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IMPLEMENTATION OF ISO 50001 – ENERGY MANAGEMENT SYSTEM IN A FACTORY IN THE ELECTRICAL AND ELECTRONICS SECTOR: MULTI-CASE STUDY

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ABSTRACT

We know that a series of factors influence and determine the degree of competitiveness of an organization, especially those that value good environmental, social, and corporate governance practices. Of course, there are other themes for competitiveness to be obtained in all fields; however, the focus on the ESG issue is another indication of how much the theme “sustainability” has gained more and more relevance in the market and consequently in business. In fact, the environmental issue was cited as one of the main points of concern for today's society in the most recent edition of the Global Risks Report, by the World Economic Forum (WEF), which highlighted issues such as extreme weather events, failures in negotiations regarding climate, environmental damage, and loss of biodiversity as major threats. In addition to the environmental aspect, society has also shown itself to be increasingly concerned with social and governance values. Socially, it has become essential to ensure a diverse corporate environment. More transparency and honesty in business began to be valued. Thus, the three pillars of competitiveness are basically focused on: Environmental protection, social responsibility, and economic success (Governance). In order to achieve all pillars, it is necessary to comply with standards established for large leading organizations in the market, to meet standards, laws, and data protection. In this context, norms and rules are presented to companies that aim to maintain compliance with these in order to obtain increasingly required certifications. Within the context discussed above, this work deals specifically with the ISO 50001 Standard - Energy Management System, where a process is described that aims to scientifically record and analyze the events that occur during the processes of monitoring energy consumption by electrical equipment significant energy use (SEU) as part of the standard certification process. During the process, all tools applied to develop the work were used such as: Strategic Planning, PDCA, Swot Matrix, and Hoshin Plan. The need is detailed in the organizational strategic planning and continues to be deployed in the organization. As a final result, the objective is to obtain certification in the standard with the understanding and fulfillment of all the items in question within the planned period. This case study that portrays the certification process of an electronics company in the Energy Efficiency Management System standard is of fundamental importance for bringing results to the organization in terms of reducing energy consumption and impact on the environment, and for improvements arising. The methodology used in the company was based on the energy diagnosis of the organization and using the PDCA method. The objective of the article is also to demonstrate, at the end, the level of knowledge of employees for the development that involves Energy Management after the organization's certification, done through field research.

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INTRODUCTION

This work is based on the process of implementation of ISO 50001 certification (first edition 06.15.2011, valid from 07.15.2011) in an industry of the industrial pole of Manaus, being one of the pioneers to obtain it in the region, using a daily measurement system of equipment to evaluate energy consumption. ISO 50001 is the specific international standard to address Energy Management – requirements for guidance for use. That is, it establishes parameters for the supply, use and consumption of energy in order to help companies use energy more efficiently, through the implementation of an energy management system and other complementary measures. Today, it is more and more frequent the concern of countries to discover ways and alternatives of how to treat forms of energy to reduce impacts on the environment. If all companies mobilized to minimize the impacts of their activities on the environment, there would certainly be improvement and added value that would benefit the entire global population. In this context, environmental issues should be considered as a business strategy, such as the use of environmentally friendly materials and processes, so the production process as a whole becomes strategic (JABBOUR; Santos, 2006). The unfolding of knowledge around energy efficiency requires a preventive way for organizations that intend to have competitiveness in the market, with the emergence of an increasing number of high-tech companies, the increase in the supply of Moderna products and consumers seeking products with excellence and low cost standard, make the dispute in the market between companies becomes a constant due to consumers are increasingly observing companies that degrade less the environment, that take care of natural resources, and that have product excellence and fair price. According to Oliveira *et al* (2005), the search for improvement and the introduction of new peripheral technologies are advanced options that would provide competitive gains in business strategy and energy efficiency.

In the productive and administrative area of the organization, machines and equipment must have a predictive, preventive maintenance plan in order to meet process stops in emergency situations which can be easily resolved or that will have to be better evaluated in any longer interruption. It is of utmost importance and advantageous to maintenance to avoid losses in manufacturing ceasing to have competitiveness in the market due to the impact on several stages of the process, such as in energy consumption, final manufacturing price, product price, and delivery to the customer. A committee is needed to evaluate, measure, and monitor the result of such factors because a machine or equipment operating abnormally will have a higher demand on electricity consumption.

The investment for a certification in a standard such as ISO 50001 entails benefits for organizations as, according to Intebras (2021):

- Better use of existing energy consumption;
- Integration with organizational management;
- Sustainable operation;
- Adaptation to new technologies;
- Systematic reports on energy consumption;
- Internal engagement;
- Credibility and positive image.

Law No. 10.295, of October 17, 2021, which disposes other measures for the national policy of conservation and rational use. As well, Decree No. 4.508, of December 11, 2002, that disposes on the specific regulation defining the minimum levels of energy efficiency of three-phase induction electric motors, squirrel cage rotor, of national or imported manufacture for commercialization or use in Brazil, presents other measures. These laws and decrees establish the maximum levels of specific energy consumption, or minimum energy efficiency, of energy-consuming machines and appliances manufactured and marketed in the country. These standards bring one more reason to purchase machinery and equipment that meet the requirements of the law. According to Hewitt (2002), energy is the ability to perform work. However, the definition of energy is not easy to understand since it is an abstract quantity that is easier to observe when it is being transformed or transferred. It has several forms such as electrical, mechanical, luminous, thermal, chemical, among others. Most daily consumed energy is electrical or chemical. Nunes and Mendes Jr. (2016) emphasize that effective energy management in industry is inserted in a specific context, as it is subject to many factors, such as location, product design, and process choice, which often make it difficult to replicate energy saving solutions from one type of industry to other sectors and/or to different locations (NUNES; MENDES Jr., 2016). There are many barriers to improving energy efficiency in industries. For Sola e Mota (2015), many projects to improve energy efficiency find impediments in organizations, even if they are economically viable. They call the phenomenon the "paradox of efficiency". Actions to improve energy efficiency in organizations encounter impediments that do not appear in investment calculations. Many projects to improve energy efficiency, although economically viable, are not adopted by companies. This phenomenon is known among specialists as *efficiency paradox* or *efficiency gap* and it is a strong evidence of the existence of barriers to the efficient use of energy in organizations (SOLA; MOTA, 2015, P.500). Morais (2015) states that, in industry, an Energy Management System (EMS) "aims to find consumption variables within an industrial facility that can be controlled and optimized, generating indicators and resources that demonstrate efficiency of the factors that directly affect the consumption and end uses of energy". For the author, the lack of an EMS brings losses in relation to opportunities in companies, hinders a systemic vision, the establishment of priorities and the management of actions that can bring greater financial return and greater impact on energy efficiency gains.

LITERATURE REVIEW

Maintenance administration: The challenge of organizations in managing the maintenance area of sites seeking to reduce energy consumption and maintenance of equipment and machines in production processes. An annual planning of the entire structure is necessary in order to always keep everything in good quality. This care is associated with healthy practices for controlling the equipment and machines that are part of the production process. It is very important to monitor maintenance management together with human resources, that is, the professionals working in the company. According to Kardec (2004), in today's globalized economy, the survival of organizations depends on their ability and speed to innovate and make continuous improvements. As a result, organizations have been incessantly seeking new management tools that direct them towards greater competitiveness through the quality and productivity of their products, processes and services. And, for the same author, the current need for agility imposed on organizations demands more and more effectiveness in decision-making by them, and has led to constant organizational mutabilities. Certainly, all this presented dynamic requires, therefore, a greater effectiveness in the operational activities that unfold in the search for Vision: Ensuring availability and the Mission: Providing results (XAVIER, 2005). In order to become more competitive, companies need the basic functions represented by the various departments of their structure to present excellent results in the pursuit of excellence or world-class status (MIRSHAWKA, 1993).

