REFRAMING THE REVERSE LOGISTICS OF ELECTRICAL AND ELECTRONIC WASTE - AN OPPORTUNITY FOR NEW BUSINESSES

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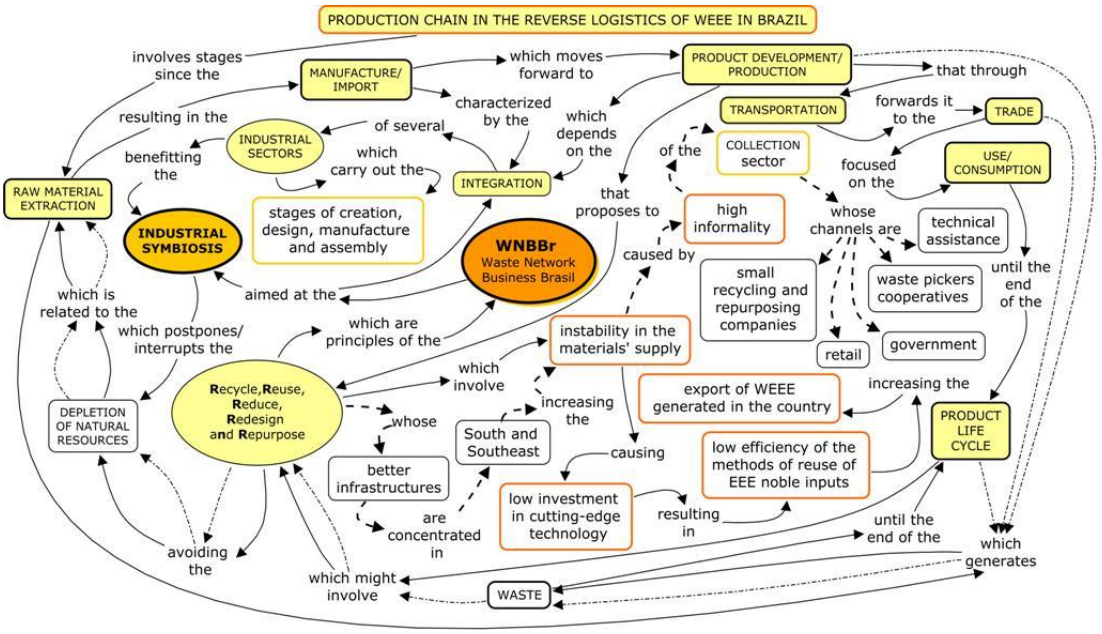
SUMMARY OF THE SCENARIO: in the treatment of solid wastes, the "non generation of waste" is a priority measure according to the determinations of the Solid Waste National Policy (SWNP), which also stimulates the incorporation of non-virgin raw materials in the production process. The increased consumption of electrical and electronic products requires increasingly complex studies of these markets, in particular of their production chains, especially their waste management. Therefore, the importance of assessing the problems arising from these wastes in a systemic and integrated view (Figure). To use the principle of Industrial Symbiosis is an innovative way to face the great challenges of reverse logistics of waste electrical and electronic equipment (WEEE) in the country.



GUIDELINES:

The regulatory imperative – the regulation establishes the boundary conditions. a strategic look at the *EXTENSION* border - *number of vertical stages of production and distribution that are undertaken by companies; is associated with the production sequence, vertical consolidation and vertical integration* - should be contemplated. That is, if the regulation exclusively takes care of how to collect and allocate, little progress will be made; **The gathering of competences** - the characteristics that currently govern technological development at a global level - the movement of people, the convergence of science and the leap of computation – make it essential that the action of "creating" knowledge to take full advantage of the WEEE covers this requirement; **Fostering the new business** – regulating and developing technology is not enough. Transforming the knowledge of the papers, dissertations and theses into businesses is essential for us to reframe the current fate of the WEEE into the desire to see them reused.

CONCLUSION: It is perceived, without much effort, that a Portal (WNBBr, Waste Network Business Brazil) - the first step toward the responsible management of WEEE - has a high potential for spreading regulation, gathering competencies and inducing market opportunities.

