in its chain the concept of closed loop with more than one sense, where the redemption value over the entire life cycle of a product come from operation and control returns from different types and volumes over time (Beamon, 1999).

In this scenario, this paper seeks to analyse the green practices that are being used by a large multinational company in the home appliance industry in Brazil.

The literature suggests several green practices, for delimitation of the study it has chosen Srivastava classification (2007) and Zhu et al. (2008), so for the writing of this article the following practices were considered: green manufacturing and remanufacturing; environmental management system; ecodesign; analysis of the life cycle; green purchasing; reverse logistics; waste management and environmental performance.

The practice of environmental management corresponds to some activities of the day-to-day operations aimed at environmental improvements in the factory, as the high and middle

management support; cross-functional cooperation for the implementation of environmental improvements; development of an Environmental Management System; environmental audit and proposing environmental goals for the plant (Zhu et al., 2008). The internal environmental management is identified as a necessary precursor to the implementation of green purchasing and ecodesign (Zhu et al., 2008).

Zsidisin and Siferd (2001) conceptualize green purchasing as a set of sustainable procurement policies, actions taken, and relationships formed in response to concerns related to the environment. These concerns relate to the acquisition of raw materials, including selection, evaluation and development of suppliers; operations thereof; input distribution; packaging; recycling; reuse; reduction of resources; and disposal of the company's products.

Reverse logistics is termed as the area of logistics business that plans, operates and controls the flow and the corresponding logistical information, the return of the aftermarket goods and post-consumer business cycle or production cycle, through reverse distribution channels, adding value to them of different nature: economic, ecological, cool, logistics, corporate image, among others (Leite, 2009). However, when we consider the logistics vision of creating a closed circle involving all actors in the supply chain system, it is called closed-loop supply chain (CLSC). Thus defined as: design, control and operation of a system to maximize creating full value over a product life-cycle value with dynamic recovery from different types and volumes of returns along the product life cycle (Guide and Wassenhove, 2009).

Ecodesign aims to generate environmental improvements from the project and the process of the product (Vachon and Klassen, 2006). The incorporation of environmental concerns from product design based on life cycle, favour the processes applied to the product after it reaches its end of traditional life (Beamon, 2008). For Zhu et al. (2008), ecodesign should consider the product functionality while minimizing environmental impacts in the life cycle.

The green manufacturing is characterised as the production processes using raw materials with relatively low environmental impact that are considerably efficient and generate moderate or no residue or pollution (Ninlawan, 2010). According to Srivastava (2007), Green production activities consisting of: reduction; recycling; Remanufacturing: recovery of materials; Remanufacturing: reuse; inventory management and production planning.

When dealing with waste management practice, Sarkis (2003) identifies five key elements that impact the management of waste generated in the supply chain, including: reduction, reuse, remanufacturing, recycling and waste disposal alternatives (arranged in a major scale to the lower environmental impact). Regardless of the amount of activities in waste management and different classifications for the environmentally conscious practices, Gupta (1995) ensures that a waste reduction plan should be organized, comprehensive and forward to the continuing effort to minimize their production.

The green practices have relative importance amongst each other, a fact that influences the consolidation of green supply chain management and thus spread the concept of close loop (Seuring and Muller, 2008).

## Methodology

The electronics sector was chosen to be studied in this research since it is an industry that has extensively studied the issue (Jabbour et al., 2013), especially in the context of development, as in China (Zhu et al., 2008), and also being an interesting subject to study in the context of

another developing country, such as Brazil, and the fact that this sector is one that tends to be affected by the National Solid Waste Policy (PNRS).

The case study is a research method that uses generally qualitative data collected from actual events, in order to explain, explore and describe current phenomena inserted in their proper context. It is characterised for being a detailed and exhaustive study of a few, or even a single object, providing in-depth knowledge (Eisenhardt, 1989; Yin, 2009).

Recognizing additionally time constraints and available resources for implementation of a case study, with descriptive approach means being viable to restrict induction analysis of environmental practices considering only one focal company, which, it should be emphasized must be selected so as to ensure that there can adequately test the theory Closed-loop supply chain.