Maintenance Management System

According to Júlio Nascif Xavier (2003), the following classification is considered quite adequate depending on the types of maintenance, being quite updated in relation to the ABNT standard:

- Corrective maintenance is the action to correct failure or lower-than-expected performance. It comes from the word "correct". It can be divided into two phases:

- Unplanned corrective maintenance – failure correction in a random way, that is, the correction of the failure or lower-than-expected performance after the occurrence of the fact. This type of maintenance implies high costs, as it causes production losses and, as a consequence, damage to equipment is greater;
- Planned corrective maintenance – is the correction made due to a predictive, detective monitoring or even by the managerial decision to operate until the failure occurs. "By its very name planned" indicates that everything that is planned tends to get cheaper, safer and faster.
- Preventive maintenance – is the action taken to reduce failures or drops in performance, obeying a planning based on established periods of time. According to Xavier (2003) one of the secrets of a good preventive is determining the time intervals. As in doubt we tend to be more conservative, the intervals are usually shorter than necessary, which imply stops and exchange of unnecessary parts;
- Predictive maintenance – is a set of activities to monitor the variables or parameters that indicate the performance of the equipment, in a systematic way, in order to define the need or not for intervention. According to Xavier (2003) when the intervention, result of predictive monitoring, is carried out, there is a planned corrective maintenance. This type of maintenance is known as CONDITION BASED MAINTENANCE (CBM). This maintenance allows the equipment to operate longer and the intervention takes place based on data and not on assumptions;
- Detective maintenance – is the carried out action in protection or command systems, seeking to detect hidden or not noticeable failures to operation and maintenance personnel. A classic example is the circuit that commands the input of a generator in a hospital. If there is a power outage and the circuit is faulty, the generator does not start. As the use of automated systems in operations increases, the more important and more used it will be, ensuring the reliability of the systems (XAVIER, 2003);

ISO 50001 certification project: The ISO 50001 certification project, as shown in Figure 1, was born out of the need to meet customers ' requirements. In this context, strategic planning was carried out based on the topics":

- Hiring Consultants;
- Hiring Certifying Body;
- Phase 1 – Assessment/Diagnosis;
- Phase 2 – Planning: Project Schedule.
- Phase 3 – Implementation: Bidding Process; Energy acquisition through free market; Project Implementation.
- Certification
- Creation of system for monitoring machinery & equipment;
- Approval of the project through the results.

Quality tools

Strategic Planning: Strategic Planning is an administrative process of top organization responsibility which aims at the systematic analysis of strengths and weaknesses of the organization, and the opportunities and threats of the performance scenario, in order to establish purposes, objectives, strategic actions that enable the increase in the organization competitiveness. It can be defined as a process of development and maintenance of action strategies between the objectives of the organization and the existing opportunities in the environment in which it operates. It is part of the company's organizational planning, along with tactical and operational planning, according to José Sérgio Marcondes, posted 10/25/2016 and updated 04/03/2020. The definition of strategy, in turn, can be understood as being the positioning and the most appropriate path to be taken to achieve the established objective. Strategy is first and foremost a choice that an organization must do, from the analysis of the probable paths to follow in the direction of the proposed objectives. The strategy, for being a greater choice, also serves as a reference so that, at the tactical and operational levels of the organization, "smaller choices" are made in such a way that one of the most important functions of an explicit and well-publicized strategy is to guide employees to make choices that arise in their individual activities and decisions on a day-to-day basis. The strategy expresses how an organization uses its strengths and weaknesses (existing and potential) to achieve its goals, taking into account the opportunities and threats of the environment. It is defined by George Day (1999) as a "set of integrated actions with the purpose of obtaining lasting competitive advantage". Strategic planning is an administrative process, of top organization responsibility, which aims at the systematic analysis of the strengths and weaknesses of the organization, and the opportunities and threats of the scenario of action, in order to establish purposes, objectives, strategic actions that enable the increase of the organization's competitiveness. It can be understood as being a process of development and maintenance of action strategies between the objectives of the organization and the existing opportunities in the environment in which it operates. The organizational planning of a company is composed by the strategic planning (strategic level) by the tactical planning (tactical level) and by operational planning (operational level). It is observed that the last two should be aligned with the guidelines of the first as shown in Figure 1.

Source: https://gestaodesegurancaprivada.com.br/planejamento-estrategico/ (2022).

Figure 1. Organizational Plan

Strategic planning defines the objectives and strategies of the organization and the intended relationship with the operating environment. Strategic planning is creating conditions for organizations to decide quickly in the face of opportunities and threats, optimizing competitive advantages over the competitor. It is the strategic direction that allows organizations to react quickly to environmental turbulence, explore market opportunities and develop new management techniques (MOREIRA, PASQUALI, DUBNER, 2003). Normally, the responsibility of preparing strategic planning is of the top of the organization (management). Because it is a set of decisions that involve the entire organization, it must be planned in the long term. While strategy is concerned with "what to do," strategic planning is concerned with "how to do it."

Objectives of Strategic Planning:

- Identify and establish opportunities for the organization;
- Establish and centralize purposes for organization (Mission, Values, future vision and objectives);
- Develop, detail, and disseminate the strategy for the organization;
- Enable the organization to adapt and react to changes in the performance scenario;
- Guide the activities of the organization towards the goals of the organization;
- Maximize productive potential considering available resources;
- Motivate people in the search for the future vision;
- Establish strategic governance

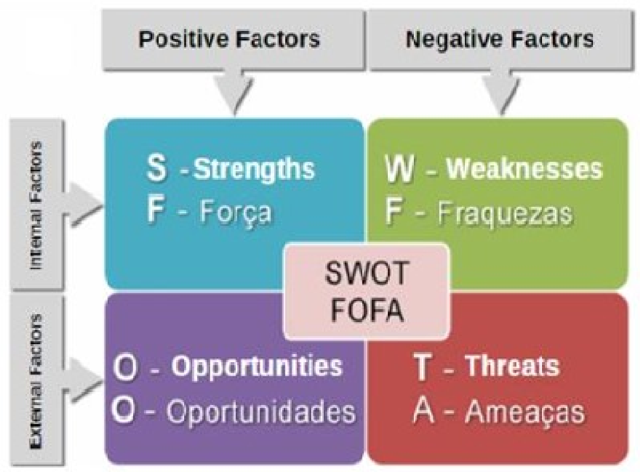
Table 1. Hoshin Plan

Execution											
SGNO 02 ISO 50001 Certification											
OBJECTIVES DEPLOYMENT			OWNER: Maintenance				PERIOD: 2022				
Objective		Target	Due Date	Responsible	Strategy		Responsible	Indicator	Target	Due Date	Status
Item	Description				Item	Description					
2.1	Hiring a consultant	100% on schedule	Aug/ 21	SGI/Purchase	2.1.1 2.1.2 2.1.3	Elaborate MD Request proposals, evaluate comparative map and select contract Issue PR	SGI/Purchase	As per deployment schedule	100% on schedule	Aug/21	OK
2.2	Hiring Certifying Body;	100% on schedule	Sep/ 21	SGI/Purchase	2.2.1 2.2.2 2.2.3	Elaborate MD Request proposals, evaluate comparative map and select contract Issue PR	SGI/Purchase	As per deployment schedule	100% on schedule	Sep/21	OK
2.3	Assessment/Diagnosis	100% on schedule	Oct/ 21	SGI/Maintenance	2.3.1 2.3.2 2.3.3 2.3.4 2.3.5 2.3.6	Team definition and planning Team training Interviews Proof of evidence Management Review Issue of the report		As per deployment schedule	100% on schedule	Oct/21	OK
2.4	Planning	100% on schedule	Oct/ 21	SGI/Maintenance	2.4.1 2.4.2 2.4.3	Preparation and organization Workshop Issuance of ISO Master Plan	Consultant / Energy Building Committee	As per deployment schedule	100% on schedule	Oct/21	OK
2.5	Implementation	100% on schedule	Apr/ 22	SGI/Maintenance	2.5.1 2.5.2	Implementation monitoring Audit report	Consultant / Energy Building Committee	As per deployment schedule	100% on schedule	Apr/21	OK
2.6	Certification	Attendance to the planning of the SGI	Apr/ 22	SGI/Maintenance	2.6.1	Initial phase I Audit Phase II certification audit	Hiring Certifying Body;	As per deployment schedule	Attendance to the planning of the SGI	02/11/22 04/25/22	In progress

Source: Authors, (21022).

SWOT: Organizational Diagnostics is the analysis of the external and internal environment. Through it the organization seeks information about the operating environment. In strategic planning, SWOT analysis is a very efficient way to identify the strengths and weaknesses of an organization, as well as examine the opportunities and threats that may be faced in its operating environment. SWOT analysis is the process of systematically identifying the strengths and weaknesses of the organization, opportunities and threats in its operating environment Figure 2.

The SWOT Matrix is a tool used to make scenario analysis, being used as a basis for management and strategic planning of an organization. It provides a comprehensive view of the scenario where the institution is located, serves as support so that weaknesses are minimized and strengths are maximized, and better used through a strategy that contemplates, at the same time, the opportunities of the environment and what the organization can best do to take advantage of them.



Source: https://gestaodesegurancaprivada.com.br/planejamento-estrategico/ (2022).

Figure 2. SWOT Matrix

Organizational Diagnostic Object

- Offensive capacity of the organization – the way in which the organization uses its forces and takes advantage of the opportunities of the external environment;
- Defensive capacity of the organization – perceptions of how the organization's forces are able to mitigate threats to the institution from the external environment;
- Offensive weakness – highlights the insufficiency of internal elements that make it possible to take advantage of the opportunities of the external environment;
- Vulnerability – indicates how the weaknesses of the organization enhance the action of threats from the external environment.

