

# **SUSTAINABLE PRODUCTION WITHIN THE CONSTRUCTION INDUSTRY: A CASE STUDY ON A PREFABRICATED COMPANY IN BRAZIL**

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## **ABSTRACT**

The demand for sustainable products and processes is growing steadily, including in emerging countries such as Brazil. The investigation presented in this paper focuses on production phase, based on the literature of “sustainable manufacturing”. It revises which strategies are feasible to be implemented to achieve more sustainable production in a pre-fabricated company. The authors have analyzed on a case study in the application of such strategies of both products and processes focusing on the economical, social and environmental dimensions of sustainability. The company this case study focuses on is among the largest in the pre-fabricated sector in Brazil. The study has adopted MEPSS tool, an online tool developed to conceive and/or diagnose sustainable product-service systems. The results shown to areas where innovation is required and where companies could gain competitive advantage through sustainability at the production stage.

Keywords: innovation; pre-fabricated industry; sustainable production;

## **INTRODUCTION**

In the beginning of the new Millennium, has grown increasingly concerned about the environment worldwide. Such attention began to be expressed around 1968, when a series of student protests - first in France and then throughout the Western world - against the model of socioeconomic development of industrial capitalism (Camargo, 2003). The term sustainability thought in its entirety, covering socioeconomic and environmental aspects and was coined in 1987 by the Brundtland Commission. His main contribution was to establish that sustainable development will meet the needs of the present without compromising the care needs of future generations. In the following decades, many global conferences were held, as the ECO in Rio de Janeiro (1992), and Rio +10 in Johannesburg (2002). At these meetings, international protocols were signed in order to develop mechanisms for sustainable development (Gonçalves et al., 2006).

Building a truly sustainable society undergoes a radical transformation in patterns of consumption and production processes. The concept of cultural development and

well being will be radically transformed. This will require solutions based on other paradigms than those that support the industrial society (Agopyan et al., 2001). Sustainability at the construction stage is often seen solely from an environmental perspective, which paradoxically can lead to unsustainable solutions. Social and economical aspects need to be balanced with the environmental dimension. Production of locally manufactured goods and services, for instance, could make a contribution by enhancing the local economy and of setting unemployment with strategic economic and social benefits to local communities. A life cycle approach to buildings necessarily has to consider an amplification of stakeholders involved on the design, production, use and recycling of buildings. Contractors, manufacturers and suppliers can contribute by minimizing any wastage, pollution, hazards and risks associated with their products, services and working practices; also, by supporting occupiers with better training and information (Halliday, 1999).

In 1999, the CIB has published pioneering Agenda 21 on Sustainable Construction (CIB, 2010), recently translated into Brazilian Portuguese by the Department of Civil Engineering of the Polytechnic School of USP. This report details the concepts, issues and challenges presented by sustainable development called for the construction industry. The role of sustainable construction has been precisely positioned and, in this view, were pointed out some challenges for the construction industry. However, most contributions to this publication came from developed countries so that many of the issues, challenges and solutions were designed only for developed countries themselves (Agopyan et al., 2001).

Somehow, the vision of first world dominates the discussion of sustainable development internationally. However, differences in relation to developing countries go beyond the obvious economic aspects. The environmental impact of corporations as the Brazilian is different because the industrial structure and consumption is different. The environmental impact of developing countries is lower than that of industrialized countries in environmentally important aspects like the generation of CO<sub>2</sub> per capita. The generation of this gas in Latin America and the Caribbean is six times lower than the U.S. and Canada (Agopyan et al., 2001).

Sustainable development also implies social equality, and this item is certainly much more important in countries like Brazil, marked by concentration of wealth. The construction of infrastructure and housing for the population is a fundamental social demand in Agenda 21 of any developing country. In some respects the construction of this infrastructure has implications related to pollution, according to the IDB in Latin America only 50 to 10% of sewage is treated (Agopyan et al., 2001) resulting in pollution of aquatic reserves. In developed countries, this problem has been eradicated for many years. In Latin America, for example, it is estimated that 16 and 24% of roads are to be paved (ECLAC, 2000; WORLD, 2010). In developing countries many of the dwellings are self-built, and there should be specific solutions for this type of construction is more sustainable. In Latin America regulations to induce or demand more responsible corporate operations are less present. In Brazil alone the deficit of new houses is estimated as 6.5 million and the amount of inadequate houses (ex: lack of toilet, no sewage system, etc) is also estimated around the same number. The problem here is that most of the people in this market do not have enough income to afford current construction costs (Santos and Amadigi, 2008).