The case selection criteria are essential to the quality of the results, therefore, the study turns to a major worldwide operating company in the appliance segment, Whirlpool, also presents it in the country. Whirlpool Corporation is a century-old company, the largest manufacturer of home appliances in the world, which owns 20% of the world market, present in virtually all countries are able to manufacture over 1.5 appliances per second, equivalent to 5000 units per hour. In Brazil, the company has three factories, two administrative offices, 4 centres of technology, 23 laboratories and 3 distribution centres. In the 2013 accumulation, the company's net profit reached $ 827 million and has about 15,300 employees.

To survey data were conducted face-to-face interviews with company executives. In turn, the constructs and variables of GSCM practices (Table 1) used in the search script were previously validated by expert opinion on the subject and adapted for the final questionnaire.

## Presentation and analysis of results

According to the constructs and variables used in the research and script based on Likert scale of 5 points (1 - not implemented; 2 - planned to be implemented; 3 - implementation at an early stage; 4 - partially implemented; 5 - implemented completely), can be seen in Table 1 in summary, the data collected. Table 1 also shows the mean and the percentage of practical implementation of each, respectively.

*Tabela 1 – Green supply chain management practices at Whirlpool*

| Variables | Escale | Average | % of practical impleme ntation |
|---|---|---|---|
| **Internal Environmental Management** | | 4,75 | 95% |
| Top management commitment GSCM | 4 | | |
| Cooperation of staff for environmental improvements | 5 | | |
| Internal environmental audit programs | 5 | | |
| ISO 14001 Certification | 5 | | |
| **Reverse Logistics** | | 4,25 | 85% |
| Practices of reverse logistics with suppliers: return and / or replacement of defective products out of specification. | 4 | | |
| Practices of reverse logistics with suppliers: Return of packaging materials such as pallets, plastic boxes, containers, etc. | 5 | | |
| Practice of reverse logistics for collection of finished products: products out of specification, malfunctioning, breakdowns in transportation, etc. | 5 | | |
| Practice of reverse logistics for collection of finished products after the end of its useful life, or for recovery, remanufacturing, recycling or disposal. | 3 | | |
| **Green Purchasing** | | 3,5 | 70% |

| | | | |
|---|---|---|---|
| For purchasing environmentally friendly materials (recycled products, biodegradable or reusable). | 1 | | |
| Suppliers with ISO 14001 certification (suppliers which the company evaluates how significant environmental impact) | 4 | | |
| Environmental audits on suppliers of materials and services (materials and services that the company evaluates a significant environmental impact). | 5 | | |
| Partnerships with suppliers seeking environmental solutions and / or development of environmentally friendly products. | 4 | | |
| **Ecodesign** | | 4,5 | 90% |
| Project development of a PRODUCT considering the impacts on the environment (impacts on the environment: consumption of natural resources, use of materials / components recycled in the production, generation of solid waste, liquid effluents and air emissions, etc.) | 4 | | |
| Project development of a CASE considering the impacts on the environment (impacts on the environment: consumption of natural resources, generation of solid waste, liquid effluents and air emissions, etc.) | 5 | | |
| **Analysis of Life Cycle** | | 1 | 0% |
| Analysis of the completion of the life cycle of PRODUCTS considering the impacts on the environment (this analysis includes all the product life cycle, including the extraction, raw materials processing, production, distribution, use, reuse, maintenance, recycling and final disposal ). Impacts on the environment: consumption of natural resources, generation of solid waste, liquid effluents and air emissions, etc. | 1 | | |
| Analysis of the completion of the life cycle of PROCESSES considering the impacts on the environment (this analysis includes all process life cycle, covering the extraction, raw materials processing, production, distribution, use, reuse, maintenance, recycling and final disposal). Impacts on the environment: consumption of natural resources, generation of solid waste, liquid effluents and air emissions, etc. | 1 | | |
| **Waste Management** | | 5 | 100% |
| Characterization and classification (Class I, II, II A or B) of solid waste generated in the production process. | 5 | | |
| Disposal of solid waste generated (marketing, recycling, reuse or disposal) performed only in accredited and authorized companies for this purpose. | 5 | | |
| Plan for Solid Waste Management (in compliance with the National Policy on Solid Waste). | 5 | | |
| Wastewater treated before disposal into the environment. | 5 | | |
| Atmospheric emissions treated before disposal into the environment. | 5 | | |
| **Green Manufacturing and Remanufacturing** | | 4,8 | 96% |
| Production equipment in regular operating conditions, as well as installed according to the project of the same (in terms of efficiency, resource consumption, etc.). | 5 | | |
| Preventive and predictive maintenance of equipment aiming its proper functioning, as well as increasing its useful life. | 5 | | |
| Practice of disassembly: method that aims to separate the finished product into its constituent parts with a view to recycling and / or reuse, either total or partial. | 5 | | |
| Practice of recycling and / or reuse of materials or failed components in the production process. | 4 | | |
| Practice of recycling and / or reuse of materials or product components after the end of its useful life. | 4 | | |