Strategic Analysis Requirements

- The SWOT analysis should consider as inputs the results of desk review, interview with the leaders and research with employees. These results should make up the matrix of strengths, weaknesses, opportunities, and threats;
- The SWOT analysis should be done in a technical meeting to be held with the strategic planning development team.

External Environment Analysis: The relationship with the external environment is a key factor of the organization and, for this reason, understanding the particularities, organization and functioning of this environment is essential for the management of the organization. To analyze the general environment, it is important for the manager to raise information on the following aspects:

- Sociocultural;
- Legal: laws, taxes, fees applicable to the sector;
- Politic/governmental;
- Economic;
- Technological.

External analysis allows the identification and assessment of present and future opportunities and threats to the organization.

- **Opportunity:** these are future situations or events, external to the organization and not directly manageable by it. Opportunities, when taken advantage of, can facilitate the fulfillment of the organization's mission. Opportunities provide a favorable potential in the organization's environment for the fulfillment of its goal.
- **Threats:** these are future situations or events, external to the organization and not directly manageable by it. If they are not avoided, they can hinder the fulfillment of the mission. Threats are the main unfavorable circumstances or impediments to the current or future position of the enterprise in achieving its goal. The identification of these two factors allows the organization to foresee opportunities – respecting its strategic foundations – and threats, from which it must defend itself. For a better work organization, both opportunities and threats are prioritized according to their relevance to the fulfillment of the mission.

Analysis of the Internal Environment

The strengths and weaknesses of the organization are identified through the internal analysis of the organization.

- **Strengths:** internal conditions or characteristics that contribute to the fulfillment of the organization's mission. The strong points or strengths are the resources or skills that make the organization outperform competitors. It is a competitive characteristic of the organization that puts it at an advantage over competitors.
- **Weaknesses:** internal conditions or characteristics that reduce the likelihood of fulfilling the organization's mission. The weak points or weaknesses are the competitive characteristics of the organization that puts them at a disadvantage compared to competitors, and these should also be recognized and treated. All characteristics, skills and competencies of the organization must be analyzed and prioritized according to their contribution to the fulfillment or not of the organizational mission.

PDCA: PDCA is an acronym that gives its name to a tool used in Process Quality Management. Its focus is the solution of problems following the four phases indicated by the letters (Plan, Do, Check, and Act). Trujillo (1974) apud Marconi; Lakatos (2004, p.18) points out four types of knowledge, namely: popular, scientific, philosophical and religious (theological). Marconi; Lakatos (op.cit., pp. 20-21) point out that although they can be distinguished, these knowledge can be used simultaneously to carry out an analysis or coexist in the same person. In the context of this article, scientific knowledge will be addressed above all.

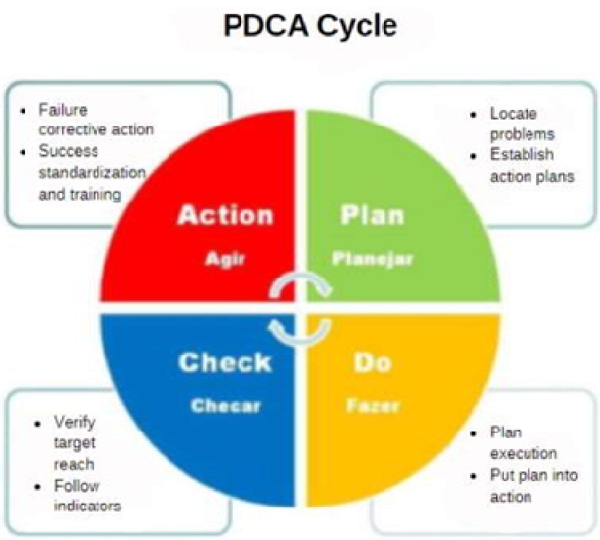
It is interesting to note that the word science, in the sense *latu sensu*, simply means "knowledge"; *stricto sensu*" does not refer to any knowledge, but to that which, in addition to learning or recording facts, demonstrates them by their constitutive or determining causes" (MARCONI; LAKATOS, op.cit., p. 23). It is this kind of knowledge that will be dealt with here. PDCA is a method of managing processes or systems. It is the way to achieve the goals assigned to the products of business systems (CAMPOS, 2014). Therefore, it is necessary to determine a goal for the use of this methodology. According to Andrade (2003), the PDCA cycle is designed to be used as a dynamic model in which the completion of one cycle will flow into the beginning of the next cycle, and so on. In addition, it states that the process can always have a new analysis, implying a new process of change. This methodology that has as its basic function the aid in the diagnosis, analysis and prognosis of organizational problems, is extremely useful for problem solving. Few instruments are as effective for the search for improvement as this method of continuous improvement, since it leads to systematic actions that speed up the achievement of better results in order to ensure the survival and growth of organizations (QUINQUIOLO, 2002). The PDCA cycle is divided into four well-defined and distinct phases which, according to Andrade (2003), can be described as follows as shown in Figure 3.

Plan: establish the objectives and processes necessary to deliver results as per customer requirements and organization policies. This stage covers: the location of the problem, the establishment of a goal, the analysis of the phenomenon (using statistical diagrams), the analysis of the process (using the cause and effect diagram) and the elaboration of the action plan;

Do: implement the processes, that is, execution of the actions established in the action plan defined in the previous phase, carried out in the determined schedule, having all actions recorded and supervised;

Check: at this stage, the effectiveness of the actions taken in the previous stage should be checked. Using the same the comparison of the results (planned and executed), listing of the side effects (arising from the actions performed), verification of the continuity or not of the problem (effectiveness of the actions taken);

Action: this phase is responsible for the standardization of the procedures implemented in the "Do" phase, that is, if the result is satisfactory, these actions must be standardized, transforming them into standard procedures. To carry out this standardization, the elaboration or alteration of the standard, communication, training and monitoring of the use of the standard are conducted. The completion of the project also occurs in this phase, and new future goals may be stipulated so that the continuous improvement process can be triggered.



Source: https://gestaodesegurancaprivada.com.br/planejamento-estrategico/ (2022).

Figure 3. PDCA cycle

Hoshin Plan: Hoshin means compass, or direction indicator; kanri, in turn, means administration, or control. Hoshin is the term used to designate the annual plans and goals of the company as a whole. Hoshin kanri consists of the process of setting goals and objectives and, more importantly, concrete plans for their achievement. It is an example of personal leadership oriented to institutional leadership. In a formal sense, hoshin kanri refers only to the alignment of innovative goals and objectives that take the company to a new level (sometimes called kaikaku); while the broader goals of the key performance indicators (KPIs) aligned with these goals is part of the daily administration of kaizen. In practice, there is not much distinction between hoshin kanri and daily kaizen, as they are all part of the company's commitment to continuous improvement. The plan is drawn up by the top management and then broken down into increasingly detailed levels; some execute the plan; and the results are verified at each level and sent to the levels of the top management, starting to undertake new actions based on the gap between the objectives and the present conditions. Part of the study stage, around the middle of the year, is to lay the foundation for planning the following year's hoshin kanri. Throughout the company, there are several smaller cycles of PDSA in operation throughout the year. Every attempt to improve a process, guided by hoshin's goals, is a PDSA. The White Belt, Green Belt, and Black Belt, in addition to the Lean of PMP.

Preventive Maintenance Plan: The focus of the preventive maintenance plan is to ensure that all equipment is performing optimally, without failures and unexpected interruptions. This way, you will keep the company running efficiently and profitably. For this, it is best to implement maintenance management. To develop a preventive maintenance plan, your company must have a defined objective. In a second moment, carry out an inventory of all equipment and assets. As a third step, create maintenance tasks to perform on each equipment/asset. And finally, create a maintenance schedule and train the team.

Energy Efficiency: Brazil, being a developing country, follows the same trend as developed countries, in which it is expected that there will be a growth in electricity consumption proportional to the development of its economy and the emergence of new technologies (Oliveira *et al*., 2017). According to the Energy Research Company (EPE, 2020), in the year 2019, Brazil presented a 1.3% progression in final demand for electricity, with the sectors that collaborated the most for this progression, in terms of absolute values, the commercial (+4.5), the residential (+3.5%), the energetic (+4.1) and the public (+2.1). Thus, it is necessary to implement measures that allow not only the increase of energy supply through renewable sources, but also its use in a rational and efficient way (Leite *et al*., 2019). According to Souza *et al*. (2019) energy efficiency can be defined as obtaining the same energy service, using less energy during the process. In this context, it is possible to provide the rational and efficient use of energy at all stages of the process, from obtaining it in primary form to final consumption. Energy efficiency is shown as a tool of relevant impact and low cost to reduce energy costs, and can achieve approximately 20% savings when compared to the acquisition of new generation sources (Silva, Oliveira & Tostes, 2017). Thus, an energy management system constantly implements technical and organizational methods that seek opportunities for conservation and efficient use of energy in facilities, aiming to reduce costs (Batlle *et al*., 2020).