Recently, in Brazil, there is a housing initiative that the government aims to build one million housing units for families with income of up to three minimum wages, but also covers families up to 10 minimum wages. The "Minha Casa Minha Vida" is made possible by the partnership between federal, state, municipalities,

entrepreneurs and social movements in the country. To achieve this encouragement of the government should present the candidate designs future development, which after initial registration will be selected after screening for program participation. The government guarantees for new development prior to the basic infrastructure of the region, the lower purchase price of housing units and tax relief tax. Those interested in participating in this program can still rely on standard projects with costs defined and offered by the National Survey of Construction Costs and Indexes (SINAPI), and the use of wood is to be mandatorily certified or coming from managed forests controlled for the enterprise, this is a parameter endorsed by Caixa Econômica Federal (CEF), as fundamental reference environmental (CEF, 2010).

Social work involved in the "Minha Casa Minha Vida" aims to intervene mainly in low-income community that involves interaction with the use of community tools, environmental education and social integration. For the second stage of the program is planned to build 300 thousand and 400 thousand homes equipped with solar panels to heat water that is used in the shower. This idea combines the preservation and energy saving, reducing the costs post-installation, and families create a sustainable education process. The forecast for the second step is to use not only solar power but also make use of reuse of rainwater, these requirements are not mandatory, but projects that focus on energy efficiency and sustainability are beginning to emerge and many people are being encouraged to create housing projects (BRASIL, 2010).

New paradigms are emerging in the market of production and consumption in Brazil in order to move the country towards sustainable development. The National Policy on Solid Waste (PNRS), National Council of the Environment (CONAMA) resolutions, and the Plan of Action for Sustainable Consumption and Production (PPCS), come against this longing. The PPCS Plan (Sustainable Production and Consumption) is a national plan that is aligned with the actions of the Marrakech Process, in Brazil aims to stimulate a vigorous and continuous process of changes and incentives for the development of patterns of sustainable production and consumption (MMA, 2012). For the first cycle, with expected time and under constant monitoring, the plan is expected to be implemented in three years (2011-2013). Initially selected priorities are: education for sustainable consumption, sustainable construction, environmental agenda in public administration (A3P), retail and sustainable consumption, sustainable procurement and increased recycling of solid wastes (UNEP, 2012). In this context, this paper revises the concept of "sustainable manufacturing", presenting the key strategies to achieve higher performance both on environmental, social and economical terms. The study was carried out at a Brazilian prefabricated company and focuses on the development of a rapid diagnosis protocol using check-lists as the main tool.

## **SUSTAINABLE MANUFACTURING**

### **Definition**

The NACFAM (National Council for Advance Manufacturing) defines it "as the creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources, and are economically sound and safe for employees, communities, and consumers." Sustainable manufacturing can be applied both to sustainable products as well as to "non-sustainable" products. Thus, the definition of being sustainable on this concept is limited to the production stage alone. In practice it implies the adoption of strategies such as: use of renewable energy, energy

efficiency, green building, and other “green” & social equity-related products (NACFAM, 2010).

Sustainable Manufacturing can also be defined as a business practice which expands to all company’s processes and decisions, including the social and natural environments where it operates and affects. Its explicit objective is reducing or eliminating any negative environmental/social impact, while pursuing the desired level of technological and economic performance (SMC, 2010).

To be considered a sustainable production is not enough to be environmental only in one respect. Must work of the three pillars, economic, environmental and social. Sustainability means operating in a way that equilibrate people, the product profit and planet. Sustainable production and products used should always be benign and should incorporate the intelligent reuse and recycling practices, without depleting resources at a lower cost and reduced environmental impact (CIMS, 2009). According to the Department of Commerce is the sustainable production creation of manufactured products that use processes that are non-polluting, conserve energy and natural resources and are economically sound as well as insurance for workers and consumer communities.

The manufacture goes beyond sustainable approaches for the prevention of pollution and waste material, is a fusion of business and social responsibility. Companies that adopt innovative ways with respect to sustainability end up demanding that their suppliers are too. This creates a sustainable chain and that is often valued by customers by creating a market differentiator (CIMS, 2009).