- Environmental Management

  Whirlpool proved to be a consistent internal environmental management company with top management commitment and employee in support Green practices also has ISO 14001 certification.

  The cooperation of employees to environmental improvements in the organization's internal environmental management is facilitated by a team of 35 multipliers, employees from all business units whose mission is to promote and coordinate the implementation of annual sustainability goals, in addition to receiving and disseminating sustainability information, and submit projects and sustainability initiatives for the organization. To ensure that this issue be addressed across the board in all areas of the business, the company created the Sustainability Committee in 2011. With the task of defining priorities and approve the strategic initiatives, the committee is composed of four

directors plus the general manager of Sustainability, and can count on other members, depending on the issues at hand.
The internal environmental audit programs take place in an integrated manner the quality and to occupational safety, and are held every semester with internal auditors and annually with the external certification body.

- Reverse Logistics

  In the case of the practical RL, at Whirlpool in addition to performing the practice of RL returns to the suppliers of packaging materials, it performs the direct recovery client packaging. In São Paulo, it was collected over 136 tons of waste as styrofoam, cardboard and plastic. Much of the collected packaging is forwarded to the Cooperative of Collectors of Recyclable Materials of Diadema (Cooperlimpa). The volume of waste collected in 2011 shows an increase of 81% over the previous year.
  Whirlpool also makes the practice of reverse logistics for collection of finished products, which are out of specification, malfunctioning or damage to the transport.
  However, the organization is starting the practice of reverse logistics for collection of finished products after the end of its useful life, or for recovery, remanufacturing, recycling or disposal. According interviewed Whirlpool, the challenges to the implementation of reverse logistics system are just enforcing the law No. 12,305 / 2010 of the National Solid Waste and have shared responsibility policy throughout the chain, as well as the government.
  Whirlpool is associated with an entity responsible for defining and organizing the management of solid waste (post-consumer), by hiring, supervision and audit services rendered by others to the implementation of collective systems of reverse logistics of large scale, beyond to promote the apportionment of costs for participation in the chain, called Abree - Brazilian Association of Recycling Electronics and Appliance.

- Green Purchasing

  Whirlpool has no preference in the purchase of environmentally friendly materials, in turn, it explains the reasons for practicing have not yet been implemented, is due to the cost and quality priorities for the company, because the cost should be compatible as well the need to meet the quality, the technical requirements of the raw material and parts.
  The company prefers suppliers with ISO 14001 certification, however minimal environmental requirement required of its suppliers is comply with all laws.
  To have control of these requirements with suppliers both materials and services, these undergo environmental audits annually.
  Whirlpool has an Integrated Management System for Suppliers (SGIF), with the task of assessing the performance of direct material suppliers regarding quality, safety, health, environment and social responsibility. In 2011, the company implemented the Management System Material Suppliers Integrated and Indirect Services (SGIF-MSI), which serves the same purpose of the version for direct materials suppliers, in order to ensure that suppliers meet the minimum requirements supply and conduct established by the company. The plan is to qualify 100% of suppliers of indirect materials and services to medium and high risk.
  The company also incorporates the practice of partnerships with suppliers seeking environmental solutions and / or development of friendly products.