The decision-making process constitutes a great challenge for managers and an important task for the growth and increase of competitiveness of an industry in the market where it is inserted. Silva *et al*. (2018), Silva *et al*. (2019) and Zanardo *et al*. (2018) suggested models, combining one or more methodologies for diagnosing the level of energy efficiency and developing consumption scenarios. Method *Bottom-up* it was applied in the works of Silva *et al*. (2018) and Silva *et al*. (2019), in order to predict the long-term electricity consumption of a specific industrial sector (pulp and paper), considering energy efficiency scenarios. Silva *et al*. (2019) emphasize that building a Buttom-up approach in Brazil, a developing country, is much more difficult since the fact that the model requires a lot of data from industries makes the process even more challenging. This difficulty can be reduced with the advent of Industry 4.0, since digitalization and connectivity are basic requirements of the concept. Regarding public policy articles, Volpi *et al*. (2006) proposed policies to assist the implementation of energy efficiency programs and adoption of renewable energy technologies in the Brazilian energy matrix. Calili *et al*. (2014) estimated the energy savings and CO2 emission reduction in 5 years with the implementation of the PNEf, created in 2011. Fabbriani and Calili (2018) defined energy efficiency public policies to be implemented in the food and beverage industrial sector. Costa *et al*. (2019) evaluated three levels of aggregation (macro, meso, micro) of energy efficiency programs (EEP) with a focus on low income.

Digital Twins: The originator of the term "digital twin" was Dr. Michael Grieves, in 2003, at the University of Michigan, in the course taught by him on product life-cycle management (PLM) (GRIEVES, 2014). The concept is broad and can be applied to all phases of the life cycle of a product or physical object, from prototype, through manufacturing to operation, evaluating its performance and wear in the real world. Although the focus of this work is on its application in the operation and maintenance stage of the product, it is important to discuss the potential of this technology in the other phases. Digital twins can be defined as a digital model of a real object, which represents its physical configuration with sufficient richness of detail or even with pertinent simplifications, fed by sensor data, which illustrates the instantaneous situation of this object in the real world (PARROT; WARSHAW, 2017). A digital twin can represent an individual asset, a system composed of different assets, or a set of several identical assets.

According to (GE, 2018), the three elements that make up a digital twin are:

- Asset model: describes in detail its structure and components, in a hierarchical manner.
- Analytics: predict and describe its behavior, enabling behavior automation.
- Knowledge Base: data accumulated from capturing variables related to the real-world asset, presented intuitively.

During the design phase, digital twins can be used in the form of simplified models to virtually test physical characteristics of the product, regardless of the total complexity of this item once finished (GRIEVES, 2014). In the next phase, manufacturing, the digital twin provides segmented and appropriate information for each stage of the construction process. At this time, the digital model is no longer running simulations, but rather reflecting in the virtual world what is actually happening on the factory floor. It starts to be fed back with physical information captured through sensors, such as screw torque, dimensions, material analysis, among others (GRIEVES, 2014). The assembly line itself has its digital twin, providing instant information on production, raw material consumption, performance, fault detection, among others, in addition to enabling each production cell to communicate with each other, adapting to the characteristics of the product (GRIEVES; THOMAS, 2015). Later, already in the era of Industry 4.0, the idea of *Digital Twin*, whose objective is not only to simulate real components and systems in a virtual environment, but to integrate these environments through communication protocols, was developed so that there is convergence and cooperation between them (GRIEVES, 2014). Tao *et al*. (2018) discusses the application of the concept of digital twins in the three phases of the product life cycle: *design*, manufacturing and service. The PLM area (*Product Life-cycle Management*) is an area of great potential for the use of digital twins, attracting the attention of the industrial segment as well as researchers (DU; LI; GU, 2007).

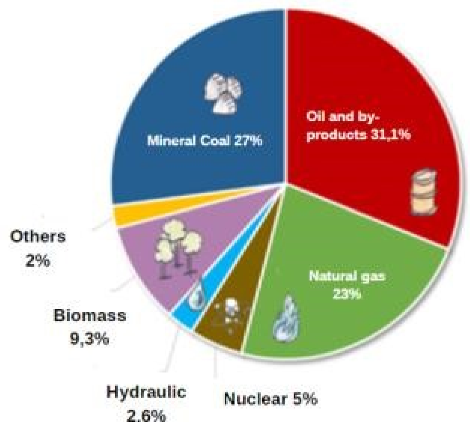
Energy Matrices: Brazil's energy matrix still relies heavily on fossil fuels, despite widespread use of electricity from hydroelectric plants. In this context, however, Brazil makes use of thermoelectric plants for electricity generation, mainly in the Amazon region, where about 93% of the electricity generated comes from this modal. Nevertheless, the country has a strong potential in terms of the use of alternative energies such as wind and solar, despite geographical limitations and high implementation costs (BRONZATTI; NETO, 2008; ROSA, 2007; MME, 2016; SANTOS *et al*., 1999).

On the other hand, the electricity market of the Amazon region can be subdivided into three types (SOUZA, 2003):

- ***Capital Markets*:** as its name suggests, it is the market of the capitals of each state, where, for the most part, it is served by hydrothermal parks (hydroelectric and thermal power plants), owned by federal concessionaires;
- ***Concentrated Electricity Market*:** it is represented by the urban areas of the countryside municipalities of the states and small localities that are in the vicinity of the capitals, served by diesel-powered thermoelectric units, medium-sized with local networks, under the responsibility of a state concessionaire or by third-party companies;
- ***Dispersed Electricity Market*:** represented by part of the population located in remote areas of the states that do not have access to electricity or have small diesel generators owned by the municipality, generating electricity for some specific uses.
- To meet the needs of each of these markets, separate studies are necessary since the reality of each is very different, especially that of the *Dispersed Electricity Market* (SOUZA, 2003).

- Bellini, Oliveira, Lagioia, Silva, & Melo (2017) point out that there is an intensification of movements to the detriment of greater participation of renewable energy matrices in energy production in Brazil, especially due to environmental issues and sustainable development. This interest drives the scientific community to research and develop methods that allow greater use of alternative energy sources (DUPONT, GRASSI & ROMITTI, 2015).

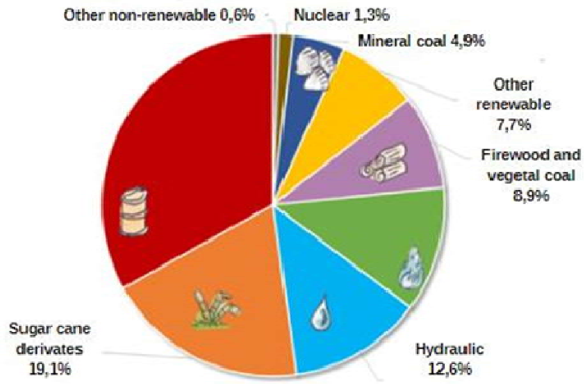
Ishiguro (2008) points out that in the choice of energy matrices, the economic competitiveness that each source offers must be taken into account, including the investments for its installation and the energy generation costs themselves. Bronzatti and Iarozinski Neto (2008) also add that the composition of the energy matrix should be considered as production potential and the probability of growth of reserves. In Brazil, hydropower is still the main source of energy in the country. Even if this resource is presented as a renewable alternative for electricity generation, the droughts of recent years show the total dependence that the country presents to this type of matrix, having its energy security strongly vulnerable to climate change (SILVA, MARCHI NETO & SEIFERT, 2016). Faced with this reality, Bondarik, Pilatti and Horst (2018) point out that the country has sought new strategies in order to maintain its renewable energy matrix and, at the same time, meet the growing demand for energy and carry out consistent economic development, taking into account environmental and social impacts. However, according to Mantovani, Neumann and Edler (2016), the country needs significant investments in technology to reduce costs related to the implementation and expansion of new matrices. Silva, Marchi Neto and Seifert (2016) affirm that the country has one of the largest hydroelectric potentials in the world that, despite bringing advantages, demonstrates a reality regarding dependence on a single type of matrix - which, by the way, is directly threatened by climate change and droughts observed in recent years. As pointed out by the authors, the diversification of the power generation mix makes it possible to increase the security of electricity supply, in addition to the need to boost the development of other renewable sources. The panorama of investments made in R&D and its relation to the Energy Matrix of energy generating companies in Brazil was evaluated in this research, pointing to a positive and significant relationship between companies that do not have 100% renewable Energy Matrices and investments in R&D, when observed in isolation. Due to the scenario and market pressures for the greater participation of renewable Energy Matrices in energy production in the country (Bellini *et al*., 2017), it is appropriate that less renewable companies disburse greater investments to try to adapt to future demands. In 2020, as can be seen below, the panorama of the Brazilian energy matrix already surpasses the world energy matrix in renewable energies comparatively.



