Business Intelligence in Decision Support Focusing on Collective Continuity Indicators

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Abstract

The expansion of organizations demands more and more information as an input to acquire greater control of activities, and for the treatment of this data. The information technology scenario has a growing and sharp curve, especially in the scope of big data, requiring attributes for analysis and compilation of the data obtained, thus ensuring the provision of information in a timely manner for more accurate and assertive decisions about the future of organizations. Thus, the present study seeks to show how the implementation of a Business Intelligence tool impacts on collective indicators of continuity of electricity supply. Energy is one of the main inputs for organizations and for everyone who depends on it. Its availability allows a guarantee of the continuity of socio-economic development. Therefore, the objective of this was to carry out descriptive research with a quali-quantitative approach through an applied study, having as locus an electric energy distribution concessionaire, approaching the scenarios before and after the implementation of the tool, making it possible to highlight the improvements in the organization through Business Intelligence. It also has an approach regarding the aid in the decision-making process through this tool, and consequently its contribution to the process of continuous improvement.

Keywords: decision support, business intelligence, continuous improvement, big data, availability

1. Introduction

The availability of electric energy has a great contribution to socioeconomic development, as it is a resource that feeds a range of organizational configurations that depends on the resource to operate in their activities. This systematic in turn, replicates in results for society in other products and services, industries, clinics and hospitals, technology companies, banks, schools, universities and public agencies, are examples of organizations dependent on this resource for the exercise of two activities as well as for delivery to society.

Thus, the quality of supply of this resource is essential, which is why the National Electric Energy Agency (ANEEL) requires energy concessionaires to maintain a quality standard in the distribution service, making the calculation through "Collective Continuity Indicators" where the Equivalent Interruption Duration per Consumer Unit (DEC) and the Equivalent Interruption Frequency per Consumer Unit (FEC) are verified.

In order to efficiently guarantee the quality of electrical distribution as well as meet the ANEEL requirement, considering the complexity of the once contextualized environment, managers seek to make decisions and outline innovative strategies, importing technological tools to the organization that help to reduce subjectivity of the decision-making process, mitigating risks and with a view to speeding up the process, which in turn may constitute a competitive advantage (BISPO, 2006; PEREIRA; FONSECA, 1997 apud FREITAS; KLADIS, 1995).

In this regard, advances in Information Technologies (IT) have contributed greatly to organizations, since technological innovations have contributed to the birth of new forms of management at different organizational levels and it is in this context that the decision support tool Business Intelligence, used by managers to bring greater clarity to the analyzes carried out by managers, regarding the continuous search for quality and to acquire a competitive advantage in the provision of services, however, Brazil has low adherence to this tool, where only 9% of companies use Business Intelligence to support the decision-making process, as demonstrated by the Brazilian Institute of Geography and Statistics (IBGE, 2010).

It is important to point out that in this study the characterization of scenarios is used in the sense of contextualization, that is, the period in which the research took place, differing from the sense of scenarios for statistical treatment. During this study, a managerial gap inherent to the allocation of resources of the studied company was identified, considering the incidence of rework in circuits where corrective maintenance interventions of the electrical network had already occurred in contingency periods, due to climatic factors that made the period even more critical due to the recurrence of high impact on the indicators, hurting the quality perceived by customers and the regulatory agent.

The present study is inclined to the application of Business Intelligence in the scope of continuity of electric energy supply, specifically in the performance in maintenance management and the impacts promoted by the tool in the process of concession of electric energy distribution in the state of Rondônia, aiming to mitigate the identified management gap. As main objective, to analyze the impact of the use of the tool in Business Intelligence (BI) in the collective indicators of continuity of the electric energy of an energy concessionaire. And, to support this, the following specific objectives: collect the historical data of the indicators performed by the company to compose a database; compare the scenarios before (2019) and after (2020) implementation of the Reincident Control System (RCS); see how a BI system can support the process of total quality and continuous improvement.

The research seeks to reverse the continuity indicators "DEC and FEC", within the goal established by the organization for customer satisfaction, energy distributors must have a consolidated and efficient management model, which is capable of granting such results. Since from their managerial contributions regarding the administration of production, specifically with regard to maintenance management with a bias in quality management. In maintenance management, the tool resembles a mix of preventive and corrective maintenance plans, thus contributing to the mitigation of new interruptions. Justified also by the contribution of incentive to other organizations to use Business Intelligence resources.

2. Theoretical Reference

It is possible to attribute to electric energy the title or status of essential inputs to society and still indispensable to socioeconomic development. According to ANEEL (2021), in Brazil, the main source of the energy matrix is hydroelectric, corresponding to 62% of all the country's capacity, passing to thermoelectric plants with about 28%, the remaining capacity is attributed to wind and imports from other countries.

The Brazilian Electric Power System (EPS), which supplies energy to the entire population, is divided into generation, transmission, distribution and commercialization of Electric Energy, as shown in Figure 1. As the storage of large amounts of energy is not yet possible, the system must have a power flow control to meet and transport the demand consumed with the quality defined by the National Electric Energy Agency (ANEEL).

Figure 1. Brazilian Electric Power System

Source: BERKAN (2020).

The generators produce the energy, the transmitters transport it from the generation point to the power distribution power substations that are normally located in large consumer centers and from this point the energy is taken to consumers through the electricity distribution networks. There are also traders, companies authorized to buy and sell energy to free consumers (generally consumers who need more energy) (ANEEL, 2021).