- Ecodesign

  Whirlpool partially implemented the practice of ecodesign in the development of product design considering the impacts on the environment, and ensures that the benefit of this practice is to find sustainable opportunities (cost reduction and reduction of environmental impacts). This impact assessment was implemented through the DfE (Design for the Environment), from the measurement of these opportunities and decide which variables are equivalent to possible implementations. The implementation of this DfE array began in 2010 with the support of experts from the University of Sao Paulo, through a cooling in the pilot project. From 2012, this methodology was integrated into the development process of other products.

  In addition to incorporating improvements that are now being adopted in other lines of refrigerators, such as: use of gases with lower global warming potential, such as isobutane and the cicloisopentano; recyclability index greater than 80%, that is, their parts and components can be disassembled and give rise to other products at the end of the life cycle; and manufactured in compliance with the RoHS European Directive (Restriction of Certain Hazardous Substances), which limits the use of restricted substances.

  The Whirlpool billing percentage from innovative products in 2010 was 23% in 2011 and 25% in 2012, the percentage was 27%.

  Moreover, the difficulty indicated by Whirlpool with respect to ecodesign is the introduction of this practice involving the new measurement variables features, pollution and waste, among many others already has to meet the development of products, such as cost, quality, deadlines, design, etc. For the company, an innovative product must be unique attributes, encouraging consumers and have the ability to generate value for shareholders. In 2012, the company obtained 73 patent applications in Brazil and became the first private company in patent deposit number at the National Institute of Industrial Property. The company also has 19 research and development laboratories and 5 technology centres in the country, dedicated to air conditioning, cooking, laundry, engines and cooling. Technology centres are references to all units of Whirlpool in the world, in every product category. These sites are developed innovative products and projects exported to over 70 countries.

  Depending on the company's Sustainability Report, with regard to the practice of ecodesign in project development for processes, Whirlpool develops in manufacturing, specifically, an approval process of process modifications, called PAS (Approval Process System), and include environmental variables that tool used by process engineers. This is a checklist complex of several steps along the development of a new or purchase of new manufacturing equipment process. In this way, it is also deemed to environmental aspects in the processes and assembly lines of business, so the green manufacturing concepts or cleaner production and environmental management are taken into account.

- Life Cycle Analysis

  Whirlpool has no practical analysis of the life cycle. However, the organization is achieving good results with the DfE, such as monitoring, measuring the consumption of materials, energy, water and waste generation associated with the product. The latter, shown in Table 2.

  With the new tool for development DfE products, technologies and materials used in the projects are specified taking into account the aspects of quality, cost and efficiency

simultaneously the environmental performance of the product, i.e., the impacts on the environment throughout their life cycle from production of raw materials to the final disposal in the post-consumer stage. These impacts are evaluated in the choice of raw materials, parts and components, the efficiency of water and energy consumption, recyclability of the product and waste minimization.

- Waste Management
  The Whirlpool Sustainability Report presents some waste management data from 2009 to 2011, as shown in Table 2.

*Table 2 – Waste Management (total weight by type and disposal method – in tonnes)*

| | **Waste to landfill** | | **Waste for co-processing** | **Waste Recycling** | | **Scraps** | **Incineration** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hazardous Gases Class I | Non-Hazardous Gases Class II | Hazardous Gases Class I | Hazardous Gases Class I | Non-Hazardous gases Class II | | Hazardous gases Class I | Non-Hazardous gases Class II | Hazardous Gases | Non-Hazardous gases Class II |
| 2009 | 304 | 817 | 222 | 126 | 9 | 11.568 | 0 | 0 | 652 | 12.394 |
| 2010 | 236 | 1.465 | 520 | 1.134 | 191 | 29.319 | 26 | 86 | 1.916 | 31.061 |
| 2011 | 112 | 1.525 | 224 | 1.081 | 224 | 34.490 | 321 | 119 | 1.739 | 36.358 |

The company has fully implemented all five variables related to waste management which appeared in the research questionnaire script, as follows: characterization and solid waste generated in the production process; disposal of solid waste generated (marketing, recycling, reuse or disposal) performed only in accredited and authorized companies for this purpose; Plan for Solid Waste Management (in compliance with the National Solid Waste Policy); atmospheric emissions and effluents treated before disposal into the environment, respectively.

