



Green factory as a factor of sustainability: the case of GM engine plant in Joinvile - SC

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Abstract

The new engine plant by General Motors (GM) in Joinville-SC, inaugurated on February 27th 2013, incorporates the most advanced automotive technology processes and broad compliance with environmental standards and energy efficiency. The initiatives implemented in this industrial plant include processes with 100% of recycled industrial waste (landfill free) and pioneer systems in energy efficiency and environmental protection, qualifying the plant to obtain the global certification of Leadership in Energy and Environmental Design (LEED). This industrial project reveals the strategic importance of the region and of Brazil in the growth of GM in the world, becoming a reference for studies and project evaluations of "green" factories in the automotive sector. The present study performs an exploratory research based on scientific publications, assessing the direct and indirect impacts on the business outcome, resulting from implementation of industrial service-oriented sustainability of its operations, referred to in this article as "Green Factory". We concluded that the adopted technologies focused on sustainability, study and development, represent a new step for the design of new plants and future expansions of the company in the region, combining

low operating cost, low environmental impact and conservation of natural resources.

Keywords: Environmental management. Green factory. Photovoltaics. Reverse Osmosis. Wastewater Treatment.

Introduction

Due to population growth and stimulation to consumption, the environment suffers severe degradations, since the world consumption is above the carrying capacity of the planet Earth. Therefore, humanity threatens to deplete natural sources at a speed that exceeds the reconstruction capacity (GOLEMAN, 2009).

Many studies have proposed to discuss environmental and sustainability issues in companies, seeking to explore their impact on the dynamics of regional economy, e.g. Vasconcelos and Teixeira (2000), Marcus and Fremeth (2009), Jabbour, Teixeira, Jabbour and Freitas (2012). These authors assert that environmental management has positive effects on the operating performance of the companies, since it tends to maximize the productivity of inputs, to reduce production costs and to generate maximum use of organizational resources. None of them directly conducted an evaluation of industrial units, especially the automotive industry, focused on operational and strategic results obtained through the implementation of "green" factory as a factor of sustainability. For this reason, the hereby study will cover a gap of the projects of "green" factories, presenting the factor of sustainability linked to operational performance and, consequently, to strategic business results.

In current publications and scientific papers surveyed, a debate about green buildings and business competitiveness can be detected through wider conceptual, theoretical and empirical approaches, built by several national and international authors. However, there is little empirical evidence of the effects of environmental management practices on operational and strategic performance of factories established in Brazil. This article explores the theoretical and empirical gap on the influences of environmental management in the performance of Brazilian factories considered "green" and sustainable, focusing on the automotive sector, which according to Womack and Jones (2004) is one of the most suitable ones for the analysis of emerging organizational trends.

The topic of "green" factory, discussed in this study, performs an exploratory and bibliographic investigation by using articles and scientific studies to identify the influence and consequences of this project on the factor of sustainability. The motivation for the development of this study arises from the large current academic and business interest in the adoption of principles and practices of sustainability in buildings and in the uniqueness of the implementing of these actions in factory projects, with the assessment of strategic business management.

The choice for this theme occurred as a result of the inauguration of the new engine plant of General Motors (GM) in Joinville (SC), on February 27th 2013, considered one of the most sustainable industrial units in the world, representing a landmark and a reference in factory projects of automotive sector related to sustainability and energy efficiency factors. With an investment of approximately R\$350 million, this unit produces engines and aluminum cylinder heads, with installed capacity of 120,000 units of

engines and 200.000 cylinder heads per year, destined for GM's factories in Gravataí (RS) and Rosario (Argentina). This new industrial unit occupies a total area of 500,000 m², with approximately 30,000 m² used in the installations of the factory and its auxiliary facilities, including courtyards and parking areas. About 200,000m² has been reserved for environmental preservation. The project and the construction were conducted according to the most advanced sustainability principles, aligned with the global policy of environmental preservation adopted by GM, with all the conditions accompanied by a sustainability committee, created by the company in 2011.

The execution of the applied research in sustainable implementations in manufacturing industrial buildings is justified by the scope and variety of applied environmental alternatives and positive impacts in the production of vehicles and their aggregates. This article presents a comprehensive and viable proposal of sustainable alternatives applied in the industry, providing a discussion about the viability of the adoption of sustainable measures in industrial environments and the use of advanced technology.

Given the above explanation, the purpose of this article is to describe the case of green GM engine plant in Joinville (SC) in a context of growing importance of sustainable industrial buildings in the field of sustainability.