Source: EPE (2021).

Figure 4. Global Energy Matrix (IEA, 2021)

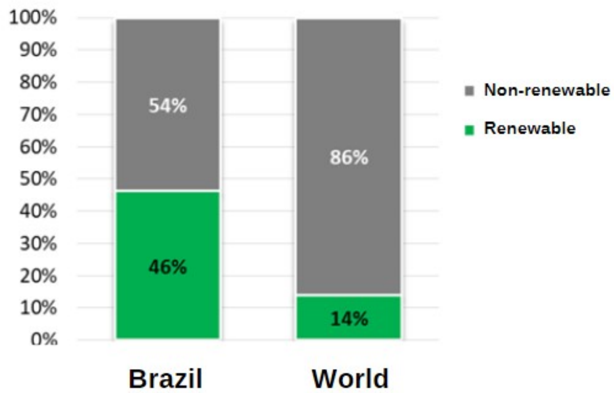
The world has an energy matrix composed mainly of *non-renewable sources***,** such as coal, oil and natural gas as shown in Figure 4. As shown in Figure 5 above, the Renewable sources such as solar, wind, and geothermal, for example, together correspond to only 2% of the world's energy matrix, pointed out as"other" on the chart. Adding to the share of hydraulic energy and biomass, renewables total approximately 14%. Brazil's energy matrix, on the other hand, is very different from the world one. Here, although the consumption of energy from non-renewable sources is higher than that of renewables, we use more renewable sources than in the rest of the world. Adding firewood and charcoal, hydraulics, sugarcane derivatives and other renewables, our renewables total 48.3%, almost half of our energy matrix:



Source: EPE (2021).

Figure 5. Brazilian energy matrix (BEN, 2021)

Comparing the consumption of energy from renewable and non-renewable sources in Brazil and in the world for the year 2019, Figure 6 graphically shows these differences:



Source: EPE (2021).

Figure 6. Comparison of the Energy Matrix Brazil x World

We can see from the graph above that the Brazilian energy matrix is more renewable than the world one. This characteristic of our matrix is very important. Non-renewable energy sources are most responsible for the emission of greenhouse gases (GHG). As we consume more energy from renewable sources than in other countries, dividing the emission of greenhouse gases by the total number of inhabitants in Brazil, we will see that our country emits less GHG per inhabitant than most other countries.

Energy Costs: The development of urban and industrial society took place without limits, without planning, at the expense of environmental degradation. Companies, over time, began to realize that more than following the legislation, sustainable practice in the production process had the advantage of reducing waste in production. The reduction in the source, the process recycling and efficiency in the use of electrical energy can reduce the amount of inputs needed for industrial processes which, in turn, will result in cost reduction in the industry (BRAGA, 2005). In the understanding, to manage an organization is to lead it towards its objectives in a concrete way, to obtain the expected results. This process should be done by a group of cohesive, competent and hard-working people who have clear objectives, as well as focus and synergy to overcome challenges and achieve overcoming. It is about planning, organizing, directing and controlling the use and application of company resources and, with this, seek to achieve the proposed objectives (CHIAVENATTO, 2011). The shape of costs relates to the function of the variation in the volume of production and can be fixed, variable or semi-variable (DUTRA, 1995):

- ***Fixed costs:*** costs that occur from period to period without variation, as a result of the volume of production;
- ***Variable costs:*** those that vary according to the volume of production, that is, the quantity produced in the period;
- ***Semi-variable costs:*** they have a fixed and another variable portion;

Dutra (1995) defines fixed costs as costs that occur period by period without variation, whose monthly value is the same, regardless of the volume produced. Variable costs vary according to production, so the higher the volume of production in the period, the higher the variable cost (DUTRA, 1995). According to Megliorini (2007), semi-variable costs have a fixed and another variable portion.

A good example is electricity for when there is no use or the consumption of this resource is below the minimum limit stipulated by the supply companies, a fixed rate is paid, characterizing a fixed cost as the use of these resources arises and, with the increase in production, the value of the bill rises, becoming a variable cost. The reduction in the source, the process recycling and efficiency in the use of electrical energy can reduce the amount of inputs needed for industrial processes which, in turn, will result in cost reduction in the industry (BRAGA, 2005).

Source: Authors, (2022).

Figure 7. BTU oven - USE 01

For Mesquita and Franco (2004), disseminating energy efficiency manuals, encouraging the shutdown of equipment that is not in use, developing proposals for replacing lamps with more efficient models and other actions are the basis of energy efficiency. According to Reis and Cunha (2006), the admission of technological implements and innovative actions to an integrated approach of economic and environmental factors is essential for sustainability in the energy sector. Reis (2011) explains that the primary sources used for electricity production are classified as non-renewable and renewable, the former being liable to be exhausted because are used more quickly than necessary for their development in nature. In this category are petroleum derivatives, corresponding to renewable sources those whose natural replacement is faster than their use, being able to mention the sun, wind, and water (REIS, 2011). Several benefits are generated as a result of energy efficiency plans, among them the increase in productivity and the generation of jobs, since less energy is used for the same work, as well as pollutant gas emissions in the environment are reduced (Panesi, 2006).

Energy cost reduction savings best practices

The use of LED lamps has a number of advantages over traditional lamps. Alper (2012) points out the characteristics of LED through some of its advantages:

- Longer service life;
- Low power consumption;
- Does not emit UV (ultraviolet radiation);
- Low maintenance cost;
- Higher efficiency than traditional light sources;
- High mechanical strength;
- Lower heat generation;

In addition to these advantages, Alper (2012) also cites some environmental advantages of LED lamps, they are:

- Absence of mercury;
- Absence of IR radiation (infrared radiation) or UV (ultraviolet radiation) in visible light.
- Low power consumption;
- Lower carbon emissions;
- Use of recyclables and corrosion resistant recyclable materials.

It is worth noting that there is a growing expansion of LEDs in the lighting market, although prices are still high compared to other technologies, such as the sodium vapor lamp, which makes it difficult for consumers to access this product. However, this difficulty is being overcome due to the great technological development in this area. Goeking (2009) confirms this theory by exposing that currently LEDs can be applied in any type of environment, including widespread tests in public lighting, with satisfactory results, despite the high cost compared to other technologies.

MATERIALS AND METHODS

Methodology for implementing the Energy Management System - Materials -implementation of improvement ISO 50001 Use- 01.00 Furnace BTU - ISO-50001 Energy Management System

Stage 1: Perform measurement using MINIPA laser thermometer in the exhaust ducts of the furnace. Temperature analysis was performed in preheating Zones 1 and 2 of the BTU furnace. Data was collected through the laser thermometer. Action: carried out preventive maintenance, cleaning and change of the ventilation system duct of the preheating zones.

Stage 2: Evaluate the temperature of the exhaust ducts that disperse smoke and heat which requires the high demand of the refrigeration system to maintain the ambient temperature within the parameters required in SSO; The temperature was evaluated by the laser thermometer and the temperature reduction was observed.

Stage 3: Establish periods for preventive maintenance and implementation of improvements that can reduce the temperature dispersed in the environment Cleaning periodicity every 3 months.
Stage 4: Set on time to turn on the machine improving energy efficiency and improvement in maintenance of the USE. Before, the oven was turned on 5h in the morning and after the analysis it was turned on at 5h30 by the Small Team.

Used Methods

Procedures 1: Thermographic analysis of the furnace exhaust ducts before and after the implementation of the improvements. Directed the laser of the thermometer to the exhaust duct of Zones 1 and 2, verified a significant improvement in the result of the ambient temperature after the above reported actions. Reduced the temperature in Zone 1 to 9Cº and in Zone 2 to 36Cº.

Procedures 2: Set periodicity for preventive maintenance of the furnace and exhaust system. Cleaning periodicity every 3 months.