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Abstract:

The Solid Waste National Policy (SWNP) established by Law 12.305, of August 2nd, 2010, and regulated in December of the same year, indicates advances in the solid waste management in Brazil. The main one is the shared responsibility for the lifecycle of products, operationalized through the reverse logistics system. This system seeks the restitution of solid wastes to the business sector for their reuse in the production chain. In the business world, environmental issues are starting to be indispensable, making companies use new technologies and encouraging the ecodesign (development of products, processes or services with reduced environmental impact) to spare energy and natural resources. It is a way of creating more value and causing less environmental impact by not generating waste. In the treatment of solid wastes, the "non generation of waste" is a priority measure according to the determinations of the SWNP, which also stimulates the incorporation of non-virgin raw materials in the production process. The increased consumption of electrical and electronic products requires increasingly complex studies of these markets, in particular of their production chains, especially their waste management. Therefore, it is important to assess the problems arising from these wastes in a systemic and integrated view. The approach of industrial symbiosis includes the flow of materials and energy through local and regional economies, involving traditionally separate industries in a collective setting for competitive advantage by promoting the physical exchange of materials, energy and byproducts. To use the principle of this system is an innovative way to face the great challenges of the reverse logistics of waste electrical and electronic equipment (WEEE) in the country, which reside in, among others: the estimates of increasing these wastes volume; the lack of infrastructure in the collection up to the difficulties of recycling and improper disposal; the limited liability of the industry; the high costs of logistics in a country of continental extension; lack of specialists; and advanced technology. At this juncture, there is a demand to implement an efficient model of reverse logistics. Thus, in order to operationalize this system, the proposal of implementing a corporate portal - the WNBBr, Waste Network Business Brazil – arises, directed towards the exchange of knowledge and information and business opportunities within the industrial waste generated throughout the production cycle of EEE in the country.

Keywords: reverse logistics; waste electrical and electronic equipment (WEEE); industrial waste; industrial symbiosis; network.

1. Introduction

In recent years, the market for electrical and electronic equipment (EEE) has increased significantly worldwide (UNEP, 2009). In Brazil, this was not different and the prospects for 2014 are that the national revenue will present a nominal increase of 7% compared to 2013 (ABINEE, 2014). On the one hand, the EEE allow, for example, the communication to be faster and more efficient, providing more comfort in our everyday life and altering, in general, the cultural standards of living in society. On the other hand, however, they require large amounts of material and energy at all stages of their life cycle. These steps include the processes of raw material extraction, passing through the stages of design, definition, production, operation and obsolescence, up to its subsequent disposal at the end of its useful life. In that lies the importance of shared responsibility for the lifecycle of the product, by means of the reverse logistics. It aims to "close" this cycle by stimulating the reuse of the obsolete product by returning it to the production chain and introducing it to the market of recycled raw materials.

The phenomenon of increased consumption of EEE is accompanied not only by the rapid growth in the flow of generated solid waste, but also by the increased demand for metals used in their manufacture. In 2007, for example, the number of units of personal computers (PCs) and mobile phones sold increased the demand for copper in 15% and in 3% for silver and gold (UNEP, 2009).

Waste electrical and electronic equipment (WEEE), also known as e-waste, are in continuous growth. Its treatment in an environmentally proper manner is complex and expensive and there is a general lack of legislation and enforcement surrounding this area. Currently, most e-waste is discarded along with other wastes. In developed countries, 80% of the WEEE that are targeted for recycling end up being sent (often illegally) to developing countries in order to be recycled by hundreds of thousands of informal workers. This globalization of the WEEE, their volume, origin and flow cause negative impacts on the environment and in health (LUNDGREN, 2012).

Many studies reveal a variety of problems involved in the management of this type of waste. Adversities range from the mining activities at the beginning of the electrical and electronic production chain, passing through the lack of infrastructure in the collection up to the difficulties of reusing and improper disposal. The limited responsibility of the industry, the high logistics costs, the lack of specialists and advanced technology - capable of enriching the network of reuse of these materials -, the environmental awareness and the possible exploitation of workers from poor communities also pose challenges to be faced by this sector (STEP 2013).

The OCIs (Organizations, Companies and Industries) face different challenges according to the type of business in which they operate. Even so, some of them have been successful with operational models for the collection, preparation for reuse and redistribution of WEEE, in for-profit as well as non-profit sectors (BAKER & KING, 2007). However, it is important that a better holistic understanding of the technological, economic and ecological structure of the value chain for the reuse of EEE is adopted in order to develop a comprehensive

framework of quality (KISSLING, 2011; CAMPOS, FONSECA & MORAIS, 2014; PRADO, M.I., 2012).

In this paper, the problem of reverse logistics of electrical and electronic wastes is addressed in the Brazilian scenario. A management model for the reuse of WEEE, throughout their production chain, will be presented. The development of this standard is based on the concept of eco-efficiency and industrial symbiosis, supported by the principles and objectives of the Solid Waste National Policy (SWNP), focusing on the common axis of global regulations, which is the shared responsibility of the manufacturer, distributor, trader and consumer.