Basically, the entire Brazilian system allows the exchange of energy to any region, excluding isolated systems, whose greatest concentration is in the northern region of the country. All this interconnection is possible through the Brazilian National Interconnected System (SIN), which, according to ANEEL (2021), has an extension of more than 100 thousand kilometers of transmission lines crossing the country.

Also, according to ANEEL, it should be considered that only 2% of the entire energy market in the country is in the condition of an isolated system, which are gradually being interconnected to the SIN. The controlling agent of the system is the Brazilian National Electric System Operator (ONS). As a fundamentalist principle, the ONS aims to guarantee the availability of the system as a whole, including in cases of disturbances, even those that may jeopardize the entire system, since load relief comes into play. In general terms, the shutdowns of substations and/or circuits present interruptions that can be purged from the indicators, which are exposed in the next module.

Above the entire institutional system of the Brazilian electricity sector is the National Energy Policy Council (CNPE), chaired by the minister of the Ministry of Mines and Energy (MME). The ministry, in turn, is responsible for controlling the National Electric Energy Agency (ANEEL), a federal agency that has greater responsibility for overseeing and regulating the entire sector in accordance with MME guidelines.

In this study, the regulatory aspects that specifically relate to the quality of service are addressed, which according to ANEEL (2016), is the evaluation of interruptions in the supply of electricity, measured from the collective and individual continuity indicators addressed in the modules following.

The methodology applied is similar to other indicators in the world, considering long-term interruptions, which according to the Rules of Procedures for Electricity Distribution in the National Electric System - PRODIST, Module 1 (2018) are interruptions with a duration equal to or greater than 3 minutes.

2.1 Business Intelligence

The growing use of resources previously linked to Information Technology (IT) has promoted the expansion and insights of new ways to maximize the monitoring potential of various items or even explore points of relationship with customers that were previously excused. Business Intelligence (BI) term coined and patented by the Gartner group, BI is used as a tool to aid in decision making, for market research and marketing. It is also used in areas linked to customer service and also allows for their collaboration on products and services.

According to the definitions of Han, Pei and Kamber (2011), BI is an information system responsible for organizing large volumes of data, this process, also known as data warehouse, can manage and facilitate the relationships between databases (2011). data mining; knowledge Discovery in databases – KDD). Finally, it can provide the user with easy-to-understand interfaces regarding the relationships between the bases, supporting decision-making with better information.

Considering BI as a tool that brings together other technologies in this way, it allows the acquisition and analysis of data as a facilitating means for decision making. Such attributes allow a greater amplitude than just the storage, organization and modeling of data, they also allow a strategic use with regard to data analysis that allow the leverage of the organization's performance, therefore, of the results.

Da Silva, Silva & Gomes (2016), define the premises for BI as: Allowing access to data and information in an interactive and malleable way for the user to define scenarios; Allow data manipulation and provide business managers and analysts with adequate analysis capacity; The possibility of obtaining different insights focused on the business through data analysis and historical events, basing decisions and/or generating forecasts that generate support for the decision-making process.

2.2 Decision Support

In the etymological context, according to Bispo (2006), the word “decision” is composed of the prefix “de” (from conceptualized in Latin as: stop, extract or interrupt) that precedes the word “caedare” (definition of splitting, cutting). In this way, the agglutination of concepts reveals a meaning of “letting it flow”, so a decision must always aim at adopting a solution to a given problem.

The author also defines some as influencing factors that are constant in organizations when they are attributed to certain items: Expansion and/or adequacy of quality; Improvement of service or personalization of the same; Competitive prices; Conditions required by customers or suppliers; Requirements of government agencies; competitors; Organizational culture in the company; Technologies employed; Targeting existing resources.

In exercising the role of administrator of an organization, the decision becomes frequent. Management decisions have an impact directly linked to the survival of the organization and even those that depend on it, that is, employees, shareholders, suppliers or customers.

Then, the decision-making agent is exposed to several influencing factors, taking as main bases, the agents involved in the organization with demands on the same problem with totally opposite solutions and points of view, and it is up to the administrator to establish priorities regarding the objectives and positions of the interested parties,

transforming the organization's objectives into collective objectives, according to (PEREIRA; FONSECA, 1997 apud FREITAS; KLADIS, 1995).

Decisions are similar to acts of power, when they direct resources, define strategies, steer the destiny of organizations and people, managers in turn end up assuming a political dimension very similar to that of a government.

Gates (2005) defines information as something that one wants to obtain and even when there is a need to pay for it; it is neither tangible nor measurable, but it is a valuable product in the contemporary world, as it is the guarantee of power.

According to Pereira, Lobler & De Oliveira Simonetto (2010) a decision-making process takes place through a system between elements of objective and also subjective aspects, such a system is indivisible, therefore, one cannot neglect any aspects when the focus is the decision-making process. .

In the scope of volumetry Silva (2010), defines the decision tree as a technique that allows the creation and organization of rules for classification and decision in a tree form. This technique is performed as a decision support tool by the graphic availability of factors from an initial decision. Also according to the author, one of the biggest advantages of the decision tree is the ability to decompose a given problem into several sub-problems and the same process can be attributed to the sub-problems, delimiting the problems as much as possible.

The use of very well-defined choices focused on the organizational objective has a direct relationship with the improvement of the company as a whole, a process that must be continued to the point of becoming a drill, in this scope the following module deals with continuous improvement.