Literature review Sustainability

The events of the twentieth century were important for professionals from different areas to seek alternatives to improve the quality of life and the protection of natural resources. The report *Limits to Growth*, published in 1972, already had considerable estimates on consumption of non-renewable natural resources and the increasing demand in a few decades, leading to the depletion of these resources. This document was important to draw the attention to the impacts of resource exploitation and the degradation of the environment, which attracted the global ecological conscience. Several specific laws came into force in 1980, intending to control the creation of new industries and to establish requirements of emissions from existing industries. The first use of the term sustainability in 1980 qualified the development.

According to Zylbersztajn (2010), the concept of corporate sustainability entails a new model of business management, which in the decision-making process considers the environmental and social dimensions, besides the economic and financial ones. Moura (2006) states that while evaluating environmental costs, companies conduct evaluation of investment and expenditures in the process of administration. They are even motivated to invest in these areas, such as the deployment of changes in processes, acquisition of new cleaner technologies and even in the implementation of an Environmental Management System, and for this they need to assess three aspects.

These aspects can be defined as: specialists in the field of Environmental Management, which will act as link members with other areas of the company; the financial area, which provides resources and assesses the profitability and return of the investment, and the accounting department, which provides guidance for analysis and decision. "Most of the companies do not know their environmental costs. However, these

costs exist and are often diffused, masked by other management costs of the company "(MOURA, 2006, p. 68)¹. In evaluating the less visible costs, it is necessary to take into account the total cost attached to that particular activity, in other words, the cost along the product life cycle.

Confirming the relevance of this thought, Coltro (2007) emphasizes the applicability of the Life Cycle Assessment (LCA), an important tool in the management and preservation of natural resources; identification of critical points of a particular process/product; optimization of product systems; development of new services and products, and optimization of mechanical and/or energy recycling. The author considers LCA an important methodology, since it clearly treats complex environmental issues, generating numbers that enable decisions to be made on objective bases. The LCA is the basis for managing the life cycle of the product as a whole, and optimizes the interaction between the project, the production, and the activities of the product life cycle.

The strategy of social and environmental management of an organization consists in addition of an environmental variable throughout the whole management process of planning, organizing, directing and controlling, using the functions that compose this management process, as well as the interactions that may occur in the ecosystem of the market in order to achieve their goals and objectives in the most sustainable way possible (NASCIMENTO, 2008).

According to Dias (2009) the competitiveness of companies is related to the amalgamation of some important factors that are interrelated and mutually dependent: costs, quality of products and services, level of quality control, human resources, technology and capacity of innovation. Over the years, environmental management has gained a prominent position in terms of competitiveness due to the benefits achieved in the production process as a whole and, in particular, to some factors that are intensified. It is possible to observe the main competitive advantages of environmental management, highlighted below:

- The compliance with the required standards resulting in improved environmental performance of a company, creating the possibility of more publicity in an even more demanding market in ecological terms, improving the company image/product with the customers and the community;
- The design of the product; following environmental requirements, this possibility becomes more flexible in terms of installation and operation, with lower cost and longer life;
- Reduction in consumption of energy resources succeeds in an improvement of the environmental management and demonstrates the decrease in the production costs;
- When the amount of material used per product is minimized, there is the reduction of costs of raw material and the consumption of resources;
- When there is a use of renewable materials, less energy is spent by the facility of recycling and the improvement of the company's image;

¹ (my translation)

- With the development of production techniques, the company is more likely to innovate, reducing steps of the production process, accelerating the time of the product delivery and minimizing the environmental impact of the process;

- By improving the use of space in transportation, it is possible to reduce expenses with the decrease of fuel consumption, which consequently decreases the amount of gases in the environment.

When dealing with the competitiveness of companies, there are two environmental variables that are relevant: environmental management processes and products. In this context, arises the Cleaner Production (CP), a methodology for minimization of waste, a concept developed by the United Nations Environment Programme (UNEP, 1990). It proposes a preventative approach to environmental management, through production with minimal impact, within the existing technological and economic limits, without opposing the concept of growth, and considering waste products with negative economic value (GASI; FERREIRA, 2006).

The constant application of strategies and techniques that integrate processes, products and services, aims to increase efficiency in the use of raw materials, water and energy, in an effort to eliminate or reduce waste. This preventive approach not only benefits the environment, but also the companies' own organizational finances, since it brings cost reduction and increased competitiveness.