### **Cleaner Production**

The purpose of eco-efficient industries is "doing more with less." This implies produce more products and services with less energy and raw material, generating less waste and pollution. Thus, eco-efficiency is more closely linked to the efficient use of natural reserves. The eco-efficient approach results in a continuous and integrated strategy, called the Cleaner Production (cleaner production) (Giannetti and Almeida, 2006). Cleaner Production includes, in addition to environmental issues in production, the economic concern. Thus, improving profitability and competitiveness is closely linked to the issue of efficiency. The anticipation and prevention of impacts are part of this approach, working, therefore, pro-active. For this, the Cleaner Production provides some tools, including:

- ✓ Analysis of the Cycle-of-life allows the quantitative assessment of inputs and outputs of the system, and the detection of critical points before, during and after the production of a product or service. It can be done with the use of computerized tools (eg SimaPro, Umberto).
- ✓ Environmental indicators: they allow the quantitative measurement of process efficiency. Are used, for example, to power the LCA with more reliable data (eg Ecoindicator).
- ✓ Environmental Labels: stamps provided by accredited bodies, certifying the environmental quality of products (e.g. FSC).
- ✓ PMA - Design for environment (DFE - Design for Environment): product design considering environmental requirements from design, also known as ecodesign. From the above list, it can be seen that, in view of engineering, design is considered as just one of several tools of Cleaner Production to prevent and reduce environmental impacts. However, the design has a potential role for sustainability that goes beyond the setting of industrial products more environmentally clean.

## **Sustainable Consumption**

According to the Commission on Sustainable Development UN (1995), refers to sustainable consumption as "the use of goods and services that meet basic needs and improve quality of life while minimizing the use of natural resources, toxic materials, contaminants throughout the life-cycle, so that does not compromise the needs of future generations. " It is evident in the proposition made during ECO'92 held in Rio de Janeiro 1992, the importance of design, especially as an element of reducing and eliminating unsustainable patterns of production, because the design is the activity responsible for the creation and specification of products and services. Furthermore, the design can also promote sustainable consumption, as it also works on the communication and marketing, especially graphic design. Manufacturing has assisted historical development of innovations systems during decades. Evolution to sustainable manufacturing:

- ✓ Traditional Manufacturing – Substitution based;
- ✓ Lean Manufacturing – waste reduction based;
- ✓ Green Manufacturing – environmentally benign, 3R based;
- ✓ Sustainable Manufacturing – Innovative, 6R based (redesign, reduce, remanufacture, reuse, recover, and recycled).

## **The Environment Dimension of Sustainable Manufacturing**

The principles that indicate the effective adoption in sustainability in production includes on the environmental dimension: system life optimization, transportation/distribution reduction, resource reduction, waste minimization/valorization, conservation/biocompatibility and toxicity reduction. Among these strategies perhaps system life optimization is the most unusual on regular business since it deals with sharing resources or increasing the durability of the same resources. At the production stage it implies, for instance, avoiding the acquisition of new equipment and, instead, acquiring their end result. The life cycle management of such equipment would remain with the producer. This is a fundamental shift from conventional production since in most companies the issue of ownership is culturally relevant. The environmental dimension can be witnessed in production through the "lean production" initiatives. Identifying and eliminating sources of waste is a constant issue on the minds of production personnel using this paradigm in their every day activities. According to Imai (1997) and Shingo (1989), sources of waste (muda) in production are classified according to seven main categories:

- ✓ Overproduction: this type of waste results from "getting ahead" with respect to production schedules. Here the required number of products is disregarded in favour of efficient utilization of the production capacity;
- ✓ Inventory: final products, semi-finished products, or parts kept in storage do not add any value. Even worse, they normally add cost to the production system by occupying space and financial resources and, also, by requiring additional equipment, facilities and manpower;
- ✓ Repair/rejects: rejects interrupt production and, in general, require expensive rework. Moreover, they may end up discarded or damaging other equipment or generating extra paperwork when dealing with customer complaints;
- ✓ Motion: any motion not related to adding value is unproductive;
- ✓ Transport: although sometimes this activity seems to be an essential part of production, moving materials or products adds no value at all;

- ✓ Processing: this waste happens when the use of inadequate technology or poor design results in inefficient processing activities. Sometimes this waste may appear as a consequence of a failure to synchronise processes, where workers achieve performance levels beyond or below the requirements of downstream processes;
- ✓ Waiting: this waste occurs when the hands of a worker are idle such as when there are imbalances in schedule, lack of parts, machine downtime or when the worker is simply monitoring a machine performing a value-adding job.