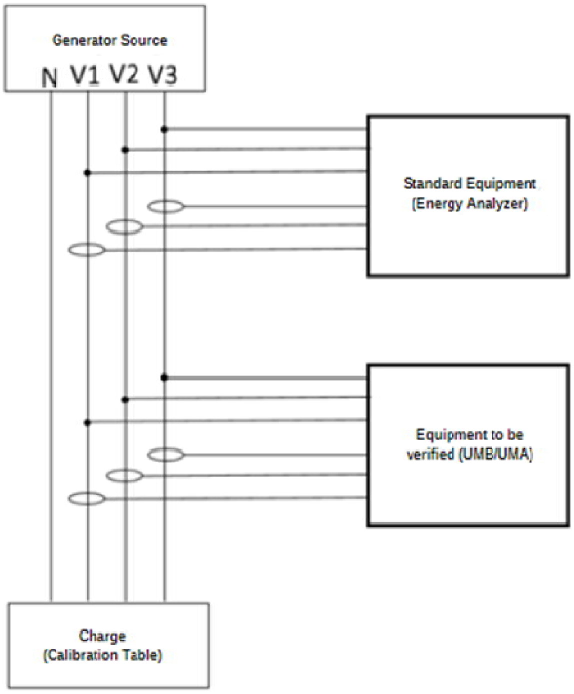
Procedures 3: Thermographic reanalysis after improvement implementation. After this evaluation, it was defined a thermographic will be done every 3 months.

Procedures 4: BTU furnaces readjustment of switching on times from 05:00 to 05:30. Measurements were carried out before the implementation of this time change and after that the improvement resulted in saving 7,9 kWh per day (we have 10 furnaces).

Procedures 5: Analysis of energy consumption with MINIPA ET-5062 electrical quantity analyzer before and after the implementation of improvements. As the photo with the graphics is demonstrating, the energy savings in the process are as shown in Figure 7.

Proposed ImprovementsPerformed

Elektro System: For monitoring the energy consumption of the BTU USE - 01.00 OVEN OF LINE SMT 10, an equipment called Elektro was developed and comes to be a data storage system, monitoring and controling energy consumption that uses digital twins for data collection. It has elements of IoT (Internet of things) and Industry 4.0. To compare and certify the results obtained and stored in the BMU (Basic Measurement Units) of the Elektro measurement system, a calibrated and certified MINIPA energy analyzer, model ET-5062, was used as a service standard, as shown in Figures 8, 9 and 10.

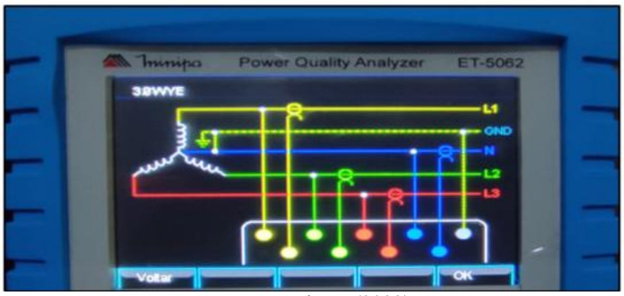


Source: Authors, (2022).

Figure 8. Connection diagram of the Minipa standard instrument Model ET-5062 and BMU Elektro

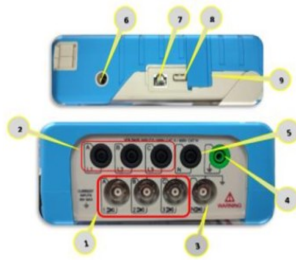
Sequential procedure for checking all measuring components:

- Leave the Switch in NORMAL mode
- Connect the power / VOLTAGE reference cables item-2.
- Check if the current measuring connectors are all well connected item-3.
- Connect CN2 battery to item-5 board.
- Connect battery CN1 item-5 to the board and observe if it has turned on all the LEDs
- If RESET is required, hold down SW1 item-6.
- Check that the main connector of the CTs is well connected item-7.



Source: Authors, (2022).

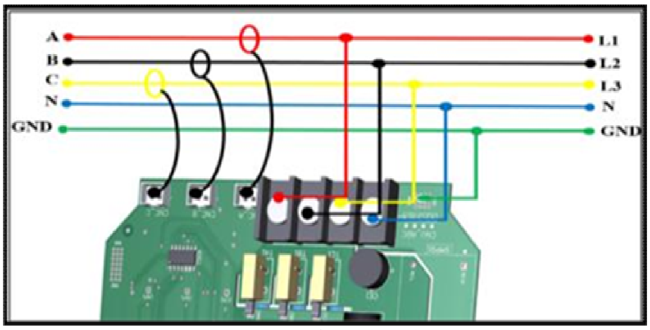
Figure 9. HMI of the Standard Instrument Minipa in the supply circuit in oven BTU USE-01.00



Item	Descrição
1	Entradas de medição de corrente (trifásica)
2	Entradas de medição tensão (trifásica)
3	Entrada neutro da referência de corrente.
4	Entrada GND (terra)
5	Entrada neutro de referência tensão
6	Entrada CA do cabo de alimentação 100-240 V 50/60 Hz
7	Entrada conector LAN
8	Conector USB
9	Tampa de proteção deslizante do cabo LAN e USB.

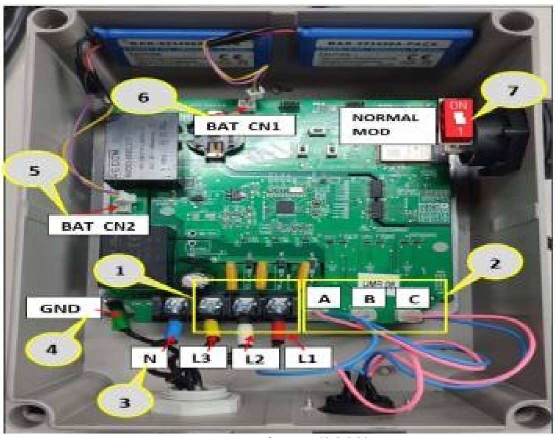
Source: Authors, (2022).

Figure 10. Rear view of the connection points entry of the standard instrument Minipa cables. Translate



Source: Authors, (2022).

Figure 11. Schematic view of the connection of the BMU Elektro in the supply circuit in the BTU USE-01.00 oven



Source: Authors, (2022).

Figure 12. Cnnection of the cables in the supply circuit in oven BTU USE-01.00

Images collected from the elektro online measurement system: The graph in Figure 13 shows when the oven was turned on at 05:00 and turned off at 02:00 on 01/11/22.

Table 2. N° OC 2021:466:01

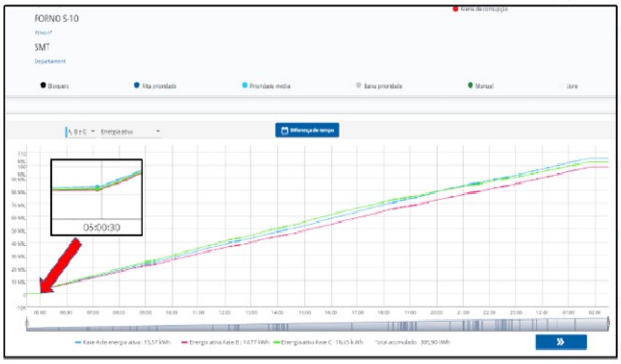
N° OC 2021:466:01.			
1-Perform energy consumption measurements in kWh, prepare the Energy Study of the USE raising the following information (static factors, relevant variables, operational characteristics, personnel involved in the process) for definition of the energy efficiency program of the USE and monitoring of the SGE Appendix: USE 1.00.xlsx ANALYSIS	Maintenance Team	Follows the measurements analysis carried out on the S10 BTU furnace, USE 1.00	12/17/2021 12/09/2021
1-1 Set oven S10 turn-on time – starting at 5:30am in order to have the best consumption and reduction. **Why**: Schedule adequacy and reduction in electricity consumption time; **How:** Creating work instruction setting the oven turn-on time; **Where:** S10 line BTU furnace; **Evidence:** We did the tests at the various times and days proposed and the result is presented in the appendix; **Appendix:** USE S10 BTU OVEN	Maintenance Team	01/07/2022 - 01/17/2022	Consumption equipment startup (peak)
2 - Training of workers who will turn on the S10 oven (USE). **Why**: To empower them and make them aware of operation; **How:** Through operational training; **Where:** S10 line BTU furnace; **Evidence:** All those involved in this initial phase were trained (operators and S10 leaders). Attached evidence follows. **Attachment:** WhatsApp image 2022-01-17 at 10: 38.19.	Maintenance Team	01/10/2022 – 01/17/2022	Consumption equipment startup (peak)

Source: Authors, (2022).

Table 3. Descriptive of the connection points of the Elektro system in oven BTU USE-01.00.

Item	Description
1	Voltage measurement inputs (three-phase)
2	Current measurement inputs (three-phase)
3	Neutral voltage reference input
4	GND (ground)input
5	CN2 connector auxiliary battery
6	CN1 connector auxiliary battery
7	SW3 factory mode / normal mode for use

Source: Authors (2022).