2.3 Continuous Improvement

During the 1980s and 1990s, discussions on continuous improvement took on volume, especially in the face of increased competitiveness in the market, to the point that products lost their nationality due to such globalization, which by the way drives companies to generate more and more value for customers. As one of the most effective ways to improve the performance and quality of organizations, since its importance in anticipating any change scenario cannot be ignored, therefore, it is fundamental as a root of permanent development in an organization (MARTINS; RAMOS, 2012).

These improvements, according to Evans and Lindsay (2001), can take one or several forms, such as: Performance improvement, which seeks the best way to carry out the process, relating to its efficiency and effectiveness; Costing activities, with a view to reducing costs; Relationship with the customer, as it is a critical moment of any process, must always be aligned with the corporate strategy and constant target of improvement.

The Kaizen philosophy has a Japanese origin, coined in post-war Japan's industries, which had as a vital need for the industry's survival the efficiency-productivity relationship. Masaaki Imai is considered the father of philosophy and defends philosophy as a way of life (ENDEAVOR, 2015).

Continuous improvement through Kaizen is a philosophy based on continuous effort, on inexpensive solutions based on personal commitment, on the involvement of all and on the central premise of fighting waste. The characters of the word Kaizen of Japanese origin and mean KAI = change and ZEN = for the better. Masaaki goes further in the Kaizen translation by defining it in four words: Everyday; Everybody; Everywhere; Improvement. Which denotes a relationship of improvement in all aspects of the individual, personal, social and professional (ILSSI, 2020).

Kaizen can be divided into two aspects, the technique that aims to discover and eliminate activities that do not add value to the product or the total elimination of waste and the other is the human one that needs everyone in the company with the predisposition for changes and new directions in processes. Thus, it is an improvement methodology that demands a continuous effort to offer better products at lower prices. There are numerous tools within this philosophy, such as Lean Six Sigma, the PDCA cycle, the PDSA cycle, the five whys, lean manufacturing, just-in-time, DMAIC, etc. (SPEJO and BUENO, 2019).

For this study, the DMAIC tool was adopted by analogy to the object of study, which refers to a life cycle approach based on Six Sigma for process improvement projects. DMAIC is the acronym for: Define, Measure, Analyse, Improve and Control. Sokovic, Pavletic and Pipan, (2010) define each phase (Figure 2) in a simplified way, they are: Define: Identification, prioritization and selection according to the project; Measure: Measurement of the main characteristics of the process, the scope of parameters and their performance; Analysis: Analysis identifying key causes and process determinants; Improvement: Action to improve the process, optimizing the performance; Control: Control the results while maintaining the gains obtained.

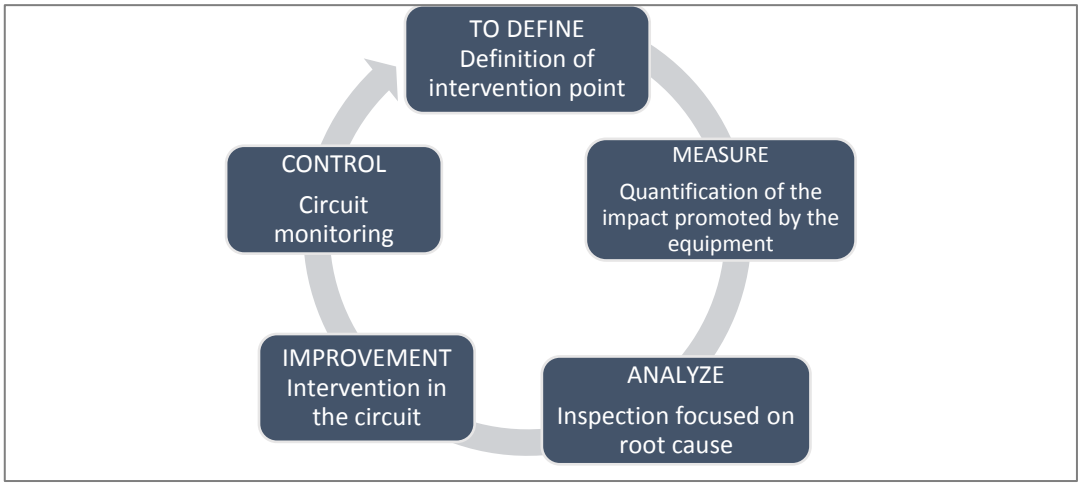


Figure 2. DMAIC Cycle

Source: Adapted from Sokovic, Pavletic and Pipan (2010)

The causes are called Sources of variation, and controlling variation by setting tolerances for sources of variation is an inherent element of the DMAIC method. According to De Mast and Lokkerbol (2012), the Six Sigma DMAIC method is a method with a wide range of application. Its principle of applicability was in the scope of variation reduction.

3. Methodology

According to Prodanov and Freitas (2013), scientific research is the realization of a planned study, in search of knowledge, based on scientific methods to produce reliable results, since it is the search for solutions to a problem that has no answers suitable. For Marconi and Lakatos (2003), "research is a formal procedure, with a method of reflective thinking, which requires a scientific treatment and constitutes the way to know reality or to discover partial truths."

As for the method, the authors define it as a set of procedures that outline the means to be adopted, which allows achieving the objective based on valid and true knowledge. In addition, the scientific method consists of a set of activities developed in order to achieve knowledge of a given problem (PRODANOV and FREITAS, 2013).

With the intention of reaching the general objective and the specific ones, applied research of a descriptive nature was chosen, developed through a bibliographic and documentary survey. The approach has an applied bias, considering the use of Business Intelligence as a determining factor for the improvement of the electricity supply continuity indicators analyzed in this study.