The Brazilian Business Council uses another widely disseminated concept of eco-efficiency proposed in Sweden for Sustainable Development (CEBDS, 1992). Eco-efficiency can be achieved through provision of goods and services at competitive prices that can satisfy human needs and bring quality of life, while it gradually reduces environmental impacts and the consumption of resources throughout the life cycle to a level, at least, equivalent to the estimated capacity for sustaining the Earth.

Frame of the automotive industrial unit

The last decades of the twentieth century were marked by geographical reconfiguration of the global scale production which is a reflection of the possibility of expanding the productive structure associated with the phenomenon of relocation of new investments. The new base technologies of microelectronics and automation of production processes accomplished a dual role in this process. In certain way, they allowed more flexibility in the location choice for deployment of the production unit, encouraging the spatial redistribution of productive platforms in different places, especially at the international and global level.

On the other hand, they potentiated the internal and external restructuring of the production, from the availability of a standard of technical solutions to problems in production order, by using as a base the integrated and flexible automation of production activities and the development of productive interfirm arrangements, demanding a proximity of industrial plants between users and providers (SALERNO et al, 2001; LUNG, 2000; BOYER; FREYSSENET, 2000).

There is the emergence of an increasingly fiercely competitive environment, with intense negotiations between governments and large corporations, aiming to attract factories and productive industrial units. The automotive industry is one of the

segments of the world economy with the biggest transformation of localization strategies, reflecting changes in patterns of production organization and competition.

From the viewpoint of macro location, there is a tendency to distribute productive platforms of the automotive industry in areas that would have hardly been contemplated for this type of investment before. On the other hand, from the standpoint of its internal organization, the tendency goes towards the major approaches of industrial plants, encouraging the establishment of arrays and networks of systems, locally integrated (FERREIRA; LEMOS, 2002; VASCONCELOS; TEIXEIRA, 2000; SALERNO et al, 2001; LUNG, 2000).

The process of relocation of the Brazilian automotive industry has taken place in the last twenty years and coincides with the recovery of its growth capacity, against the background of increasing pressure of the competition on a global scale. This required from the automakers a significant cost reduction, rationalization of activities and, currently, the incorporation of technological innovations, focused on the economy of energy of consumption and on the safety of manufactured vehicles.

In addition, the establishment of the automotive system in the country encouraged the regeneration of the segment; on the one hand, the installed automakers expanded and restructured their productive capacity, seeking the modernization of production platforms; on the other hand, we could observe the entry of new manufacturers into the market, participating with low production. The result was the intensification in automotive production and innovation of factories and productive units located in Brazil.

Sustainable building industry and the Green Factory

According to Correia (2008), industrial building, by owning the process as a determinant factor, needs to adapt to different routines and tasks carried out in its interior, for the incorporation of aspects by the industry such as: process optimization; economy in the use and maintenance of the building; flexibility of these facilities, providing comfort, health and safety for its users; pointing out aspects that would help in the recycling process. In other words, incorporate sustainability issues in the process of the project.

In today's business environment, to study an industrial project, apart from knowing specific processes, it requires understanding the industrial situation in the country where it is located, the tradition of the sector and its technological development. It is important to consider the concepts of the projects denominated sustainable and, consequently, to provide conditions for the compliance with the demands of the process and the habitability of the spaces.

The strategies implemented in sustainable industrial buildings, known as green factories, consist in the adoption of energy efficiency practices and industrial eco-efficiency; e.g. the efficient use of water, sewerage, industrial supplies and utilities; rationalized and optimized lighting systems, climatization, refrigeration and effective management practices of industrial waste.

Photovoltaic energy

Photovoltaic energy is a viable alternative to complement electricity generation provided by an energy company. It can be used everywhere, by generating electricity at the point of consumption itself, without the need of energy transmission through lines and networks. This variety of energy can be used anywhere in the factory, producing clean and renewable electricity from the sunlight.

Direct conversion of solar energy into electrical energy involves transfer of photons of the incident radiation to the electrons of the atomic structure of the material. In semiconductor materials, under the effect of light radiation, the energy of the incident photons is directly transferred to the electronic system of the material, which can excite electrons from the valence band to the conduction band², giving rise to the creation of electron pairs (absorption). To obtain an electric current, a separation structure of charge carriers photo-generated by the action of the internal electric field is created, before recombining. It immediately follows the extraction of charges for the use in continuous current. This physical phenomenon is called the photovoltaic effect (RIBEIRO, 1999).