This classification could extend further with the inclusion of vandalism, theft and other sources of waste. Koskela (1999) proposes the inclusion of a type of waste that occurs frequently when production operates under ‘sub-optimal conditions’. Congestion of a workstation in small places, work out-of-sequence and excessive stops in the flow are examples of these conditions that lead to production having sub-optimal performance (Koskela, 1999). Formoso et al. (1999) adds that it is possible to find waste due to ‘substitution’. This waste happens when, for instance, there is a monetary loss caused by the substitution of a material by a more expensive one or when the execution of a simple task uses over qualified workers.

### **The Social-Ethical Dimension of Sustainable Manufacturing**

The notion of “social responsibility” of construction is not a new theme in the American continent recently it became a clear source of competitive advantage. International organizations, trade unions, human rights lobbyists and regulators have contributed to bring the attention of construction companies to the ethical business behavior. Nowadays, with an ever increasing frequency in this continent construction companies in the continent are coming under scrutiny to prove that their activities are conducted in a way which is socially acceptable to those who may be touched by it (Santos and Amadigi, 2008).

In order to achieve a better social performance it is already known the principles that indicate a more sustainable production. Vezzoli (2010) proposes the following principles on product-service systems that the authors of the present paper believe are also valid to production systems: employment/working conditions, equity and justice in relation to stakeholders, empower/valorize local resources and, finally, enable responsible/sustainable consumption. Some of these principles are already fully regulated (although not fully complying) and are implemented by coercion and law enforcement. Safety issues and the employment of handicapped personnel are examples of areas where legislation has contributed to production have a better performance on the social dimension of sustainability. The contribution of production to equity and justice in relation to stakeholders and the improvement of social cohesion are, perhaps, the principles that so far were not so much on the core agenda of production managers. Normally, production managers in construction overlook injustices that occur throughout the supply chain regarding economical and social equity. Also, they often overlook the impact of production on promoting social cohesion which in practice means stimulate a higher level of tolerance among people with different ages, religions, culture, gender, etc.

Corporate Social Responsibility (CSR) is a key driver for private sector companies seeking to embrace sustainability in their business. CSR is the recognition by companies that there are benefits to integrating socially responsible behavior into their core values. Its key principles relate to:

- ✓ Integrity;
- ✓ Transparency;
- ✓ Responsiveness;

✓ Fairness and diversity; (WRAP, 2010).

The design of products and components used in construction can play an important role on enabling better social responsibility not only within construction companies but throughout the entire construction supply chain. For instance, it can enable more equity, allowing a fair distribution of resources at the local level or increase social cohesion by respecting fundamental rights and cultural diversity, helping to combat discrimination in all its forms (Santos and Amadigi, 2008).

### **The Economical Dimension of Sustainable Manufacturing**

According with SMC (SMC, 2010) products and processes will require significant changes in order to qualify as sustainable. Investing in sustainability will provide great opportunities for growth, competitiveness and innovation to manufacturing companies. Formal definitions for “sustainable manufacturing” continue to evolve

For sustainable production must take into account the economic dimension. In it we highlight the following items: market position/competitiveness, profitability/added value for companies, added value for costumers, long term business development/risk, partnership/cooperation, macro-economic effect.

Economic sustainability, framed in the context of sustainable development is a set of measures and policies aimed at incorporating concerns and environmental and social concepts. Traditional concepts of economic gains are added as factors to take into account the environmental parameters and socio-economic, thus creating an interconnection between the various sectors. Thus profit is measured in part financial, environmental and social. The tool of Corporate Social Responsibility (CSR) plays a key role in this context; the construction industry is the sector that employs more than representing a promising field. There is a clear awareness of the growing construction industry in South America for new means of CRS. It has evolved from a perspective of more complex approaches to philanthropy CRS, aligning more closely with the competitive strategies of companies. Two social issues are addressed as primordial: the need to reduce the housing deficit in the country and improving the employability of low income families. The experiences observed in Latin America show that altruistic and utilitarian motivations can and should coexist and intermingle in practice when construction companies try to approach the needs and aspirations of the community (Santos and Amadigi, 2008). This maximizes the correct use of raw materials and human resources. In the economic dimension as some items are highlighted for example: requirements of customers among manufacturers that have a sustainable production. This factor triggers an increase profit and competitive advantage.