The construction of the instrument was carried out using the tool provided by the Microsoft company, Power BI Desktop, whose license is free. The October, 2019 version (2.74.5619.621) available on the page https://powerbi.microsoft.com/pt-br/downloads/ (MICROSOFT, 2019) was used. In the construction, the bases of assets (equipment), events, and georeferencing of assets were linked.

All the aforementioned bases were extracted from access to the company's Energy Distribution Management System (SGD) databases. Access was through the SQL (Structured Query Language) programming language, which is the standard declarative search language for relational databases (SQL, 2016). The Structured Query Language in Portuguese, Structured Query Language commonly referred to by SQL, which according to Costa (2007), is a declarative search language for databases.

Also, according to the author, the development of SQL took place in the early 70's specifically in IBM laboratories, which initially was part of the System R project which later became the base language of statistical software, its prototype was named SEQUEL, an acronym of Structured, English, Query, Language. Although born in IBM laboratories, SQL was improved by the American National Standards Institute (ANSI) in 1986 and by ISO in 1987, consolidating the language used.

Finally, the treatment of the data that compose the structure of the tool, the base was treated by ETL (Extract, Transform and Load - Extraction, Transformation and Loading) observing in the process, the suitability for the concatenation of the databases.

After the construction of the tool, the implementation phase of the tool began. Throughout this phase, the areas of direct intervention in the network, alignments around deadlines and attributions, were involved.

Regarding the delimitation of scope for action, the following premise was adopted: to define the degree of priority through the feeder segmentation, an entity of the distribution network that can be defined as a line intended for the transport of medium voltage energy (between 13.8 kV and 34.5kV).

For the purpose of better understanding the structure of an electrical feeder, the analogy of a tree will be used, so that the trunk is equivalent to the main part of the feeder, leaving the substation (the roots), thus feeding the circuit shunts (branches).

Distribution feeders have the following segmentation:

T_0: Part with the greatest impact potential from transmission lines (networks between 69kV and 138kV);

T_1: Main section of the feeder trunk comprising the substation circuit breaker to the first recloser, greater offensive potential the possible proportion that an interruption in this section can take;

T_2: Section from the first recloser to the beginning of the branches (branches), that is, the remaining part of the feeder trunk;

T_3: Section that is linked to the branch branches of the feeder trunk, section of smaller coverage, therefore, it has a lower degree of priority.

Figure 3 graphically represents the segmentation of an urban perimeter feeder. The same segmentation is equivalent for rural circuits. Circuits with attributable characteristics for definition as T_0 were not addressed due to the peculiarity of the circuit.

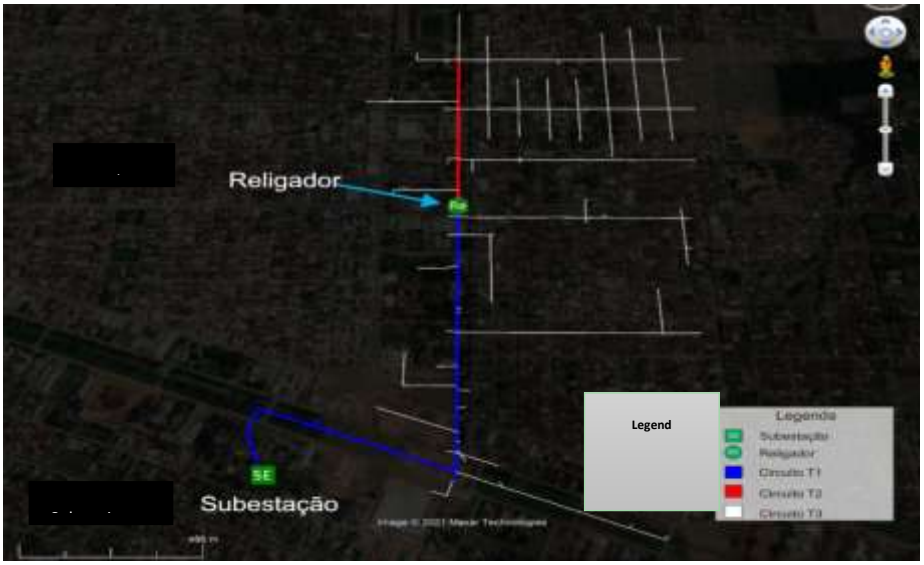


Figure 3. Circuit segmentation

Source: Data from this research

After defining the scope and priorities between the Transmission Maintenance Departments (DEMT), Distribution Construction and Maintenance Department (DCMD) and Operation Department (DEOP), the deadlines for servicing the equipment were defined, as follows: T_0 (transmission) and T_1 – 01 (one) day, T_2 – 07 (seven) days and finally T_3 with 15 (fifteen) days for service.

4. Results and Discussion

Currently, the ENERGISA Group is one of the main groups in the Brazilian electricity sector, and is considered the 5th largest in energy distribution. Serving 862 Brazilian municipalities and present in all regions of the country, operating in the most different areas of the electric sector such as generation, distribution, transmission and commercialization and also provides services and integrated solutions in this same market. One of the first Brazilian companies to go public, in 1907 (ENERGISA 2021b).

The company's core business activity is energy distribution, according to Energisa (2021b), in 2014, the company completed the acquisition of eight new companies in the distribution area, promoting it to a new market dimension.

In 2018, the group acquired at auction CERON and EletroAcre, companies of the Eletrobras Group responsible for the distribution of energy in the states of Rondônia and Acre respectively, the company was also able to acquire in auction, but this time for transmission, the transmission right in Pará that will act as reinforcement and improvement for the North of Mato Grosso and also for the West of Tocantins (ENERGISA, 2021c).