2. Summary of the scenario - a multi-disciplinary approach

Changes in perception on the business world related to environmental issues have already been noticed, making companies use new technologies to spare natural resources and energy, as this offers the possibility of gain. Considering that business processes were designed in a linear fashion until very recently (consume resources, produce goods and throw them away), it is concluded that the reduction in the use of resources – proposal of one of the concepts of the Natural Capitalism (HAWKEN et al, 1999) - is closely connected to the treatment and reuse of these resources, reducing the costs of raw materials acquisition and final disposal of the product. Thus, it is possible to create more value causing less impact, by not generating waste (CAMPOS & FONSECA, 2012).

Following this approach, Chertow (2007) provided a historical overview of the motivations and means to persuade the industrial symbiosis in order to include the physical exchange of materials, energy, water and byproducts between different OCIs clusters. He demonstrated that the "discovery" of existing symbiosis led to sustainable industrial development more easily than the attempts to design and build eco-industrial parks incorporating physical exchanges. In a broader approach, the author recommends the stimulation of the identification and discovery of the "core" of the existing symbiosis, as well as policies and practices to identify the precursors of the initial stage of possible symbiosis, which can be further cultivated and developed.

The symbiotic exchanges, both environmental and economically desirable, are all around us, so it is time to shift our gaze to discover and foment them.

The production chain of electrical and electronic products, for example, gives an indication of the tight integration between various types of OCIs, which occurs during all stages of the production process: creation, design, manufacture and assembly. Up ahead, a comprehensive approach to of the EEE production chain will be discussed, evaluating the difficulties of each one of these stages.

3. Current situation of the Electrical and Electronic Wastes

Currently, we are undergoing a crisis of global wastage. According to the World Bank, 1.3 billion tons of urban wastes are produced every year, and the volume is

expected to increase to 2.2 billion tons in 2025 (Hoornweg & Bhada-Tata, 2012). The threat posed by the poor waste management is particularly prominent in low-income countries, where the rates of waste collection are often less than 50 percent (GPWM, 2012).

In this scenario, the wastes of electrical and electronic products stand out. This occurs because in terms of waste generation in the industrialized environment, the fastest growing segment is the electrical and electronic equipment one, causing negative environmental, social and health impacts (GPWM, 2012).

Concerned with the large volume and handling of the WEEE and the expansion of the export of these used equipment to developing countries, in 2006, the Basel Convention has established in its high-level segment at the eighth Conference of the Parties (COP-8) the following theme: "Creating innovative solutions through the Basel Convention for the environmentally sound management of electrical and electronic wastes". It is worth noting the vulnerability of some countries in ensuring environmentally sound management of such wastes, and thereby increasing the risks associated with the uncontrolled importation of these products (BASEL CONVENTION, 2006).

In order to approach the problem of the electrical and electronic waste with a technological and multidisciplinary perspective, it is necessary to identify the size of the challenge, that is, how much of this type of waste is there in Brazil and how fast does its flow grow.

In Brazil, the technical and economic feasibility study of the reverse logistics of electrical and electronic equipment, released on the National Solid Waste Management Information System (SINIR), reveals surprising data on the potential volume of WEEE generation (Figure 1). The analysis was made by segmenting the WEEE into two major groups: the large-sized ones - from the white goods (refrigerators, stoves, washing machine and air conditioning) - and the small-size ones - all other WEEE (TV/monitor, lcd/plasma, dvd/vhs, audio products, desktops, laptops, printers, mobile phones, mixer, blender, electric iron, drill) (SINIR, 2012).

According to the results of this study, it is expected that the volume of WEEE, in the country, continues to grow until 2020. At this juncture, it is urgent to implement a model of effective reverse logistics. However, it is clear that there are many obstacles, especially because of the expected volume estimates and the geographical dispersion of the waste. Additionally, there are still other challenges concerning the shared responsibility for the products life cycle: the concern of manufacturers, importers and traders with the costs of this process and the design of a system that ensures equality and minimizes the risks of competitiveness loss; the stakeholder responsible for paying the reverse logistics of orphan products (those whose manufacturer or importer is unknown); the way of promoting the adhesion of consumers and importers to the system; and the consensus if the WEEE will be considered dangerous or not at the logistics phase (SINIR, 2012).