According to Michael Porter industries must follow five points to highlight the economic question, namely: the number of competitors and their rivalry at one point, the entry of new competitors, the bargaining power of customers, the bargaining power of suppliers, and the emergence of substitute products. For him to excel beyond those points where the industry should minimize their fixed costs, either through partnerships with other companies or creating strategies to optimize their equipment.

## **RESEARCH METHOD**

The analysis intentionally focuses on a Brazilian prefabricated producer as a case study. From data collected through a questionnaire, direct observation and a field analysis, it was possible to diagnose the current situation of the production system aimed at the construction site. From the data collected and using the system called

MEPSS - Methodology for Product Service Systems (PSS) was possible to raise the company's sustainability parameters and diagnose where possible changes could be implemented in order to obtain a more sustainable production system. The analysis is a qualitative and strategic, not characterized as a quantitative study.

### **MEPSS – Methodology for Production Service Systems**

MEPSS it's a Successful PSS innovation that asks for a strategy that focuses on designing and selling an interconnected system of products and services. It's an innovation methodology and tools assist the organization in creating new product-service offerings. All innovative organizations - regardless of their size and market sector, can use the MEPSS methodology. The MEPSS project bring together methodologies in various fields of expertise that are needed to cover the various aspects to take into account developing, implementing and monitoring product service systems. The tool phase model supports decision making - bringing the right PSS ideas to commercialization – and thus can open up huge new market opportunities.

Dominant fields of expertise that were developed in MEPSS, include:

- ✓ Design and implementation related aspects of PSS;
- ✓ Assessment of the impacts of PSS innovations on the dimensions People, Planet, Profit (e.g. through Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) or new approaches);
- ✓ Success and failure factors in the development and implementation of PSS.

The objective of this tool is to orientate the design process towards sustainable PSS solutions, setting sustainability priorities (using checklist), using sustainable design orienting guidelines (using Idea Tables) and checking and visualizing (through proper radar diagrams) the improvements in relation to an existing reference system and its sustainability priorities (SDO-MEPSS, 2010).

## **RESULTS & ANALYSIS**

### **Charaterization of Production System**

The building industry where was developed the case study it's a construction company specialist in prefabricated elements, located in city of Curitiba, since 1974 and it's one of the main industries of prefabricated in the State of Paraná. A clear advantage of company is its pioneerism, being one of the two largest companies of prefabricated of the State of Paraná, which also granted the company a position in the local market on the business of prefabricated elements. The prefabricated company has an area of 158,000 square meters, producing pieces of concrete prefabricated elements, acting in the areas of sanitation, energy, transport, mining, buildings and correctional facilities and prisons

The production system of the company has some advantages, among others, quality control process, speed of execution, cleaning and optimization of the construction site. According to field evaluation, there is no product stock and production is done according to the demand.

The company began its first steps in implementing Management Systems in 1997. In 1998 obtained the first Certification of your Quality Management by the German Association for Certification of Management Systems. In 2004, the company started implementing Environmental Management System, and defined the Waste Management Program, the procedure for the Evaluation of Environmental Aspects and Impacts, training of the fire brigade among other actions. In 2005, adopted the Integrated Management Policy, in order to deploy its Integrated Management System