- Green manufacturing and remanufacturing
  Whirlpool has its production facilities in regular operating conditions, as well as installed according to the design thereof; perform preventive and predictive maintenance of equipment aiming its proper functioning, as well as increasing its useful life; performs the disassembly of the finished product into its constituent parts with a view to recycling and/or reuse; In addition to performing the practice of recycling and/or reuse of materials or failed components in the production process.
  Referring to the practice of dismantling, Whirlpool has a disassembly line at the factory that is intended for products which have defects in production and also in the logistic transport (distribution).And for the products at the end of its life the company has partnered with Abree the appropriate disposal in this category is for recycling, disassembly, in order to meet the National Policy on Solid Waste.
  The organization also has the practice of recycling and/or reuse of rejected materials or components in the already consolidated production process. However, the practice of recycling and/or reuse of materials or product components after the end of its useful life is in the initial phase of implementation.

- Environmental performance
  The company uses as a methodological tool for managing and tracking targets the Global Reporting Initiative, an international organization whose mission is to define criteria for the preparation of annual sustainability reports. Table 3 shows some of the environmental desemprenho data from Whirlpool.

*Table 3 - Environmental Performance Whirlpool*

| | **2010** | **2011** | **2012** |
|---|---|---|---|
| Water consumption (m³) | 843.000 | 693.000 | 684.000 |
| Volume of air emissions (ton) | 89.476 | 77.336 | 91.075 |
| Volume of solid waste generated (ton) | **Hazardous**<br>Embankment: 236<br>Co-processed: 520<br>Recycled: 1.134<br>Incineration: 26<br><br>**Non-hazardous**<br>Embankment: 1.465<br>Cooprocessados: -<br>Recycled: 191<br>Incineration: 86 | **Hazardous**<br>Embankment: 112<br>Co-processed: 224<br>Recycled: 1.081<br>Incineration: 321<br><br>**Non-hazardous**<br>Embankment: 1.525<br>Co-processed: -<br>Recycled: 224<br>Incineration: 119 | **Hazardous**<br>Embankment: 44<br>Co-processed: 517<br>Recycled: 980<br>Incineration: 13<br><br>**Non-hazardous**<br>Embankment: 1.457<br>Co-processed: 48<br>Recycled: 611<br>Incineration: 323 |
| Rubbish and scrap (ton) | 29.319 | 34.490 | 31.852 |

From 2010 to 2011 water consumption was reduced by 17%, this decrease was due to the review of manufacturing processes and testing procedures, exchange of discharge valves and installation of water networks with visual control pipes, allowing the identification of leaks and repair more quickly and the construction of rainwater catchment systems and investments in wastewater treatment, saving the year, 14 000 m³ of water.
The reduction of total greenhouse gas emissions in 2011, reported in the company's Emissions Inventory, reached a total of 9,303 tons of carbon equivalent, accounting for 18% less than the previous year. The factors that contributed to this decline were the exchange of gases HFCs (used in refrigerators cooling circuit) and HCFCs (used in expanding polyurethane foam) by hydrocarbons (HCs) and isobutane cicloisopentano, which, in addition to not batter the ozone layer, have low global warming potential.
When dealing with the operating expenses / investments with environmental management, was only reported the 2012 budget, with a total value of R $ 12.9 million, distributed in percentage between: grants, hazardous waste management, water savings, management non-hazardous waste, monitoring of water and soil, emission control, energy - conservation and maintenance, among others, as shown in Figure 1.