Solar heating

Solar heating consists in using the sun's thermal energy to heat water, used for the purposes of personal, commercial and industrial processes. It is interesting since it is a clean, abundant and free energy source. Water heating using solar collectors with photovoltaic cells has represented one of the most viable residential and industrial use applications, but is limited by the high costs of collector systems and technical viability of storing and maintaining stored water heated through this system, requiring the use of hybrid heating systems with electricity and liquefied petroleum gas (LPG) or natural gas (NG) (RIBEIRO, 1999).

Wetlands-type systems for effluents treatment and wastewater

The term Wetlands has been used in the control of water pollution since the mid-1970s, especially in European countries - Germany, Austria, France, England, but also in the United States of America, starting to occupy space in technical and scientific literature in the 1980s. The term is widely disseminated in specialized journals, electronic websites and in scientific meetings around the world.

The 1st Brazilian Symposium on Application of Constructed Wetlands in Wastewater Treatment in Brazil was held in the city of Florianopolis through the Federal University of Santa Catarina (UFSC) from May 9th to 11th, 2013. Currently, different research groups from several universities in Brazil are applying Wetlands systems

² The valence band in solids is the highest of electronic energy intervals (or bands) in which its electrons are present at a temperature of absolute zero (-273.15 ° C). The conduction band is the interval of electronic energy (above the valence band) which is necessary to liberate an electron from its connection to an individual atom in order to allow its free movement along the atomic structure of the material (ELETRONUCLEAR, 2001).

built under different settings and arrangements in the control of water pollution, especially for the treatment of wastewater. It is also important to mention the engineering companies, which are applying these systems in real scale for the treatment of sewage, industrial effluents and percolates in landfills in different regions of the country.

The construction of wetlands is a low cost alternative for the treatment of industrial wastewater. The treatment occurs by interaction of microorganisms, vegetation and substratum, comprising physical, chemical and biological processes, including sedimentation, filtration, precipitation, chemical adsorption, microbial activity and processes of sorption and liberation of components by vegetation.

One of the alternatives currently implemented is the garden filters or planted filters, with macrophytes of horizontal subsurface flow (HSF), used in residential, commercial and industrial environments, with low operating costs and good treatment efficiency. The HSF works passively without the need of pumping, with the gravity force in the sewer. It flows slowly through the filter device, where it undergoes several processes of physical and biochemical order (PHILIPPI; SEZERINO, 2004).

Reverse Osmosis

Reverse osmosis is a separation process in which a solvent is separated from a solute, of low molecular weight, by a membrane permeable to the solvent and impermeable to the solute. This phenomenon occurs when a lot of pressure is applied on this aqueous environment, contradicting the natural flow of osmosis. Due to this fact, the process is called reverse osmosis. In this process, membranes retain particles whose diameter ranges from 1 to 10 Å. The particles retained are low molecular weight solutes, such as salts or simple organic molecules.

The osmotic pressure of the solutions is proportional to the solute concentration. For the reasonable production of permeate, the hydrostatic pressure difference through the membrane must be high - for water it ranges from 2 to 100 atm. Among the main applications and uses of reverse osmosis, always related with the separation of ions of the materials, we can highlight the desalination of sea water; watering with the removal of accumulated salts; supply of pure water to feed industrial boilers; wastewater recovery in factories, and others (CRHISTOPHER, 2004).

Methodological aspects

This is exploratory research, seeking to identify technologies for the protection of the environment, associated with a case study with data analysis, implemented by the company object of this study. The present study aimed to describe the characteristics of this plant and the establishment of environmental adjustments in its physical structure and processes. It required the use of standardized techniques of data collection: form and systemic observation. The case study involves the profound and exhaustive study of one or a few objects, in order to allow their extensive and detailed knowledge (GIL, 2009). This study also included the analysis and examination of records, observation of events and interviews.

According to Manzini (2004) there are three types of interviews: structured, semi-structured and unstructured. In this case, we chose the semi-structured interview, applied to the directors of the departments of manufacturing, chemical industrial process and engineering of industrial utilities. As an instrument for data collection, the observation provided important information, which has corroborated in documents and speeches analyzed in the present article and will be used for further research.