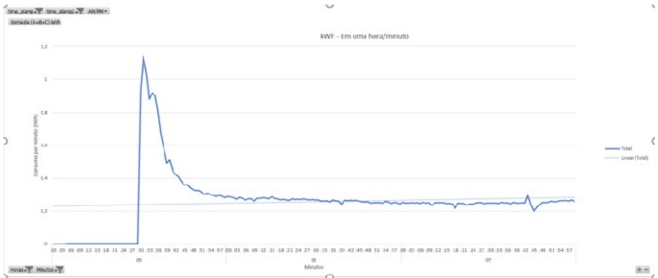


Source: Authors (2022).

Figure 13. Graph measuring the increase in daily consumption

Figure 14 shows the images collected from the elektro online measurement system where access is made by the infrastructure area and responsible for each USE. If any trend change occurs in the process, actions will be taken. Demonstration chart when the oven switched on at 05:30 and switched off at 02:00 day 03/22/22, resulting in a calculated saving of 7.9 kWh per day, or for 10 (ten) ovens a saving of 79 kWh/m or, 1,738 kWh/m (for twenty-two days of switched on ovens).

BTU furnace maintenance: Service improvement in the system of the exhaust duct of the furnace BTU-10 USE 01.00 (preventive maintenance). For this step, a maintenance schedule was defined to always keep the machine within the expected energy efficiency consumption, being of fundamental importance to achieve the expected results as shown in Figure 15.



Source: Authors (2022).

Figure 14. Graph with change in departure time

Source: Authors (2022).

Figure 15. Cleaning the ventilation cooler

Preventive maintenance in the ventilation and duct system of the BTU furnace: Exhaustion – two channels, one inlet and one at the outlet of the furnace. At the moment, the oven has 10 remelting zones (paste from liquid to solid). Pulling the gases through the flow, the flow is withdrawn from the process. Maintenance of the pipeline is carried out. Chemicals for cleaning the duct are used, so employees wear protective equipment. The vacuum cleaner is used, so as not to accumulate residues. For replacement of exhaust ducts, see Figure 16.

Service improvement in the system of the exhaust duct of the furnace BTU-10 USE 01.00 (preventive maintenance)

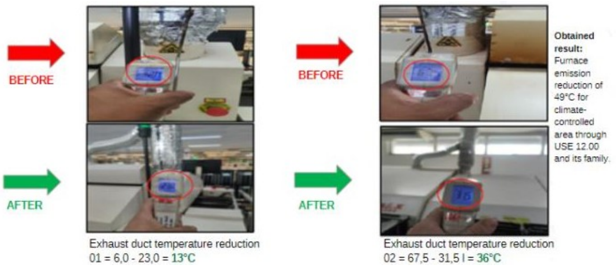
Source: Authors (2022).

Figure 16. Cleaning the ventilation cooler of the heating zones

Ventilation cooler maintenance

- Dismantling of the heating system of Zone 1; 2; 3;
- Lubrication of motors and retightening of electrical connections;
- Changing bearing of fans;
- Retightening of the conveyor belt of the plates;
- Cleaning with a vacuum cleaner is done and then wiped a C86-22 chemical.

Temperature analysis of the exhaust duct system (zone 01 / zone 02 furnace BTU SMT-10 USE-01.00 after maintenance).



Source: Authors (2022).

Figure 17. Yield results after maintenance

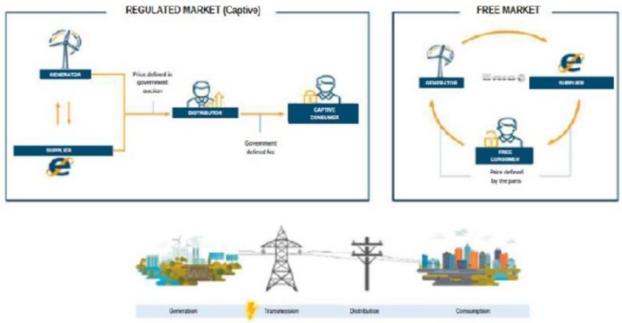
RESULTS AND DISCUSSION

Characterization of the industry: The system implementation takes place in a foreign multinational electronics manufacturing company – considered one of the largest producers of monitors and televisions in the world, with a Brazilian branch headquartered in the city of Manaus since October 2003. The company's mission is to produce monitors and televisions of its own brand and O&M with the highest technology, providing quality products and extensive customer service, always aiming at customer satisfaction with competitive prices in the market. Having an Integrated Management System policy defined and communicated to all levels of the organization and certified RBA (Responsible Business Alliance) code. Beginning its operations in the industrial pole of Manaus and built in Moderna facilities, the company has contributed to the development of the region, which started with 150 jobs and a partial production capacity of approximately 25,000 products/month. Currently, the branch has more than a thousand employees and is considered one of the largest producers of monitors and televisions in Brazil, producing approximately 250,000 products/month. The organization where the study was conducted is categorized as a large enterprise. It seeks the development and improvement of its processes from the use of continuous improvement tools, aiming to make its products the most competitive in the market. Its production is characterized as an intermittent process since its volume is determined from the demand or lots ordered by large customers who are commercial, business or state establishments.

Integrated System Management Process: The Integrated Management System area is responsible for coordinating the certification process in the organization based on the goals defined by senior management. This area is responsible for the system database with the data of all procedures, instructions, policies and registration and controls all revisions. It is also responsible for the planning and implementation of internal audits, and also for hiring a certifying body to officially maintain certifications. Supports all areas in the implementation of standardized processes seeking greater control and productivity of the business and effectiveness of activities on a day-to-day basis. Controls and maintains the monitoring of all improvement actions opened by internal and external audits, by customers or specific situations in the areas. This monitoring is done monthly. It supports the organization through the control of the organization's indicators, reports with the results of audits, monitoring reports of non-conformities and process improvements, critical analysis by senior management and strategic planning. Always using PDCA as a tool to achieve the results, a follow-up is carried out at each stage of the ISO 50001 implementation process in reference to the work in progress.

Preliminary Design for Customer Service: To become increasingly competitive in the market, it is important to be attuned to the guidelines and vision of customers. As the planet goes through many storms, one of the actions is to reduce the emission of polluting gases in compliance with goals of reducing energy consumption and input costs. This certification seeks, through new procedures implemented, to reduce energy consumption and energy efficiency of existing machinery and equipment. And to acquire new ones, the new guidelines described in the procurement procedures will be followed.

Problem Found: One of the major challenges of the ISO 5001 implementation project was the transition from captive to free market energy consumption. The main differences between the two markets, in order to make more evident the benefits that are part of the migration to the FTE (Free Trading Environment), are: In *captive market* (Regulated Market Environment - RME), customers are required to contract electricity directly from utilities in the region and follow the values established by it. As for the *free market* (Free Trade Environment - FTE) the contract is bilateral, that is, the amounts, prices and deadlines are negotiated directly between the generator and the buyer.

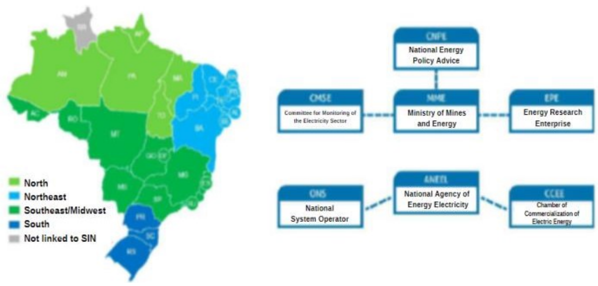


Source: Ecom Energy (2021).

Figure 18. Free market vs. captive (regulated)

Therefore, we can say that the contracts in the FTE are broad and diversified, adapting to the client's consumption profile and the type of investment they intend to make. The migration process to the Free Market (figure 18) was monitored by the entire technical team of the infrastructure and the acquisition team of the new process. It was a stage of a lot of negotiation, monitoring the process with a specialist in the area and consulting so that we did not have problems of lack or interruption of energy in the organization. In addition, a training was carried out with all the team involved in acquisition, support and system to understand the process and resolve existing doubts. Following the differences between markets, benefits, energy consumption, and migration to the free market and associative contribution.