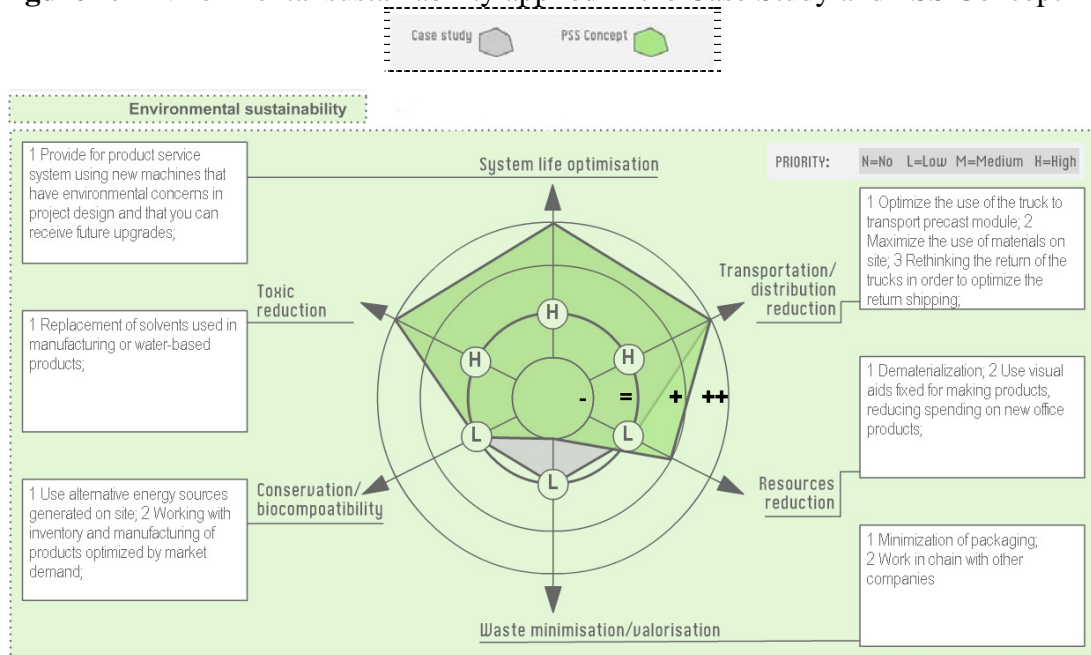


by integrating social responsibility policies. Currently, due to high demand of residential houses in Brazil by the Government program "Minha Casa Minha Vida," there is an interest of the company to apply existing technology in prefabricated housing aimed at the implementation of low-income population.

The spiders diagrams below shows a correlation of the three dimensions of sustainability evaluated in the company.

### Evaluation Environmental Dimension

**Figure 1.** Environmental sustainability applied in the Case Study and PSS Concept

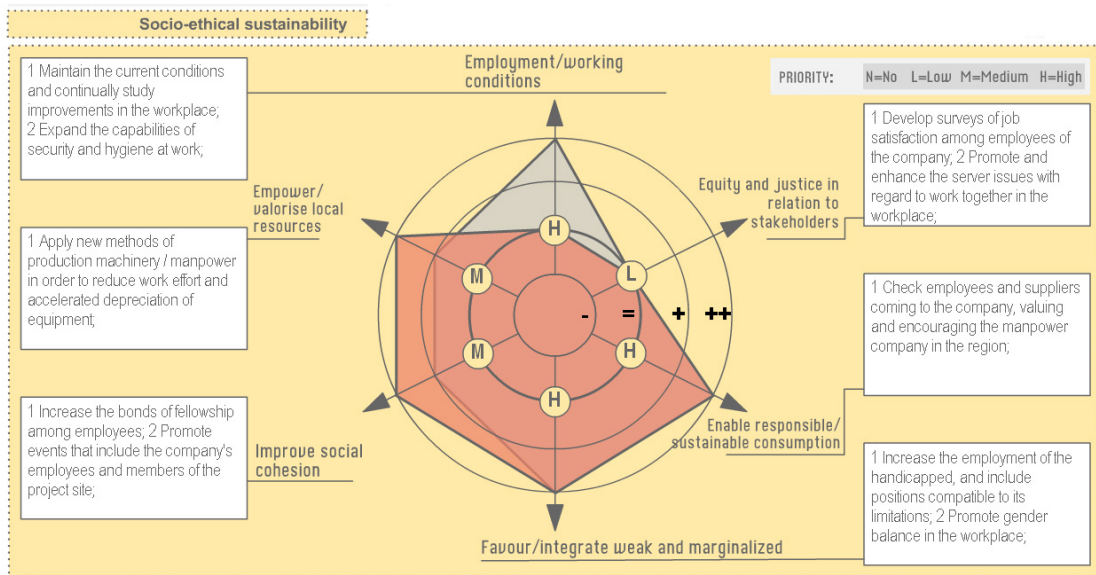


According to the diagram analysis of the environmental dimension in the current system of production of all the principles discussed three main focus points to a significant improvement in the company, the transportation / distribution reduction, system optimization and life in toxic reduction. There heavy use of transport in the delivery and distribution of products which means more spending on fossil fuel. The machinery for production has a short life cycle and the use of solvents in the repair and maintenance of equipment are toxic. All this translates into a negative impact on the environment.