The case of engine plant of GM in Joinville (SC)

General Motors of Brazil inaugurated sustainable factory in Joinville (SC) on February 27th, 2013. The industrial line produces engines and aluminum cylinder heads. The installed capacity of 120,000 units of engines and 200,000 cylinder heads per year is destined for GM's Gravataí (RS) and Rosario (Argentina) factories. The new plant is the first to implement a group of pioneering systems in the area of energy efficiency and environmental protection, especially the photovoltaic energy – generated from sunlight, recycling of industrial water by reverse osmosis and an unprecedented treatment of effluents and sewages through garden filters.

The initiatives, which turn it into a sustainable plant, include processes that make it one of the first in Brazil to have 100% of industrial waste recycled (landfill free). Through the "Zero Landfill" program, all the residues from the production process will be reused, recycled or co-processed. The pioneering systems in the areas of energy efficiency and environmental protection accredited the GM plant in Joinville the global certification of Leadership in Energy and Environmental Design (LEED).

In Brazil LEED is represented by the Green Building Council Brazil (Brazil GBC), related to the United States Green Building Council (U.S. GBC), the most important global organization in evaluation of sustainable buildings, in terms of energy efficiency and environmental protection.

The concept of sustainability is historically connected with the global performance of General Motors. Recently, the premises of sustainable development gained even more importance in the operational process of the company, from the creation to the commercialization of vehicles. When taking decisions, the words consensus is always pursued, to ensure a balance between economic factors and consequently ensure business continuity, environmental, and social aspects, in a wide-ranging view and in the long-term.

Corporate responsibility characterizes the operations and relationship with customers, business partners and members of the communities surrounding the GM units in Brazil, among other public priorities. Such positioning can be expressed in the development of standards and in all production processes of the company.

It is also part of the daily search for solutions, in fact, to achieve a reduction of environmental impacts and consumption of natural resources, be it in terms of lower consumption of water and energy, reduction of residues or the development of products that add new technologies and reduce air emissions, besides using components exempted from elements that are harmful to the environment.

The strategy adopted for the construction of this green plant comes from the deployment of corporate strategies in the short and medium term, focused on sustainabil-

ity as part of the DNA of the global enterprise. The plant studied adopted energy efficiency and environmental protection systems, considered pioneers in the country in terms of environmental practices in the construction and operation of the plant. This is obtained through using the process of effluent treatment and sewage, with filtering gardens, reusing of water by reverse osmosis system, and recycling and reprocessing 100% of generated industrial waste.

Construction

During the planning of the construction of this factory, several sustainability initiatives were considered in the process of construction, as shown in the following results: over 90% of residues generated in the construction were reused and recycled; more than 20% of the material used in the construction has a local origin; 100% of the wood used in permanent installation of doors and frames is certified, confirming the controlled origin and compliance with laws and international treaties; 100% of the wood composites used in room and bathroom partitions is urea-formaldehyde-free, which contributes to the preservation of the health of users; use of water-based paints with low volatile organic compounds (VOCs), installation and commissioning of the related energy consumption systems, inspected by a specialized company, ensuring that all facilities are in accordance with the executive project.

For the land management and work execution, a series of environmental control criteria were adopted, minimizing the interference to the environment and to the development in the region, such as: protection of the hillsides, to prevent erosion and entrainment of sediments, monitoring of the surface water resources, appropriate packaging of chemical residues and products, drainage system on the land, newsletters in the work for environmental education, use of rainwater, use of materials with recycled content, use of certified wood, among others.

Photovoltaic energy for lighting

For the studied factory, we chose kits of photovoltaic cells with an installed capacity of 300 kWp³, 1,280 photovoltaic modules were installed in an area of 2.115m², ensuring an annual generation of 365 MWh. This is equivalent to approximately 3% of the annual consumption of the plant, avoiding the generation of 10.5 tons of CO²/year. This energy production is sufficient to feed the administrative areas and the lighting of the plant.

³ Watt peak (Wp) is a measure of energy power, normally associated with photovoltaic cells. The units used are Wp or kWp MWp, where Wp is the measured power from a given photovoltaic system that runs on direct current, when this system is irradiated by a light that simulates sunlight with a power of 1000 W, at a temperature of 25 ° C. (ELETRONUCLEAR, 2001).

Solar Water Heaters

The solar heating system of Joinville provides 15,000 liters per day of hot water for 750 people. This system will save 8,800 m³ per year of natural gas, avoiding the generation of 17.6 tons of CO²/year.

