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Clean Technologies and Environmental Management: A Study on a Small Dairy Industry in Brazil

Luciano Mendes

Federal University ofMatoGrossodoSul (UFMS), Brazil

Abstract Environmental management has become a wild card to the companies, especially small and medium enterprises. Pressures from governments, civil society organizations and the market itself, have been pushing companies to adopt an environmentally friendly approach. Such situations of pressure driving companies to invest in technology called "end of pipe" or "turn key" showing that the adoption of the environmental variable is presented largely as business costs. The objective of this paper was to study how the process was the incorporation of environmental variable on a small dairy industry. Because the situation of low capital investment, especially in micro and small enterprises, alternatives to the adoption of the environmental variable has been the search for clean technologies and eco-efficiency. Therefore, in order to be the case study of a small dairy industry, the theoretical discourses on clean technologies and eco-efficiency, in order to present another alternative is that companies seeking to benefit from environmental attitude that are being driven to adopt. The results show that environmental management in the proposed model for clean technologies and eco-efficiency provided by, among several benefits, generating new revenues from the sale of byproducts previously considered waste. It is therefore concluded that the dairy industry gained numerous benefits, especially the way the project was conducted and it was adopted a proactive stance.

Keywords Clean Technologies; Environmental Management, Small Dairy Industry

1. Introduction

The incorporation of the environmental variable by firms has focused primarily on the adoption of technologies "end of pipe" and then integrated technologies in the production process. This attitude has had high costs due to lack of return on invested capital. As the main cause is the growing pressure from civil society, market and government, with the imposition of strict environmental legislation. Moreover, there is also the value of the high fines imposed on companies that do not meet the legal requirements[1].

On the other hand, if companies use cleaner production technologies, which seek to minimize waste, acting in the production process and managing materials in order to prevent waste, will be holding the technical knowledge of how these activities become less aggressive. With this approach companies reduce investments in expensive technologies and complex treatment of final production, ensuring compliance with environmental legislation, as well as reducing costs by more efficient production process[2-4].

In the current context it is apparent that large corporations are a more advanced stage in terms of environmental management. However, since small and medium enterprises face a number of difficulties in conducting its business, environmental management is generally seen as a secondary action and expensive and that has been driven by the pressure of the organs of control[3,5].

Studies in the dairy industry in Brazil as part of a Project of Environmental Control Technology Research identified that the major technological deficiencies are contained in the small and medium enterprises. It is also important to mention that this segment are the production units with less ability to search for technological solutions needed to integrate the environmental management of its activities. Another major factor that occurs in this segment of the dairy industry, by its very nature, is a great harm to the environment, caused mainly by effluents generated[6].

In an attempt to search for solutions to small and medium-sized companies are making partnerships with public and private institutions in Brazil, Research and Development (R&D) in order to meet their technological deficiencies. This is because these companies do not invest in technology due to high costs of R&D[7].

This paper aims to study the process of incorporating the environmental variable in a small dairy industry. More specifically: to verify the methodology used in each department; understand the impact of actions taken; present the results and finally verify the benefits that small dairy industry study obtained with this method. The next topic of this paper deals

* Corresponding author:
lucianobtos@yahoo.com.br (Luciano Mendes)
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with the theoretical framework that will guide the discussion of results.

2. Clean technologies and eco-efficiency

Waste of raw materials and energy occur through the intense generation of waste and emissions. This conclusion is based on a new business approach that seeks to reconcile environmental protection and competitiveness. The business concern is to respond positively to the imperatives of sustainable development[2,8,9].

The objective in the worship of clean technologies and eco-efficient technologies at the expense of "end of pipe" or "turn key" is to absorb the externalities arising from the development of the industrial system. These investments are no longer reactive technologies ("end of pipe") for preventive care (clean technologies), which reduced costs, increased use of raw materials and improved the efficiency and effectiveness of industrial systems. With the change of attitudes of entrepreneurs is that there was the emergence of methodologies aimed at the implementation of the concepts of widespread discussion on clean technologies[10-12].