### Evaluation Social-Ethical Dimension

**Figure 2.** Social-ethical sustainability applied in the Case Study and PSS Concept

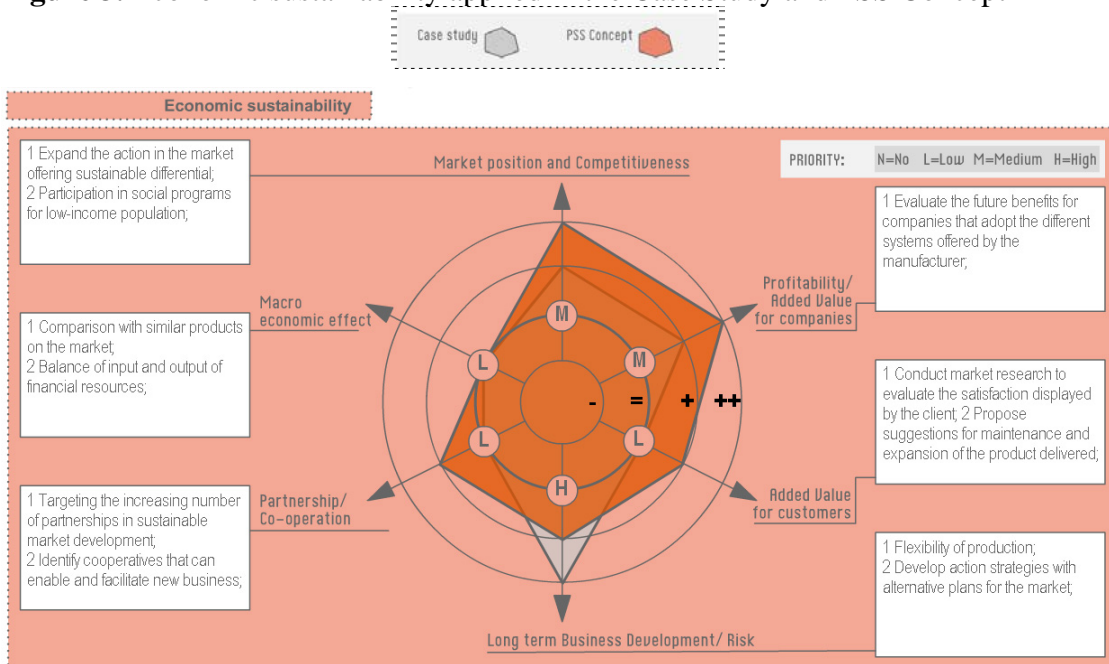




In this case, Favour / integrate weak and marginalized, Enable Responsible / sustainable consumption and Improve Social Cohesion are the main focus of this analysis. The imbalance in gender and disability workforce as the production of manufactures shows are quite significant. There is a need for the company contributing to the consciousness of workers and employees of social responsibility for sustainable consumption and production.

### Evaluation Economical Dimension

**Figure 3.** Economic sustainability applied in the Case Study and PSS Concept



In the economic dimension requires a majority stake in the investment of a more sustainable market position, pointing at the main focus, Market position and Competitiveness, Profitability / Added value for companies, principles that are highlighted in this analysis.

## CONCLUSION

Based on the results of case study applied in PSS using instruments adapted from the design industry, we can see that it can not fully meet the three basic dimensions of sustainability, economic, social and environment. However, this study may lead to a new opportunity to gain additional improvements for the tools to manage the company to create products without pollution, saving energy, reducing natural resources and affordable to all members of the product work.

The PSS can provide useful concepts and promising to take the project in a sustainable direction, but the participants in the cycle can not only operate on the set of separate way, everyone involved in the system must achieve an integrated solution not only meet the desires of customers (UNEP, 2010).

Programs such as "Minha Casa Minha Vida" tend to raise the sustainable market in Brazil, helping low-income together with the federal government. Seeking to expand this focus to medium-term recovery projects with sustainable planning in conjunction with the program should be more careful in the future, increasing demand in the approval of projects accepted standards for housing.

With the new government of Brazil planned to start in 2011 and continued Acceleration Plan (PAC), the goals of sustainable country are aimed mainly at reducing social inequalities, rational stimulation of entrepreneurship and encourage the production of renewable energies clean sources, prioritizing and ensuring the environmental protection criteria (BRASIL, 2010).

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