With regard to distribution, the Group is composed of 11 companies, located in the states of Minas Gerais, Sergipe, Paraíba, Rio de Janeiro, Mato Grosso, Mato Grosso do Sul, Tocantins São Paulo, Paraná, Rondônia and Acre, serving 7.7 million customers, reaching an approximate number of 20 million people. The combined capacity of the business units corresponds to 2,034 million km ² of distribution concession area, around 19,600 km of transmission lines, more than 600,300 km of distribution lines fed by 683 substations, subsidizing a consumption of 34,749.2 GWh of electric energy and a human capital of 19 thousand employees and third parties (ENERGISA, 2021b).

Energisa Rondônia is responsible for the sale of electricity throughout Rondônia, 52 municipalities, serving approximately 670,000 consumer units, equivalent to a population of 1.8 million people, fed by 78,800 km of distribution networks (ENERGISA, 2021a).

The company established itself in the state after the acquisition of the concession agreement for the distribution of electric energy in the state, thus acquiring the defunct Centrais Elétricas de Rondônia [CERON] in mid-November 2018, for this reason the historical base begins in the year of 2019 (considering the concessionaire's "zero" year).

The company was characterized before the implementation of the Recidivism Control System [SCR] and then the study will point out how the scenario is after the implementation of the system. Finally, the analysis between the scenarios will be used. After the acquisition of the company by the Electricity Distribution Public Service Concession Agreement No. 02/2018 - ANEEL, Energisa Group restructured the hitherto CERON, especially with regard to investment in the distribution network

The analysis of the indicators was carried out as follows: there was a follow-up plan for the main offenders of the collective continuity indicators (DEC and FEC). This monitoring was aimed at repeating electrical feeders, that is, circuits that have a great impact on global indicators (company).

The concept of equipment recurrence can be applied equally to electrical feeders, however, unlike the SCR, the previous focus was based on the indicator of what was performed on the feeder regardless of the recurrence and type of intervention, thus accounting for even scheduled maintenance indicators. This indicator is recognized as “good”, that is, without recurrence, based on the premise that the indicator is already expected.

It is important to define the strategic scope of segmentation of the state of Rondônia into regions and centers that it already had before the distributor's concession, as shown in Figure 4. The entire concession area has three regions: North, Center and South. And, internally, in the regional, poles are delimited which are linked to affluent cities capable of subsidizing the surroundings, as follows: Porto Velho, Guajará-Mirim, poles of the North Region; Ariquemes, Jaru, Ji-Paraná, centers of the Regional Center; Cacoal, Rolim de Moura, São Miguel do Guaporé and Vilhena, poles of the Southern Region.

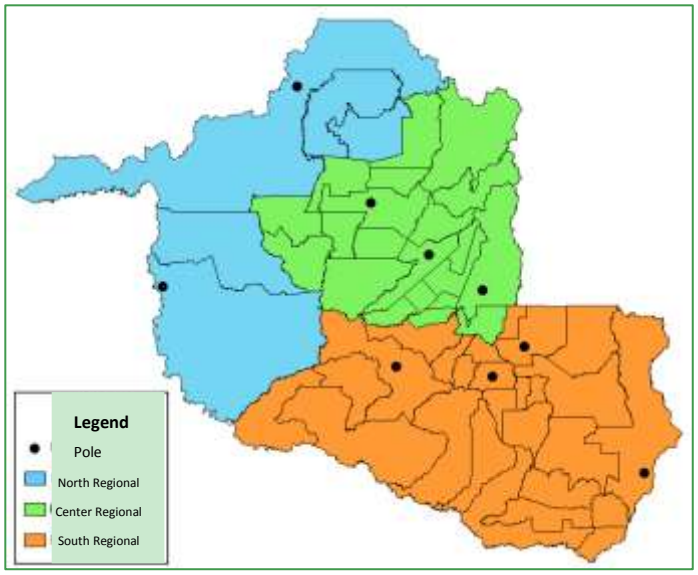


Figure 4. Segmentation by Energisa Rondônia's concession area (ERO)

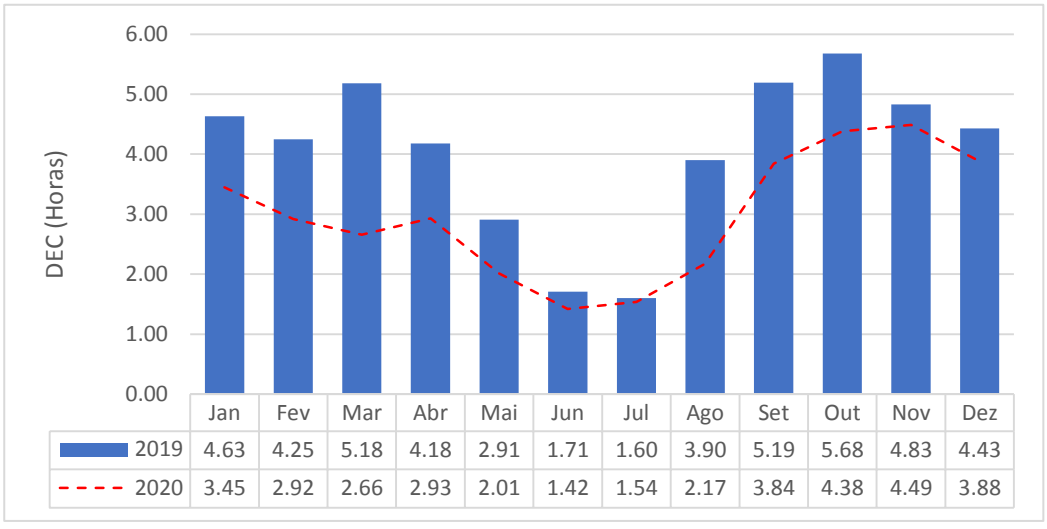
Source: Data from this survey.