There are two types of clean technologies: control and prevention. Clean technologies are Control Stations Wastewater Treatment (WWTP). Clean technologies are established in preventive actions aimed at reducing the use of toxic materials, eliminating waste during manufacturing industries, the reduction of waste generated, among other preventive actions. These clean technologies also include prevention technologies used to produce goods and services that do not destroy the environment. For example: a) recycling paper, cans, among others, 2) use of alternative energies such as wind, solar, biomass and photovoltaic cells, 3) biodegradable products, 4) technologies for reducing and preventing air pollution, the water, soil or noise, or solid waste and visual[2,13,14].

Reduce pollution through the rational use of raw materials, water and energy means a more definitive option environmentally and economically. Reducing waste leads to greater efficiency in productivity and lower investments in solutions to environmental problems. The final products can be cheaper and therefore more competitive. It is not just a matter of money. Pollution on the factory floor creates risk to health and safety of workers. Working with Clean production reduces this risk, increases labour productivity and improve product quality, and also help to strengthen the image of the company in the community and environmental authorities[5,12,13,15].

There are frequent references in the literature on the use of clean technologies similar terminology such as "Cleaner Technology", "Cleaner Production", "Low-Waste Technologies," among others. Even the existing range of terminologies, clean technologies are defined as the continuous application of a strategic economic, environmental and technological integrated processes and products, in order to increase efficiency in the use of raw materials, water and energy through the non-generation, minimization or recycling of waste generated in all productive sectors. Minimize waste and emissions also means increasing the degree of utilization of raw materials and energy used in production (increased efficiency), ensuring a productive process free of waste and emissions[3,4,7].

Faced with this issue on clean technologies the design of Lavoisier that "in nature nothing is created, nothing is lost, everything is transformed" is taken up by companies when they seek to close the sustainable production cycles. While the conventional system of production the question that entrepreneurs did was: what can be done with the existing waste and emissions? In logical reasoning driven by clean technology changes to this question: Where does our waste/ emissions and because ultimately become waste/ emissions?[5,7].

As is visible in Figure 1 (industrial process based on conventional management), despite the investment in Wastewater Treatment Plants (WWTP), although the production system continues to generate air emissions, high power consumption and high amount of solid waste. This means that the productive system of these companies failed to eliminate completely, much less reduce solid waste, liquid and gas generated[7,11].

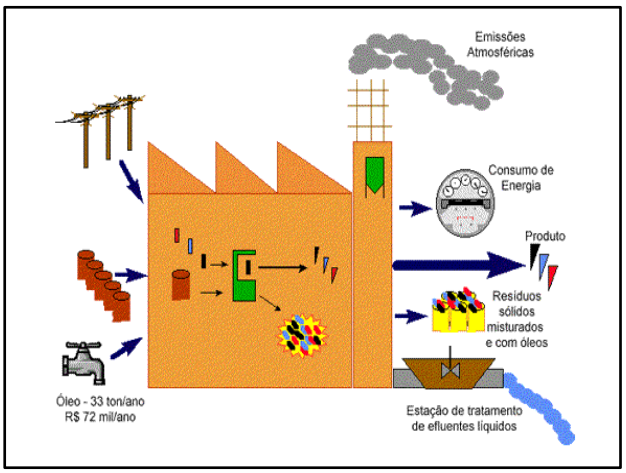

Figure 1. Industrial process of an enterprise based on the conventional management

Figure 2 shows a completely contrary to what is shown in Figure 1. Figure 2 is based on the logic of action that is based on the use of clean technologies, where the focus is to reduce or eliminate the generation of liquid, solids and gases during the production process, increasing efficiency, reducing wastage of raw materials. These attitudes allow preventive increase in the company's profitability by reducing costs of waste[3,7,16].

The methodology of implementation of clean production processes will enable obtaining of lasting solutions to environmental problems. This methodology is based on the identification of options for non-generation of waste produced in these processes. The integration of clean technologies to the environmental management system provides what might be called "eco-efficiency" [5,15].