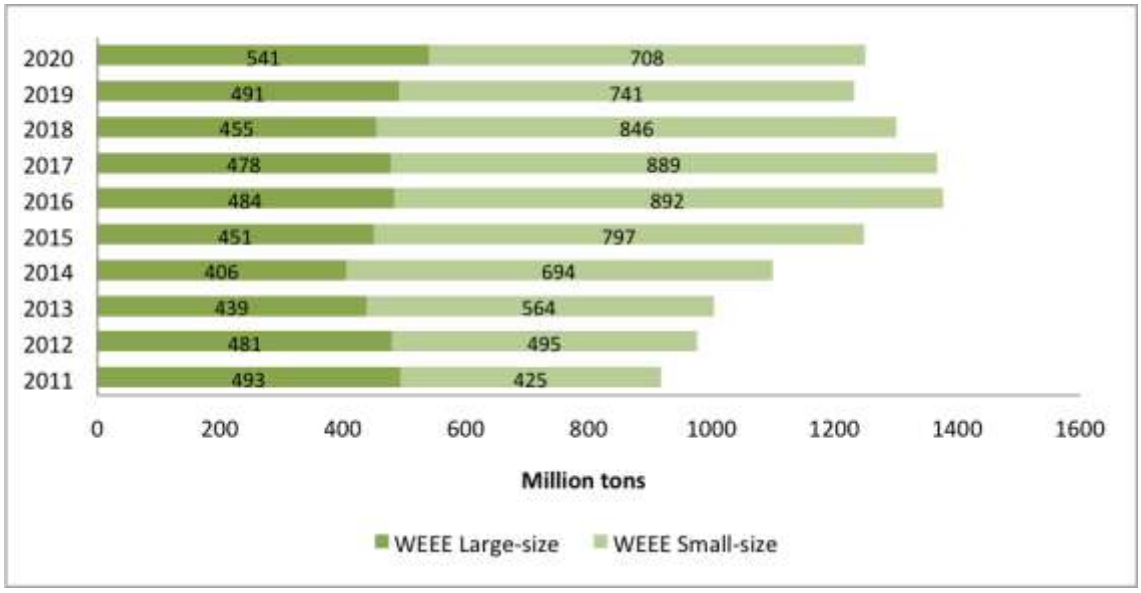

Figure 1: Estimate of the generation of WEEE in Brazil (Source: SINIR, 2012)

From another perspective, research conducted by Cempre (Business Commitment for Recycling) indicates a significant increase in the number of Brazilian municipalities that have selective waste collection programs. Even so, only 766 municipalities (about 14% of the total) operate these programs. Data also point to a prevailing concentration of these programs in the South (34%) and Southeast (52%) regions (CEMPRE, 2012).

It is worth mentioning that only 0.5% of the collected waste is from electrical and electronic equipment, representing the lowest percentage in relation to the total waste collected (CEMPRE, 2012). However, there has been an increase compared to 2010 (when the rate was 0.2%), the first year in which these materials were separately registered.

Also noteworthy is that the volume of WEEE in the country has considerably increased in recent years, in a complex scenario of problems. With a still precarious infrastructure to receive this entire disposal, most of them are forwarded to the informal market, causing some complications. A portion of the equipment is sent for reuse. Part of the material that cannot be reused is added to other types of waste, going straight from the consumer to a system that is characterized by irresponsibility, in which quantities of WEEE are processed without the proper training or appropriate safety equipment, in warehouses without the necessary environmental licensing. It is common to launch wastes that arise from these processes together with other wastes, or forward them to incineration, without any emission control. Still, even more recklessly, there are situations in which the material is crushed and illegally exported to countries that are more vulnerable than Brazil, with regard to regulation and supervision (SINIR, 2012).

4. Systemic view of the production chain in the reverse logistics of the WEEE

The production chain of the EEE is delineated by the complexity of this type of equipment: tight integration between manufacturers and suppliers of parts, spare parts and components (PSP&C); production and marketing on a global level; expressive range; and direct relationship with the consumer market. The technical and economic feasibility study of reverse logistics of the EEE identified the stakeholders in the production chain of the WEEEs. They are: manufacture, importation, consumption, trade, collection, recycling, raw materials and final disposal. It is worth to include other equally important stakeholders: transportation and repurpose, reuse and redesign activities, which act as complements to recycling. In the following paragraphs, an approach of each one of the stakeholders in the production chain of the EEE will be made, emphasizing the challenges to be faced in the reverse logistics of its waste.