Based on a macro vision aimed at reducing Energisa Rondônia's (ERO) electricity supply continuity indicators, the "Top 10 Feeders" project was developed in 2019, with the objective of observing the first 10 feeders of each region, observing the DEC impacts. At the same time, the "Owner of the Feeder" project was created, where technicians were tasked with the mission of inspecting and maintaining the feeder with up-to-date maintenance inspections. For that, shutdowns were programmed and/or included the precarious section, located by the owner of the feeder for the intervention to occur.

After the termination request, the regulatory agency provides for a minimum period of 15 days for personalized notice of group A customers and broadcasting notices of termination in mass channels. ERO's distribution network has 336 electrical feeders.

The Top 10 project was disseminated internally to interested departments as a newsletter, via e-mail. Maintenance of network sections and/or equipment is at the discretion of each department.

As a comparative average, Graph 1 shows the improvement in performance related to the duration of interruptions.



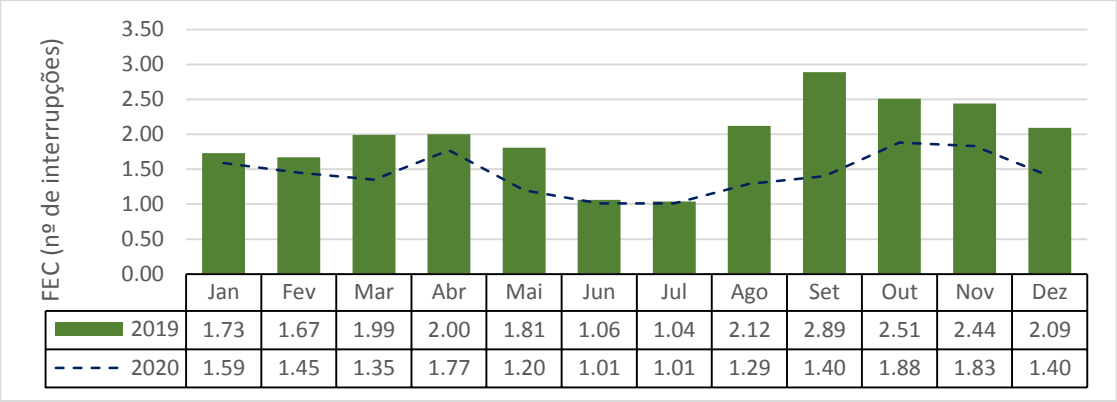
	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
2019	4.63	4.25	5.18	4.18	2.91	1.71	1.60	3.90	5.19	5.68	4.83	4.43
2020	3.45	2.92	2.66	2.93	2.01	1.42	1.54	2.17	3.84	4.38	4.49	3.88

Graph 1. Comparison between DEC (2019) and DEC (2020)

Source: Prepared by the authors

In general, the year 2020, after using Business Intelligence (BI), had a lower average interruption compared to 2019. The results also suggest that the contributions of BI occurred in a constant throughout the year 2020. It is also worth noting that the first four months presented the most expressive results regarding the improvement in performance, since it represents the first period of monitoring of the process, with a period of greater verification and adjustment of the processes, converging with what Sokovic, Pavletic and Pipan guides (2010), for improvement and efficiency in results.

It can also be inferred, explanatory for the averages presented in the months of June and July of the years 2019 and 2020, given that in both years they differ from the other months of the year, which is due to the dry period in the region studied, which is why which there is rationality in the supply of electrical energy. However, comparing the averages in those months, the year 2020 still has less interruption in supply, and therefore, corroborates the effectiveness in the application of Business Intelligence associated with the decision-making process. Graph 2 presents the comparison in the FEC evidences the performance with a bias for load blocks.



	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
2019	1.73	1.67	1.99	2.00	1.81	1.06	1.04	2.12	2.89	2.51	2.44	2.09
2020	1.59	1.45	1.35	1.77	1.20	1.01	1.01	1.29	1.40	1.88	1.83	1.40

Graph 2. Comparison between FEC 2019 and FEC 2020

Source: Prepared by the authors

In January 2020, there was a massive event with an approximate proportion of an interruption of 6% of the entire state of Rondônia.

A relevant and noticeable fact is the reduction of load blocks even in the most critical period, the rainy season. For comparative purposes, ERO closed the year 2019 with a DEC indicator of 48.57 hours and the FEC of 23.40 interruptions, by analogy, these indicators denote that Rondônia, in 2019, had a sum of duration of interruptions of 48 hours and 34 minutes through 23 blackouts.

For 2020, ERO closed the year with a DEC of 35.70 hours and an FEC of 17.20 interruptions, therefore, a sum of the duration of interruptions of 37 hours and 42 minutes through 17 blackouts.

The contribution to the continuity of supply indicator corroborates the one proposed by Martins & Ramos (2012), together with the understanding of Evans and Lindsay (2001), so that the authors culminate the concepts about the continuous performance of an organization with a focus on of efficiency and effectiveness. The SCR became a tool of wide application within the ERO, as a basic premise was the follow-up of the NS attendance, however its applicability went beyond, allowing managerial views within the technical scope, such as regions and/or poles that most offended the indicators of the company, follow-up of service notes, follow-up on the effectiveness of the intervention in the device/circuit, in addition to the follow-up of repeat equipment, including current and historical scope views, especially at the end of 2020, this tool was used as an input. for the preparation of legal aids.