Energy efficiency - Other initiatives

Some initiatives have been adopted to optimize the energy performance of the plant, such as: high-efficiency lamps (LED), natural lighting, high-efficiency climatization system – coefficient of performance above the industry standard, verification in all the systems of energy and if what was installed attends to what was designed and achieves the goal of 10% reduction in energy consumption of the plant.

In addition to these initiatives, a zipped metal tile was used for roofing, slab of concrete and mineral liner; concrete block was adopted for the frontage; Dry-Wall insulated with glass wool fiber; the internal floor was made of reinforced concrete, ceramic coating, vinyl flooring and zenithal openings of the translucent tiles for the use of natural lighting.

Sewage treatment through Filtering Gardens - Wetland

The Filtering Garden installed - Wetland - is considered a highly sustainable treatment process of effluents, because it uses zero chemicals, has low consumption power, has a removal efficiency of 90% of pollutants, and reduces solid waste generation. In the Effluent Treatment Station (ETS), 3500 m² of the factory area was used. The landscaping was integrated into the environment, with the use of vegetation adapted to the location. With this technology, the process of highly sustainable treatment resulted in a saving of electrical energy, if compared to a conventional installation of 124 MWh / year, preventing generation of 3.6 tons CO²/year, beside the cost of implementation, 40% smaller than in a conventional installation of the same size.

Recycling of Water by Reverse Osmosis Process

Produces excellent quality water, superior to the water source, which allows unrestricted industrial application, with low salinity, conductivity, and inexistence of microorganisms. This technology will allow the reuse of up to 22,000 m³ of water per year. The adoption of the mentioned technologies is in accordance with the principles directed by the global company, whose actions intend to preserve the environment and ensure sustainability, constantly evaluated in terms of impacts of factories and products on the environment and in the community.

Analysis and discussion

Sustainability in construction is directly related to the reduction of energy, water, and material used in the work and improvement in the environment. Sustainability in plant operation has a relation with energy efficiency of wastewater treatment and sewage, reduction of water consumption and zero-disposal of industrial residues.

Some difficulties were encountered to meet the deadline in the project planning: obtaining government and environmental licenses for the beginning of the work, weather conditions, with heavy rains in the region, 35% of the days impractical for civil works and problems of hiring manpower by the construction company. Faced with the fact that new technologies are not yet implemented by the companies in the region, the project team assumed the risks inherent in the deployment of technology, the use of which was not completely mastered by the project teams and plant operation.

For the success in the development of the project, implementation and operation of these technologies, the difficulties were overcome by the company that could rely on the global project team, who shared their experience with the project team in the region, with a high level of commitment and technical expertise - teamwork was definitely essential.

It is noteworthy that the technologies adopted and directed towards sustainability, the result of constant research, study and development, represent a new step for the conception of new plants and future expansion of the company in the region, adding low operating cost, low environmental impacts, and conservation of natural resources.

For further study, it is recommended to accompany if the results in the operation of the plant are in agreement with the plans and to prevent deterioration over time. It is also worth a future study in expansions and constructions of the company and if the lessons that were learned from this project are being effectually implemented.

Concluding remarks

The purpose of this article was to present an existing case applied in the development-oriented implementation of a green factory as a factor of sustainability. The development of the theme was based on technical and economic viability of sustainable actions and projects, which provided conditions for obtaining feedback and ensured constant savings in operations and maintenance of the GM engine plant in Joinville (SC).

In the first part of the article, practicable measures that could be considered relevant for the application in industrial buildings were identified through studies and applications oriented towards sustainable buildings. According to these studies, four sustainable measures were highlighted: the use of photovoltaic energy in manufacturing operations; solar heating; the Wetlands systems applied in wastewater treatment, and the application of reverse osmosis as a mitigation alternative for contaminations and residues. Associated with these applications, several operational actions were introduced in the factory, which potentiated and enabled the introduction of sustainability in the industrial environment of an automaker.

This article also pursued to break the paradigm that the industrial environment precludes the adoption of sustainable projects and actions due to the intensive use of technology, in addition to the negative impacts caused by the generation of waste scraps, inherent to the production process. The presentation of the green factory is a model to be followed by manufacturers, which beside complying with environmental responsibility also enables measureable and significant savings to reduce the cost of operations and maintenance of the industrial segment.

In conclusion, the viability of a green plant, according to the studied case of GM in Joinville (SC), is based on the commitment between operational teams, the "factory floor", the designers teams, and constructors, who should always consider the reality of the company and the local environmental features, to mitigate impacts and provide the best results for the manufacturing operations of the segment.

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