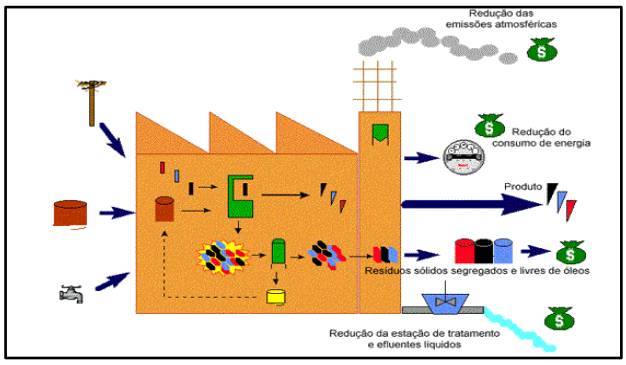

Figure 2. A processing company based in clean production

The eco-efficiency can be considered a form of corporate environmental responsibility, it encourages the company in any industry, size and geographical location to become more competitive, innovative and environmentally responsible. The main objective of eco-efficiency is to make the economy grow qualitatively, not quantitatively. The ranges of eco-efficiency features are basically three types of gains for companies. The first is economic, because the actions that aim to more rational use of raw materials and energy company allow the reduction of waste generated. The second is the environment, due to the decreased volume of waste being dumped in the environment and less consumption of water and energy because they are non-renewable resources[3,7,17].

The third gain is that of environmental marketing company. Environmental responsibility has been an important criterion for the competitive business world, since consumers are increasingly aware of the importance of preserving the planet. The drop in shares of a company can occur quickly when the company concerned any environmental damage. Still, companies can associate their products or services to environmental responsibility, making the products or services within the logic Green[8,17].

Thus, eco-efficiency means combining economic performance and environmental performance to create and promote values with less impact on the environment by: 1) reducing consumption of materials with products and services, 2) reduced consumption of energy products and services and 3) reduced consumption of toxic substances, 4) increased recycling of materials; 5) maximizing the sustainable use of renewable resources, 6) extension of product durability and 7) adding value to goods and services[2,5,15].

3. Method

The research was characterized as a case study. The case study is characterized by intensive analysis of an individual unit (can be a person or a company) through intensive exploration of the characteristics of this unit. This research method is used to understand the aspects of interest to researchers in certain contexts. This type of study, usually qualitative, seeking information that would lead to a comprehensive understanding about a phenomenon specific to individual units. Moreover, the case study can be reconciled with other research tools[18,19].

The company under study is located in the city of Cantagalo, state of Rio de Janeiro, southeastern Brazil. Three young entrepreneurs in the agribusiness sector founded the small dairy industry in 1939. The average daily volume is 31,000 litters of milk. With this volume of litters of milk a small dairy industry produces long-life milk, mozzarella cheese, butter and cream cheese.

The research was conducted at the company from semi-structured interviews with owners and employees. The intent of these interviews was to understand the process of implementation of clean technologies in the various departments. The semi-structured interviews are held when the researchers have only a set of interviews, with questions or topics that cannot be forgotten or overlooked during the research[20].

Before and during the execution of these interviews, it was necessary to make a documentary survey. This survey was intended to obtain numerical data that were generated before and after the implementation of environmental management process through the logic of clean technologies. Despite the documentary surveys show quantitative data generated during the implementation of environmental management system, the intention was to use these data only support and strengthen the actions identified through semi-structured interviews.

The understanding of what is a document goes through two different meanings: as a document file and document while registry. The files include diaries, letters, stories and field notes. The registers include marriage certificates, construction contracts, based on data on investments and business information. This research used the document as a registry because the intention was to collect information about the archived documents of the small dairy industry study on the actions in the implementation of clean technologies[21].

Owners of small dairy industry study issued permission for data to be used in this paper. This is because, given the difference between registers and archives, under certain circumstances researchers may have broad access to certain types of "files" and, conversely, have restricted access to certain types of "registers". In many researches register private, confidential and not available. In this context, the sources of documentary research were: data on investment in the deployment of clean technologies, the cost of water, raw materials, energy and materials wasted, before following the implementation of environmental management system[22].

4. Results and Discussion

The intent of this part of the paper is to present data and information obtained from the research, striving to achieve the proposed objective in the introduction. To this end, the first part will be necessary to present the situation of small dairy industry before deployment of clean technologies with respect to: Generation of waste (4.4.1) and solid waste gen-

eration (4.1.2). After this discussion, in the second half will see the implementation of clean technologies, focusing on the actions taken and results achieved in the industry, focusing on the: Cooling system (4.2.1), Steam Generation System (4.2.2), environmental management and occupational safety (4.2.3) and environmental management and quality control (4.2.4). In the third part will present the programs that were established resulting the shares in clean technologies and the implementation of environmental management system, which were: Program energy and water economy (4.3.1), Program Management of solid waste (4.3 .2) and Program management of liquid noble (4.3.3). Finally, the quarter part of a summary economic and financial (4.4) on investments, the actions taken and results.