Such visions thus allow decisions focused on results and demand management, considering that the entire tool was built on the concept of sight management, striving for the rapid absorption of the requested content in addition to a dynamic and interactive interaction so that even those who do not outside the area can interact with the tool. Figure 5 represents the tool's initial screen.

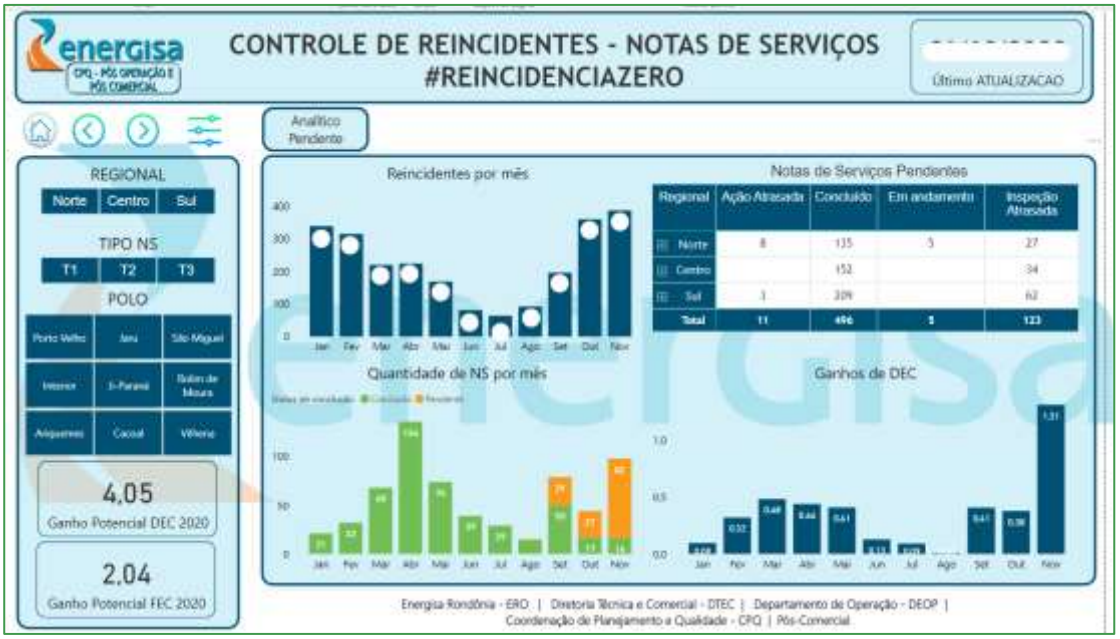


Figure 5. SCR home page - Control of repeat offenders - Service Notes

Source: Relapse Control System - SCR (2020)

The capture of the SCR (backup prior to migration) demonstrates the possibility of monitoring focused on the scope of the indicator and also pending. Still in this proposal, Figure 6 allows a look at the impact specifically on pending issues, that is, indirectly suggesting which service note should be prioritized, also delivering a brief summary of the latest device events.

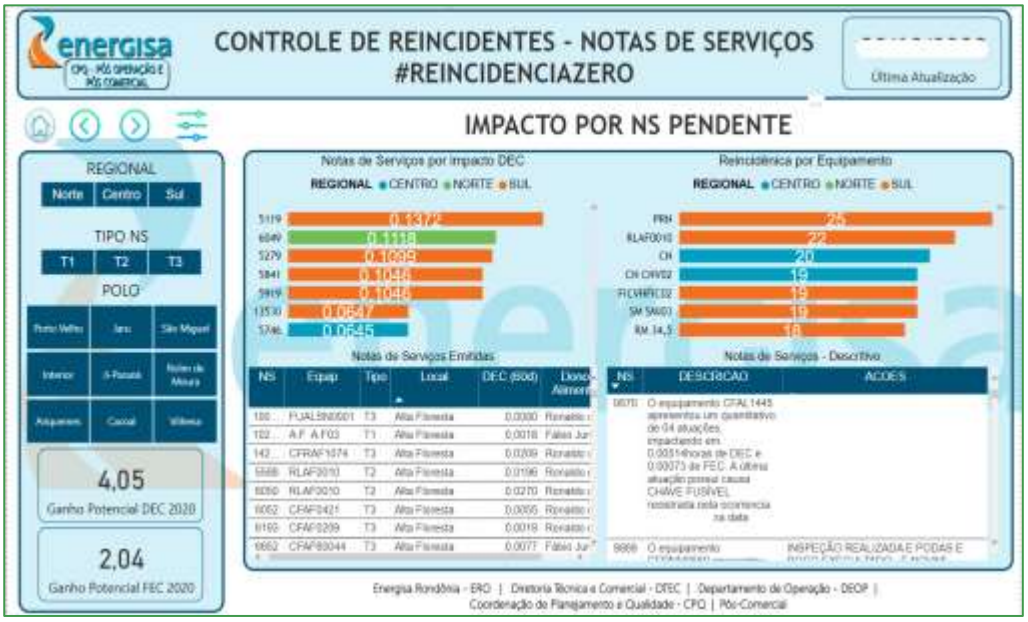


Figure 6. Pending impact page - Control of repeat offenders - Service Notes

Source: Relapse Control System - SCR (2020)

The purpose of the screen shown in Figure 6 is precisely to facilitate the end user with the end-of-project proposal, that is, agility in matters of content observations and simplicity for extracting information, as in the case of the aforementioned one, a field technician would access the system and would prioritize the grades with the greatest DEC impacts or the greatest number of actions that are directly linked to FEC.