With regard to **manufacture**, an aspect that is worth noting is that in recent years, the choices made on the design of electrical and electronic equipment have been fairly questioned. The most criticized aspects are the lack of standards in the accessories; and the deliberate restriction to the repair of appliances - caused by the lack of spare parts or by the total impossibility of replacing parts. These characteristics, together with the adoption of measures that reduce the useful life of the products and components, and the use of advertising, which encourages continuous replacement, are part of the planned obsolescence. However, some companies have challenged these criticisms, stimulating the ecodesign, which is based on a systemic and integrated view to develop products, processes and services with reduced environmental impacts. They are based on the principle of ecosystems, which ensure their own perpetuation, to inspire production cycles that reduce waste materials to the most.

Given the international scenario of raw materials and PSP&C and the particularities of the EEE manufacture, the **importation** plays a fundamental role in the manufacture. Many PSP&C are imported to be assembled in Brazil. In addition, the large volumes of equipment importation (formal or informal) generate consequences to the WEEE panorama because a considerable amount of discarded material is not manufactured in the country. It is important to weigh the interests of national manufacturers and importers and apply the principle of shared responsibility to each one.

Although the **consumption**, another stakeholder of the production chain, has already been discussed, the aspect of conscious consumption, which is an attitude advocated by organizations dedicated to reduce the environmental impact and waste in society, should be mentioned. Recycling, reusing, repurposing and redesigning the EEE coupled with environmental awareness are relevant because they avoid the loss of aggregated value in this type of equipment.

It is worth mentioning **trade** as the main flow channel of the EEE production, because it is the one who performs the sale of the products to the consumer. It has a strong geographic presence and penetration through the retailers, small businesses and e-commerce websites. It develops a direct and continuous relationship with the consumer, and that is why it represents a strong potential for

reverse logistics actions. However, it faces some challenges regarding the management of WEEE, such as the physical structure (little free space); mismatch between demand and collection; and the lack of interest in the reuse by the retailers (complex issues of warranty, service and environmental risk).

The **collection** of WEEE is distinguished from the other stakeholders because it includes different stages in its activities: receiving, temporarily storing and forwarding the waste. Thus, this activity should use caution in relation to the treatment and handling of materials and rely on flexible and suitable spaces to store a certain kind of product. It follows a regulation to ensure legal support, both for those who are giving away the equipment as for the businesses who receive the materials. The relevant channels to accomplish the collection of WEEE are the retail, technical assistance establishments, the government, waste pickers cooperatives and small recycling companies.

Currently the collection and logistics of WEEE in Brazil have a high degree of informality, causing instability in the supply of materials for **recycling, reuse, repurpose and redesign**. Moreover, the industry cannot afford to invest in the cutting-edge technology. A considerable amount of WEEE generated in the country needs to be exported to receive appropriate treatment. In 2011, 20 thousand tons of waste generated from electrical and electronic equipment (among plastics, iron, batteries and glass) were exported from Brazil (SINIR, 2012). Another important aspect that the recycling industry claims is the tax readjustment of the WEEE. International research relate the high recycling rates to the existence of formal economic incentives (BOHR, 2007). Indeed, the recycling cost is proportional to its efficiency: the greater the rate of recycling (generating a smaller amount of wastes), the more expensive is the process. In Brazil, the current demand is small relative to the installed base. Therefore, a quantitative increase would also encourage a greater investment in technology, which, in turn, would increase the efficiency of recycling.

The **raw materials** used in the manufacture of electrical and electronic equipment are varied and also of diverse origins. A great part of the copper, for example, is derived from Chilean mines, while the silicon (used as a semiconductor in electronic circuits) is extracted in different regions around the world. Tantalum, in its turn, used in the manufacture of capacitors and internationally known as coltan, is found in the mineral columbite-tantalite, whose reserves are concentrated in the Democratic Republic of Congo (DRC). Its extraction is related to the civil war background, which has been highly destructive to this country. In addition, the actual extraction, often performed by children, is done under very adverse conditions (FITZPATRICK, C. et al, 2013). In Brazil, a current problem lies in the fact that wastes with high aggregated value, containing gold and other precious metals, are exported with prices that are equivalent to the common WEEE scrap. Thus, in order to avoid the exit of great amounts of this material to foreign countries, it is important to invest in cutting-edge technologies that increase the efficiency of recycling and decrease the extraction of these natural resources.

The issue of the **final disposal** of the waste (material whose reuse is not feasible) generated in the processes of WEEE recycling is complex. Since this waste consists of, mostly, potentially hazardous elements (heavy metals like cadmium and lead)

its incineration is not recommended. This is because the process would require a special treatment of the combustion gases and of the incineration wastes, endangering the economic viability of the process (FRANCO, 2008).