4.1. The Generation of Wastewater and Solid Waste before Implementationof Clean Technologies

4.1.1. The Generation of Effluents

The effluents generated in the small dairy industry include: the industrial wastewater, the sewage and rainwater captured. It is estimated that the total volume of waste generated each month should be close to water consumption that is around 1600 m3/month (0.71 m3 of effluents / m3 of milk received). This estimate is due to the fact that the industry did not perform control measures of effluent. In a study conducted in other dairy industry in southern Brazil found the value of the relationship between the flow rate of liquid flow and water consumption typically be between 0.75 and 0.95[6]. The values presented in this study are consistent with the estimated in the case of small dairy industry.

In this estimate, also the volume of serum is generated by:

• in the production of mozzarella cheese is around 5.9 liters / kg of cheese produced, converting approximately 236,000 liters of whey per month (236 m3 per month);

• in the production of cream cheese curd is around 2.5 liters / kg of cream cheese produced by converting it into about 2,500 gallons a month (2.5 m3 per month).

• in the production of butter is around 1.8 liters / kg of butter produced by converting it into 16,200 liters per month (16.2 m3 per month).

Another important finding is that the transport and handling of milk within and outside the small dairy industry is no loss of about 50 liters per day, translating into 1,500 liters of milk per month.

The rinse water resulting from the hygiene operations of the Dairy installations is those that contribute most to the volume of wastewater generated in the company. It was found that hygiene procedures are not documented, generating responses uncertain about the volumes of water, as well as on the volumes and types of chemicals used for cleaning.

4.1.2. Solid Waste Generation

The amount of solid waste generated by small dairy industry is divided into two groups: industrial waste and waste generated in toilets, in the refectories and offices.

The first group of waste can be said to include papers from the offices, food scraps, paper towels, toilet paper, disposable plastic cups and various packaging. Its volume and danger are not significant, being the whole amount for the public collection.

With regard to industrial waste, its composition is as follows:

• ends of the bags originating cheese packaging (average of 120 bags / month);

• packing boxes of butter defective (average 90 cases / month);

• Soot originating from the operation of the boiler (not quantified);

• organic waste generated by pasteurization of the milk (average of 4 kg / month).

It is noteworthy that the first three types of solid waste generated are intended for public collection.

4.2. Actions Taken and Results Obtained

4.2.1. Refrigeration System

In this system where they are stationed ammonia compressors and cooling towers, the actions taken and results are summarized in Table 1.

Table 1. Action Taken e Result Obtained in Refrigeration System.

Actions	Results
Reform of the compressors (return piping, ammonia displays, seals and safety valves)	Increasing the energy efficiency of the cooling system
Signalling	Reducing the risk of accidents
Restricted access areas	
Implementation of maintenance programs	Drastic reduction of corrosion and deposition processes
Implementation of analysis programs and water treatment of cooling tower	Control of microorganisms in cooling water
Partial automation	Reduction in hours / man to operate the system
Proper storage of cylinders of ammonia	Elimination of leakage of ammonia
	Reduction of maintenance cost.

The actions performed in the refrigeration system are in agreement with the discussion on clean technologies, where prevention and standardization of processes are central. Thus, the gains are many, from the prevention of accidents in the workplace to reduction maintenance costs[2,3,16].

4.2.2. Steam Generation System

This system is steam boilers. The actions taken and the results obtained are summarized in Table 2.

This system has the technical standards and regulatory standards established by the Brazilian government for its operation. In addition to these standards of care, although the actions and clean technologies employed earnings as possible: 1) human gains: less risk or danger of accidents at work, 2) environmental gains: the atmosphere less polluting and less waste generated at the end of the process production, 3)

financial gain: less spent on maintenance, problems with the system in general and better use of raw materials used. Such actions, in addition to meeting the technical standards and regulatory allows greater efficiency of the system[10,11,15].