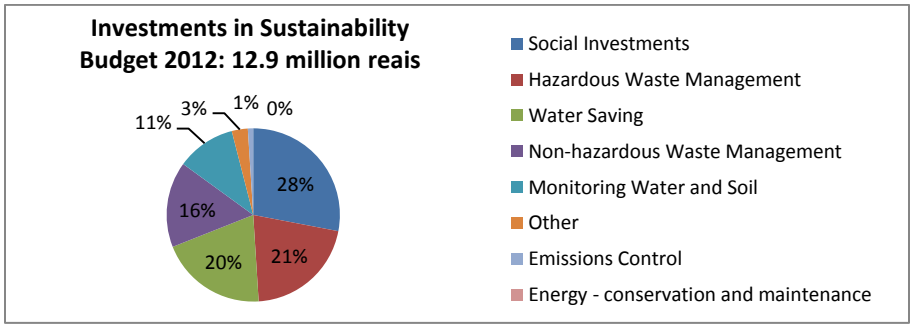


*Figure 1 –Whirlpool´s investments in sustainability in 2012*

The energy savings can be explained by the substitution in a shrink assembly line, plastic shell coolers, the stretch hood, elastic plastic film that does not need to be heated to adhere to the product.

With regard to waste management variable, the plant decreased by 18% the amount of industrial waste sent to landfills. In addition, it collects, transports and recycles 382 tons of metal, plastic, electrical wiring and refrigerant gases coolers and freezers used.

Finally, in order to provide the overview of the collected results can be seen in Figure 2 the adoption of green practices in Likert scale enterprise 5 points.

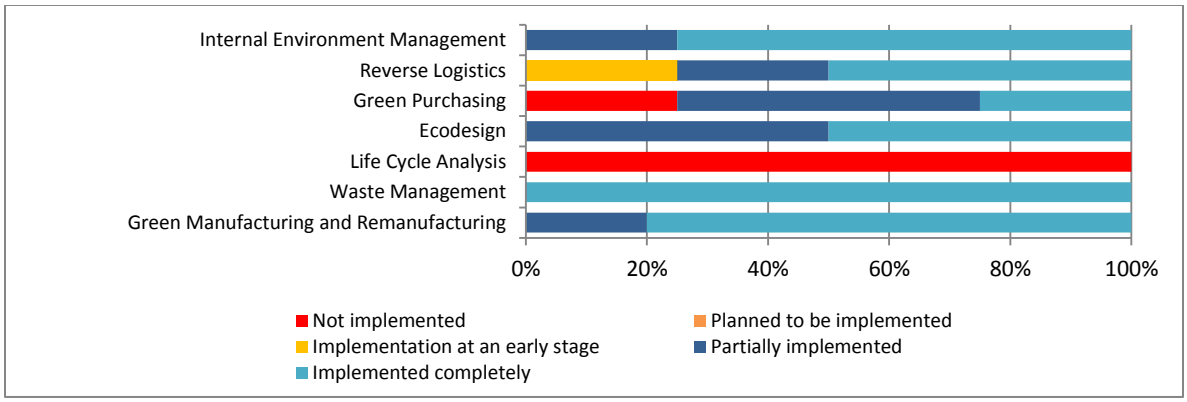


*Figure 2 – Summary of results*

Note that the green practices most adopted by the company are related to green manufacturing and remanufacturing and waste management. However, in the case of less widespread practice is green purchasing and analysis of the life cycle.

## Conclusions

The high adoption of waste management practice may be strongly associated with current law regarding the management, treatment and disposal of waste. Srivastava (2007) argues that the disposal of waste has been an intense problem, a fact that has led to green conscience. In this study it was observed that efforts to minimize this waste disposal has been the focus at the expense of other practices.

The practice of internal environmental management was positive for the implementation of top management commitment variables in GSCM, cooperation of employees to environmental improvements and internal environmental audit programs.

In relation to ecodesign it was found that the product development project variable is better accepted by the company when compared to the development process variable.

In respect to the practical analysis of the product lifecycle process and these were not completely incorporated. However, this assessment is extremely necessary for the environmental preservation comprehensively, taking into account that we consider all products and services used, from manufacturing to the final disposal after their useful life

The practice of green purchases showed a low result of implementation, considering the increase in material cost and limitation of qualified suppliers, due to the demand for different materials and components.

The low awareness, insufficient communication and tax and financial barriers are factors that delay the implementation of reverse logistics practice and consequently, recycling and / or reuse of materials or product components after the end of its useful life.

Based on the results of this study, one can demonstrate to society, academia, business and other stakeholders, the development of commitment to environmental preservation.But the closed-loop supply chain approach still has a long way to consolidate.

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