The **transportation** of WEEE is an important stakeholder in the reverse logistics system, because the major obstacle to implement this system effectively and efficiently resides in it. According to the SWNP, the manufacturers have an obligation to receive the post-consumer waste, and it is the consumers' responsibility to deliver them to the manufacturers. However, the law does not specify who is responsible for the transportation and all logistics, nor it elucidates the required collection points, whether exclusive or shared. Therefore, what should be further evaluated is the following: how to transport (either the intact or disassembled equipment), how much would it be possible to carry and what would be transported. The plastic components, for example, can be locally sent for recycling without the need to return to the manufacturer. This way it would be possible and essential to define where to install the collection points, with possible agreements with municipalities, and share these points among the manufacturers.

Facing the reality of WEEE in the Brazilian scenario, a variety of problems for the implementation of the reverse logistics system of these wastes can be evidenced. A priori, the problem of instability in the supply of materials for general reuse can be emphasized because it triggers a number of other deficiencies. Such phenomenon undermines the investments in cutting-edge technologies, promoting a low efficiency of the methods of recycling, reuse and redesign of the EEE noble inputs, which consequently increases the export of WEEE generated in the country. A systemic approach to this situation is presented in the conceptual map in figure 2.

In a systemic view - there is no other way to address the problem because of the complexity explained above - some guidelines can be constructed, as follows:

a) The regulatory imperative - it is clear that the regulation establishes the boundary conditions that, if properly elaborated, guide and promote the development of attitudes that transform societies. In this sense, a strategic look at the EXTENSION border - *number of vertical stages of production and distribution that are undertaken by companies; is associated with the production sequence, vertical consolidation and vertical integration* - should be contemplated. That is, if the regulation exclusively takes care of how to collect and allocate, little progress will be made;

b) The gathering of competences - the myriad of actors and environments involved in the WEEE theme, imposes the articulation of skills in no way restricted to one, two or three areas of knowledge. When paying attention to the characteristics that currently govern technological development at a global level - the movement of people, the convergence of science and the leap of computation - it is essential that the action of "creating" knowledge to take full advantage of the WEEE covers this requirement; and

c) Fostering the new business - regulating and developing technology is not enough. The papers, dissertations and theses, although not many in this area, are already responsible for dusting hard drives of information from

government agencies, universities and science & technology institutions. Transforming this knowledge into business is essential for us to reframe the current fate of the WEEE into the desire to see them reused.

That said, it is perceived, without much effort, that a Portal - the first step toward the responsible management of WEEE - has a high potential for spreading regulation, gathering competencies and inducing market opportunities.