Table 2. Action Taken e Result Obtained in Steam Generation System

Actions	Results
Implementation of a rigid program of maintenance and operation	Reduction of maintenance costs
Preparation of inspection reports	Reduction of unscheduled downtime
Overhaul, painting, replacement of the valve control and security seals	Drastic reduction of the processes of corrosion, fouling and drag.
Renovation of physical facilities	Increasing the life of the whole system
Signalling	Appreciation of the work environment
Restricted access area	Increased security and elimination of accidents at work
Full compliance with the Safety Standards (NB-55) and Regulatory Standard number 13 (Concerning the Boilers and Pressure Vessels) of the Brazilian Association of Technical Standards (BATN)	Compliance with government regulations for steam generation systems
Use of BPF oil best quality	Elimination of leaks BPF oil
Installation of solenoid valve in the engine the refrigeration system	Increasing energy efficiency of the boiler
Installation of collect-soot	Removal of particulate emissions in the atmosphere
	Attention to the demands of the surrounding community
Implementation of a program of analysis and treatment of water supply.	Reuse of water in the system

4.2.3. Environmental Management and Occupational Safety

With it was found in the two previous topics, unauthorized persons focused many of the steps taken to affect a system of environmental management on the organization of the workplace, signage and access restrictions. In accordance with the Standards Regulating health and safety at work in Brazil there is a need to establish an Internal Commission for Accident Prevention (ICAP), formed by the employees themselves. This committee aims to inform, monitor and issue reports on situations of risk of accidents in the workplace.

In the case of small dairy industry was the partnership between the Internal Commission for Accident Prevention and Environmental Management Company, with intent to prevent, improve and create humane working conditions. In order to minimize or eliminate workplace accidents, was adopted preliminary actions such as cleaning activity and permanent organization of the workplace in all sectors, preventive medical examinations, use of uniforms, equipment Individual Prevention (EIP) and maintenance of equipment and facilities. This concern for employees in the workplace has been the focus of actions aimed at deploying clean technologies and eco-efficiency[6,12,17].

4.2.4. Environmental Management and Quality Control

In the small dairy industry was an awareness of officials to the microbiological quality control of products and facilities. Microbiological control is the need to cleanse the areas of production and storage of products. For cleaning the small dairy industry used a lot of water and energy, affecting the generation of waste (water, milk and production inputs). Thus, one of the main actions was focused on water economy can ensure clean and efficient use of limited water supplies.

For this to be effective, employees have been trained to understand the processes of microbiological control of dairy products, learn good manufacturing practices, cleaning practices run more efficient and rational water use, inputs and energy used in cleaning the environment. Given the need to limit the use of water have been installed flow control valves in the cleaning tube, allowing pressure and less expense in the use of water.

The small dairy industry conducted training of laboratory technicians and extensive microbiological diagnosis of health conditions for the actions of microbiological quality control were continuous and long term. Thus, we obtained a greater awareness of employees; economy inputs, water economy, better hygiene in the production area; technical qualification of laboratory analysts.The human factor is essential for the perpetuation of the actions and deployment of clean technologies, ranging from wastewater treatment technologies to small activities to improve and organize the work environment[3,5,6].

4.3. Programs developed in the dairy industry to maintain the environmental management and clean technologies

4.3.1. Water and Energy Savings Program

The small dairy industry have their own water supply (surface mine) and is also supplied by the Water and Sewerage Company of the State of Rio de Janeiro (CEDAE). The high level of wastage of water has led to implementation of a comprehensive economic program based in the following actions:

• implementation VALLEY ECO-EFFICIENCY which is the additional remuneration of employees proportional to economy of water and energy. About 30% of the savings was divided among the employees of the company;

• implementation of employee awareness program, which aimed to pay attention to employees the importance of economy of water and energy;

• implementation of program of repairs and maintenance of the power grid, hydraulic system and equipment, with the intention of eliminating waste problems by system malfunction;

• the small dairy industry wage supplementation granted to all employees by donating monthly food parcels for those actions are maintained in the long term.

With this program, economy water and energy to small dairy industry obtained the following results:

• Increase energy efficiency by 28%, from 0.032 to0.023 kWh per liter of milk;

• zero consumption of water supplied by Water and Sewerage Company of the State of Rio de Janeiro by more than 20 consecutive days;

• total water consumption of only one 32m3/day to capture 45,844 liters of milk / day;

• increased satisfaction of all industry employees with salary supplementation VALLEY ECO-EFFICIENCY and monthly food parcels.

These actions economy of water and energy linked to the benefits generated for the company's employees become strategic to support the deployment of clean technologies and environmental management system. For this reason the program was implemented[11,12,16].