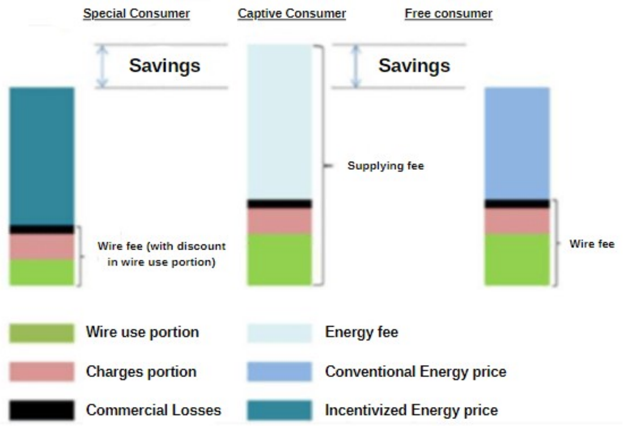
Brazilian Electricity Sector: The Brazilian electricity sector was structured to guarantee the security of electricity supply, the universalization of service and the moderateness of tariffs and prices. Linked to the Ministry of Mines and Energy (Mme), the National Electric Energy Agency (ANEEL) is the regulatory body of the sector according to Figure 19.



Source: ANEEL (2022).

Figure 19. Regional distribution of Brazil by the regulatory body of the electricity sector

Energy cost in the FTA (Free Trading Environment): One of the points that most attracts the attention of consumers in the free trade environment is to be able to work with predictability of the prices that will be paid during the entire term of the contract, since the contracts fix the prices of each contracted year, focusing only on the inflationary correction of each period. This security ensures that the amount charged is not influenced by tariffs and government or sectoral decisions, for example, in the face of more or less favorable generation scenarios, such as the recent water crisis as shown in Figure 20.

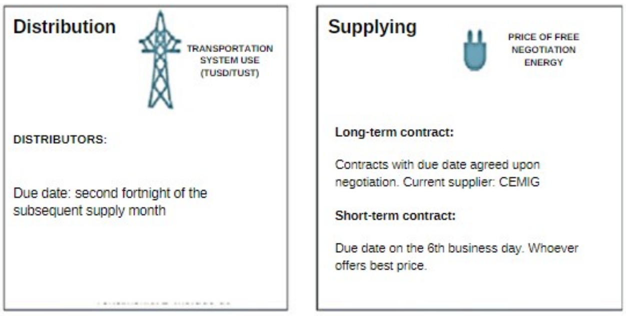


Source: Ecom Energy (2021).

Figure 20. Energy cost – in R$/MWh

Migration to the Free Energy Market: Migration to the free market is to opt out of the captive electricity market where the customer is obliged to contract directly from the regional distributor and choose to make an electricity contract in a free contracting environment, where tariff negotiations and contracting deadlines are negotiated and fixed according to figure 21.

Rates adopted by the Free Market: These fees must be paid by the purchasing company even if it is transferred to the free market: TUSD / TUST distribution system usage rate (wire usage parcel); Share losses; commercial losses.



Source: Ecom Energy (2021).

Figure 21. Free Market benefits.

Benefits of the Free Market: Cost reduction, freedom of negotiation, budget predictability, no tariff flag, energy allocation power between own units, energy price is the same both off-peak and on-peak and load (Figure 22).

Impact of the problem found: The migration from the captive market to the free market was the biggest challenge within the implementation project of the certification in the standard. Any unplanned step could entail drastic consequences for the energy supply to the organization, so everything was well planned and evaluated by the Energy Efficiency Committee so the goal has been achieved smoothly without causing disruption or losses in production for the organization. From the interruption of the contract and shutdown by the concessionaire to the purchase of energy by the free market, where we have a consultant to meet such needs.

Source: Ecom Energy (2021).

Figure 22. General benefits in the Free Market Environment

Generation of continuous improvement in the USE's: A QR code system was created with the objective of the participation of all who want to give suggestions for improving energy efficiency for the USE's defined by the organization. The system is simple and has been shared with everyone aiming at contributing to continuous improvement and keeping the efficiency process of machines and equipment increasingly robust and sustainable. The suggestions sent by the team responsible for each USE are evaluated monthly and feedback is given to the participant, whether positive or negative, with respect to the descriptive content. In this way, we have everyone involved sharing and disseminating a new organizational culture that can be taken even to their homes. Figure 23 appears in all the USE's defined in the organization so that improvements are sent by the QR Code system.

PDCA cycle: The methodology used for the implementation process of the standard was was PCDA. For this, we have the opportunity to monitor each step of the process and make the necessary adjustments to obtain the desired result. This was the illustrative configuration for the development of the process steps, as shown in Figure 24.

Source: Authors (2022).

Figure 23. USE Model identification

Source: Authors (2022).

Figure 24. PDCA system

Planning (Plan): After the diagnosis of the organization, the action plan for implementation in the standard was drawn up. In this, the description of all activities with a deadline and the ones responsible was considered. The plans have already been presented in the previous topic of this document.

Execution (DO): The execution phase of the process required a lot of commitment from the team involved, since the development of the measurement system of the USES machines. The construction of an energy efficiency policy, development of procedures and practices to reduce energy consumption, training of all employees and contractors, communication and awareness of the importance of this issue. Daily activities of the infrastructure team in the analysis of existing machines and equipment was of fundamental importance in the certification process. The adaptation and improvements implemented in all the USE defined on the site.

Verification (Check): In this phase, the data found in the measurement processes that resulted in the decision process of our paths to be taken or processes to be implemented were checked. Both the systems part for improving energy processes and reducing energy consumption, as well as the methodology part of the definitions of measurement indicators, objectives and targets and policies and procedures. This check was carried out at each weekly meeting with the Energy Efficiency Committee and expert advisor. And what did not suit the process was carried out a new proposal to support the project. In this context, an integration video was developed so that all visitors and customers understand and seek influence in their organizations regarding the importance of the need to increasingly have a change of culture.

Action: After monitoring the cycle and verifying the actions taken by the committee, new improvement actions were proposed to obtain the best result through the graphics presented by the elecktron system. Actions on the equipment and machines that are not monitored daily by the infrastructure team, where the graphs and trends are evaluated, are possible problems to be corrected. Overall, we know that this is a continuous process where excellence in energy efficiency and consumption reduction is sought to remain competitive in business.

Implementation of ISO 50001: The implementation of this type of energy management system must be carried out with the support of an independent and specialized consultancy. Able to support the internal team in collecting data and information on energy consumption and generating an effective action plan for certification.

Expected Achieved Results: The result obtained after the work was to achieve the certificate through a recognition body in the ISO 50001 standard. Achievement that was only accomplished due to the commitment of the entire team involved in the certification process. The organization is a reference in the industrial pole of Manaus given the pioneering certification in energy efficiency management.

DISCUSSION

To implement an energy efficiency management system in an electronic manufacturing company, it is necessary to primarily have people prepared and focused on this objective, seeking efficient methods and systems to measure the company's energy consumption daily and monitor the results. The follow-up through meetings with senior management, other managers and those responsible solidified the process and the response speed to each action. The training plan where I can reach all company employees and contractors, and a specific plan for key employees responsible for implementation. The methodology of the elektron system that was created by the virtual representation of objects, processes and systems (digital twin), being an encapsulated software that mirrors a single physical objective, process, organization or other abstraction. With this, we had the real-time measurements of the USEs defined at the beginning of the Energy Efficiency Project. This monitoring was fundamental to develop the action plans for improvement of the 13 USEs defined and made a difference in the result. Having entered the free market for energy purchase was also a differential with the energy bill at the end of each month. Energy efficiency indicators have been defined monthly during meetings with senior management, as well as the annual critical analysis evaluation of the management system and internal and external audits. Energy efficiency management system has come to compose within the organization what we need to deal with solutions to reduce consumption and protect the environment, as if the standards were to complete ISO 14001 of Environment and ISO 50001 of energy efficiency. What is gained with everything is the new generation. If more companies had the commitment to seek through the implementation of system, devices and machines with reduced energy consumption, this would be a glimpse to a better future for the next generations. Embracing the level of knowledge in all areas within this project and disseminating actions in general until reaching the employee's home is an extremely important and social process that only generates a firm foundation for this project.

CONCLUSION

The aforementioned project tackled within an electronics company the certification of the energy efficiency management system of the ISO 50001 standard was a success and achieved results in record time of 8 months since the beginning of the decision by the challenge. The gains with respect to energy savings were good in consideration of what we had at the beginning of the project. At the beginning of the project, our energy consumption had high cost and with the certification and action plan for the improvement of USEs, awareness of employees and contractors, it took a meaningful turn. Of course, learning is ongoing and we already have other training in technical concepts for employees regarding energy reduction processes and energy efficiency improvement. In addition, all employees and hires, on the first day of work, already have the training in ISO 5001 so that they earlier understand the basic concepts and daily actions to be followed by all. The elektron system is being implemented in other machines to have a daily evaluation of energy efficiency to evaluate possible improvements such as preventive maintenance in parts and/or in their operation. With the action plan implemented for each USE, the difference in the process was made, and, from now on, the acquisition of new equipment/machines are analyzed and made with respect to energy efficiency and consumption of the same.

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