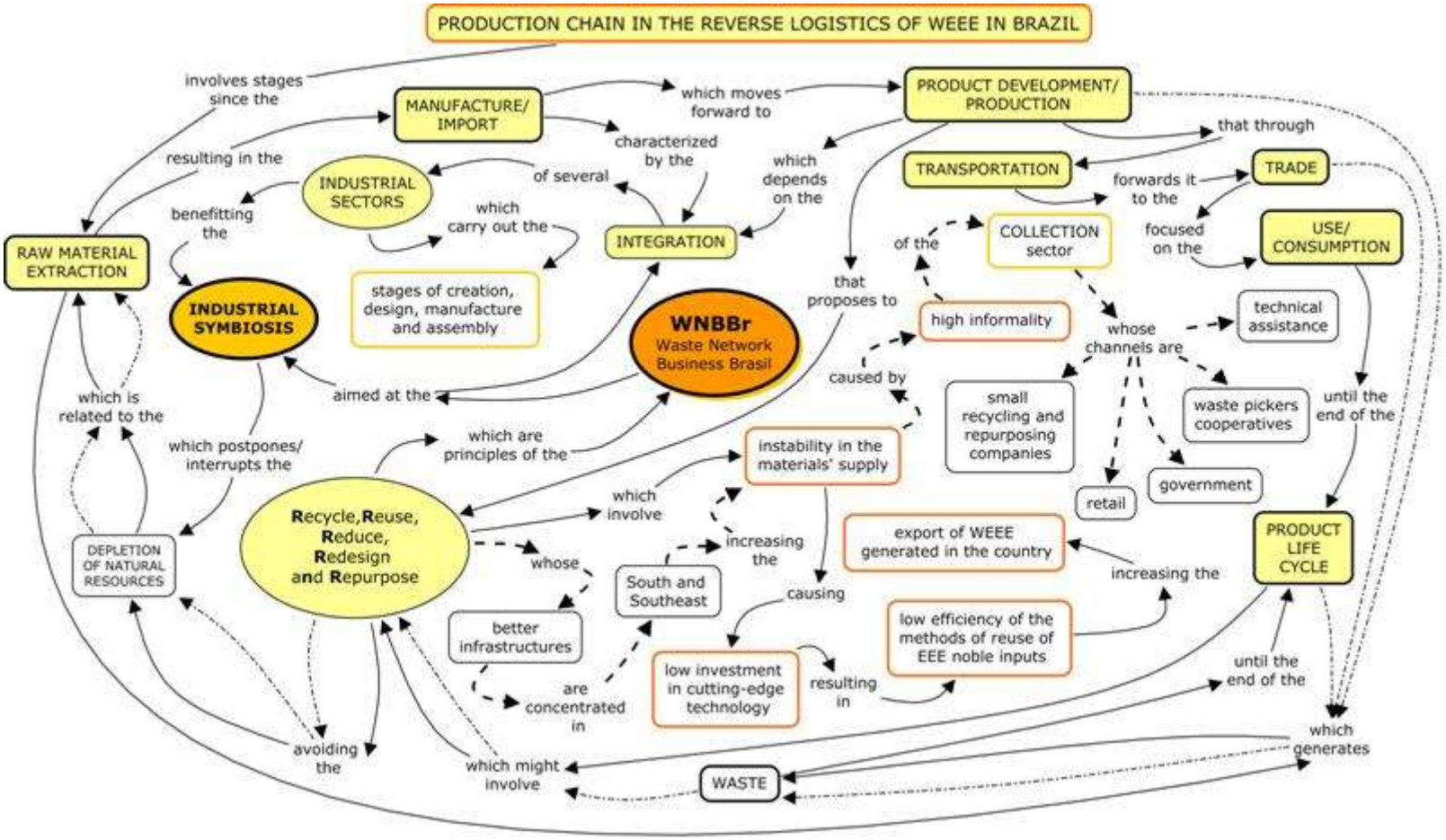

Figure 2: Systemic view of the production chain on the reverse logistics of the WEEE.

4. Presentation of the proposed model

Given the situation exposed herein, the incentive to develop this model came from a reflection that points to the need of articulating efforts that are already being developed. These efforts are related to the area of utilization of the industrial waste of the electrical and electronics sector with the potential of environmentally sound solutions. Once the importance of "cleaning the planet", efficiently and effectively, but also covering social, economic and technological aspects, is understood, the proposal of implementing a corporate portal emerges - the WNBBr, Waste Network Business Brazil - directed toward the exchange of knowledge and information and of business opportunities within the industrial waste generated throughout the production cycle of EEE in the country.

The WNBBr aims to establish access bridges between the generators of electrical and electronic wastes, companies that are interested in reusing it, R&D institutions, government development agencies and investors. These partnerships can generate environmental solutions, that is, create procedures for the protection of the environment, through sustainable development; business competition; and social inclusion through the generation of employment and income.

The conceptual map in figure 3 describes the structure of the WNBBr.

5. Method and strategy

The development strategy of the networking actions configures itself as an important approach when, to overcome the technical barriers in the context of elevated competitiveness on a global level, we face the need for multidisciplinary solutions. Additionally, companies cannot waive a fast channel to access the competencies required nationwide, since the regional peculiarities aggregate differential approaches in the solution of problems and in solutions focused on product, services and processes innovation.

Thus, the WNBBr project is configured as the logical path to the startle of Brazilian competencies in the area of reusing electrical and electronic industrial waste, intending to seek and induce the implementation of self-sustaining and innovative solutions. Therefore, the success resulting from the implementation of the WNBBr will take place from the articulation proposed between the stakeholders involved (waste generators, companies interested in reusing the waste, companies operating with waste management, researchers, STI institutions, state environmental agencies, national and international organizations linked to waste management, investors, accelerators and strategic connectors), which is represented by the understanding of the complementarity of each others missions.

The WNBBr will be characterized as a knowledge platform, for it is a point of convergence of information platforms (provide access to information), cooperatives (provides tools of cooperative processing) and specialists (connects people based on their experiences and interests), so it is able to provide personalized content according to the activity of each user.

6. Final considerations

If on one hand the challenges are identified, on the other, it is possible to recognize innovative business opportunities. Reverse logistics has the potential to promote environmental benefits, social and economic returns such as generation of employment and income and the reuse of PSP&Cs, thus avoiding the depletion of natural resources. Moreover, this scenario is seen as an opportunity to encourage the development of more efficient technologies, encourage the training of specialists in the area of reuse of WEEE and contribute to the creation of a more robust and dynamic market for recycling, reuse, repurpose and redesign (CAMPOS & FONSECA, 2012; CAMPOS, FONSECA & MORAIS, 2014).