4.3.2. Solid Waste Management Program

After conducting a detailed assessment of solid waste generated, it was necessary to classify them and quantify them. With this, they implemented a program of selective collection of solid waste. The non-recyclable materials were used for the municipal landfill. Waste resulting from cleaning floors and creamers (pieces of dough) and the return of products with expired date were donated to farmers in the region for animal feed. The waste oil GMP, unfit for use in boilers, came to be reused by small dairy industry for the treatment of fence posts. These separation processes, reuse and proper disposal of solid waste generated in these types of dairy industries are essential to sustaining processes of environmental management[11,12].

4.3.3. Nobles Liquid Waste Management Program

In the processing of products of small dairy industry are generated sour (average serum / cheese 2,832,000 liters / year + whey / curd 30,000 liters / year + serum / butter average of 194,400 liters / year) as a result of manufacturing of mozzarella cheese, cream cheese and butter respectively, totalling an average of 3,056,400 liters / year. Moreover these byproducts are considered noble feedstock in the manufacture of beverages and for animal feed.

Because of the limitations of small dairy industry to invest in the installation of a new structure for manufacturing milk products, the owners opted to sell the serum to farmers in the region for use in animal feed. This sale generated approximately $ 6,000.00 per month for the dairy industry. The owners have acquired a tank for storing the 10,000 liters serum. Thus, farmers who needed the serum could remove it in the tank. The results were: increased profitability from the sale of these by-products, increased facilities for the producer to obtain the product.

4.4.Economic-Financial Summary

Investments by small dairy industry during the execution of the project to establish a system of environmental management and clean technology were a total of $ 39,000.00. That investment spending was removed with the installation of Effluent Treatment Plant (WWTP). These investments were made as the execution of each stage of project implementation of environmental management system.

The small dairy industry before the completion of the project environmental management had a daily uptake of 31,230 liters of milk. Upon execution of the project the dairy industry obtained an increase in the uptake daily starting to receive 45,844 liters of milk.

This increase in the quantity of milk should be purchased impacting increased amount of liquid, solid and gaseous, which does not occur. There was a 54% reduction in relative liters of water / liter of milk captured, from 1.73 to 0.80 liters of water / liter of milk. Most important in this case was a 86% reduction of water supplied by Water and Sewerage Company of the State of Rio de Janeiro, Brazil.

The reduction in the amount of electricity used was also very significant. Increased from 0.032 to 0.023 kWh / liter of milk, which represents 28% savings. What is observed is therefore a significant reduction, considering that these results were immediate.

The small dairy industry went from a daily water overall spending of $ 50.00 to $ 34.40, saving $ 17.73. Electric power also had a significant saving from $ 29.10 to $ 20.96, saving R $ 8.18 daily.

With these values can be observed that, in relation to water, small dairy obtained an annual saving of about $ 10,246.20 / year. As for the electricity economy was R $ 3,069.28 / year. These two results ($ 10,246.20 + $ 3,069.28 = $ 13,315.48 / year) combined with revenue from the sale of products ($ 6,000.00 / day * 12 = $ 72,000.00 / year) revenue totalled $ 85,315.48 / year. Adding cats with the implementation of environmental management system ($ 39,000.00) to spend on the purchase of 10,000 liters tank ($ 20,000.00) a small dairy industry got an expense in the amount of $ 59,000.00. With this, we can infer that profit in this case was $ 26,315.48. In addition to the company to meet the Technical Standards Brazilian government, implementing the environmental management system, still allowed a profit at the end of the program, which confirms the discussion on clean technologies[11,15-17].

5. Conclusions

The aim of this paper was to study the process of incorporating the environmental variable in a small dairy industry. This study focused on verifying the methodology used in each department, particularly in departments that generate

more solid waste, liquid or gaseous. The departments were: the area of production of mozzarella cheese, butter and soft cheeses, and the areas where they are steam boilers and cooling system.

The actions performed in the small dairy allowed adaptation to the Regulatory Standards and Technical Standards, as well as positive results in all departments in the environmental management system performed by the clean technology has been deployed. The data presented in the previous part shows that the gains were not only environmental, but gains human, structural, economic and financial. The results confirm that the actions generated in clean technology have long ceased to be seen only as costs, to represent a number of benefits to industries, especially small and micro enterprises.

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