Indeed, waste management, if handled properly, has great potential to create markets, turning the weaknesses and threats of the industrial waste into opportunities and strengths for generating employment and income. Thus, the WNBBr is a model that presents a new way of inducing businesses in the context of using industrial waste in the electrical and electronics sector based on the SWNP.

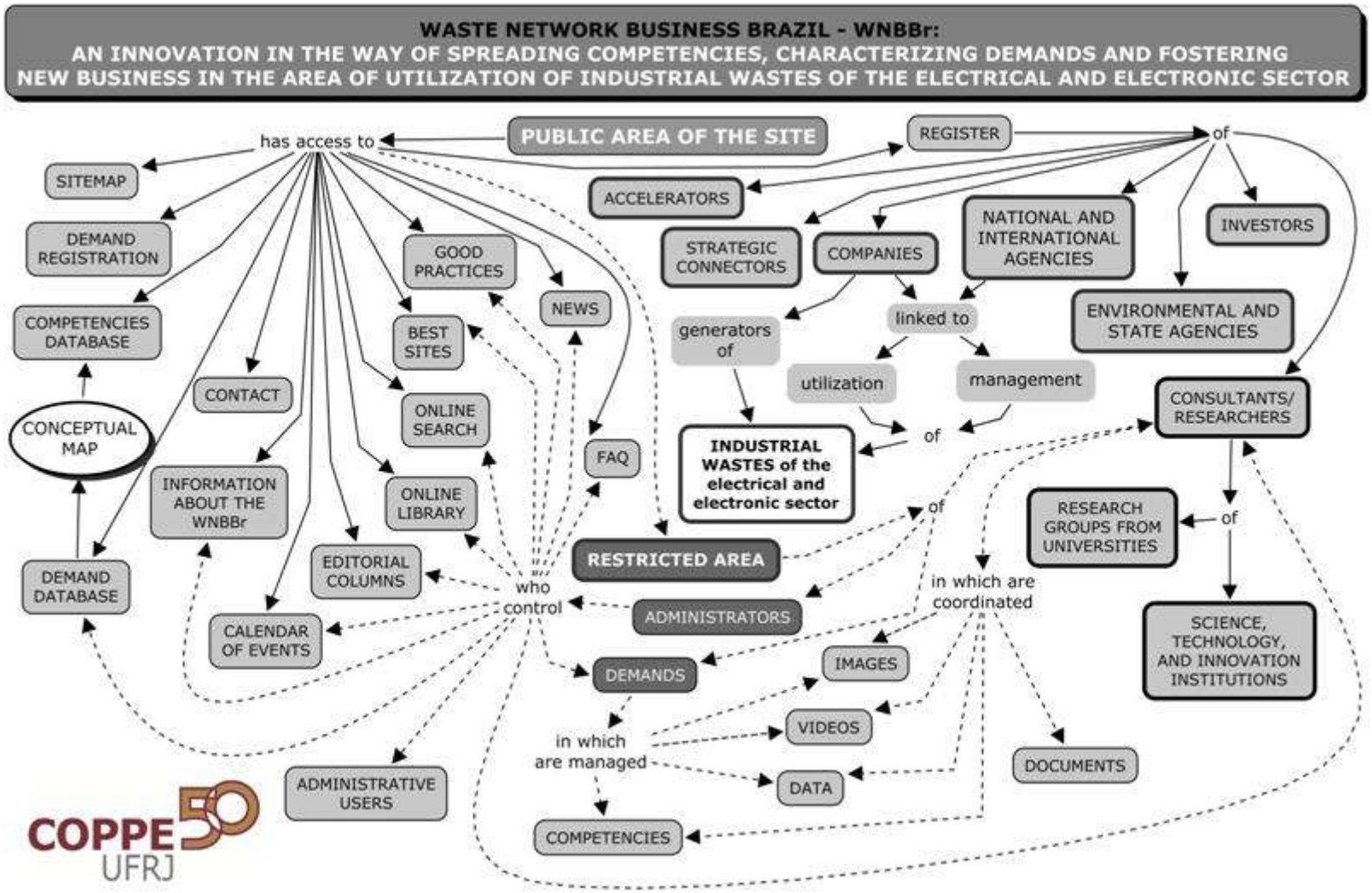

Figure 3: Structure of the WNBBr

7. Acknowledgements

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