Visions like these promote inputs for internal alignments and when added to the visions of intervention effectiveness, each regional and pole can better direct their actions. The proposed tool follows the idealized Sokovic, Pavletic and Pipan, (2010), following the flow from the dimension of the repeat offenders, impact measurement, analysis from the Pareto principle, Improvement given from the intervention to the distribution and control network in through the tool itself in a period after the maintenance.

As evidenced in the findings of the study, the performance of ERO during 2020 was positive in terms of shorter duration of interruptions and also smaller and smaller load blocks, through the SCR 635 service notes were issued (until migration of systems), the precise targeting of sensitive points in the distribution network resulted in a total gain of 4.05 hours of DEC from 12.87 hours and a reduction compared to 2019. The FEC scenario is 2.04 interruptions of the 6 reduction interruptions when compared to 2019, the SCR alone avoided 2 2-hour blackouts throughout the state of Rondônia. Figure 7 highlights the scenario of repeat offenders found in January 2020.

Figure 7. Map of equipment in January 2020/ Map of equipment in Nov. 2020

Source: Relapse Control System - SCR (2020)

The construction of the tool was made in such a way that the greater the number of recidivism will be the size of the circumference, each point means an equipment that is in the condition of recidivist. Based on contrast, Figure 8 represents a similar capture of the repeat offenders scenario in November 2020.

Clearly a sharp reduction in the central and southern regions of the state, thus demonstrating the effectiveness of the tool in the 2020 cycle. It is important to note that the period observed for ERO was in contingency, due to the breach of contract with a company that provided services to the concessionaire further reducing the number of personnel in the field, in addition to facing storms with a higher level of damage to the electrical network than usual.

In this scope, as exposed by Da Silva, Silva & Gomes (2016) about BI, the availability of information capable of supporting a foundation of a strategy linked to the maintenance of the distribution network. In addition to confirming what was proposed by Pereira, Lobler & De Oliveira Simonetto (2010), about decision-making observing the objectivity of the items and the subjectivity attributed to each decision-making agent influenced from the influence items defined by Bispo (2006), especially with regard to the expansion and/or adequacy of quality, which in turn is directly linked to continuous improvement.

Another point to be considered is the noticeable impact on the extreme regions of the state. This fact is due to the difficulty of allocating resources to the locations in the period, difficult access. A determining factor is that, for the most part, the points are feeders of Thermoelectric Power Plants (UTE), so the ERO faces an attribution field, since the UTE is responsible only for the generation of energy, however a a considerable part of the interruptions are of

external origin, therefore, the distributor's actions stop at charging for the maintenance and synchronization of the generation machines.

From this study it is possible to establish a relationship between the tool and the DMAIC of Sokovic, Pavletic and Pipan (2010), so that the definition of the point and/or equipment for intervention through the Pareto principle based on the measured impact, which in this study was about DEC and FEC, analyzing the intervention proposals from the DEC and recidivism index to define priorities. The improvement is in the intervention itself and control through the tool, observing the incidence of new interruptions after the intervention. All this control provides the return of the equipment to the list of possible interventions, making clear the relationship with continuous improvement, therefore, the Kaizen philosophy.

5. Conclusion

This chapter presents the considerations regarding the entire study carried out and exposed above. It is observed that the specific and general objectives were met, and thus, the requirements of this monograph.

In this way, the present study was dedicated to analyzing the contributions of a system based on Business Intelligence in the indicators of continuity of electricity supply, thus understanding the related factors between the support for decision making offered by the BI, making this possible way to improve the quality of the energy distribution service.

Likewise, the study carried out through this work analyzed the impact of the Business Intelligence (BI) tool on the collective continuity indicators of a power utility, especially after the concession of the distributor, having to execute an improvement plan throughout the network. of energy distribution in the state of Rondônia, definitions of the regulatory agent, together with the narrowing of the targets imposed by the regulator and the growth of the impact factor within the items of regulatory governance.

It was observed that the applicability of the tool in the scope of continuity exceeded expectations, responsible for 1/3 of the performance improvement compared to 2019. In addition, only factors linked to continuity of supply were considered, with historical bases of indicators carried out in the years 2019 and 2020. Specifically, an approach focused on the DEC and FEC indicators, therefore, indicators of a collective nature.

In view of this, the limitations found for the development of this study occurred due to the reduced volume of data in this study view. Another limiting factor is that the previous maintenance plan was of a much broader scope, making the comparative effect of gains in indicators unfeasible by contrasting methodologies. The gains promoted by the implementation of the tool are impacted by the following factor: the interventions accounted for in this study are linked to live line maintenance (without disconnections), therefore, gains from high impact interventions, both structural in the distribution network and in the scope of continuity, given the need for shutdown for major interventions.

Regarding the first specific objective, where it was intended to collect the historical data of the indicators performed by the company, it was evident that there are deviations in the registration of interruptions, mainly in points that violate some items of regulatory compliance, that is, the records were not reliable to the interruptions. in the field. Such deviations were located to a lesser extent in the 2020 base. These deviations were organizational defects of the real-time operation of the state-owned period, it is even concluded that the applied policy promoted positive results both in the managerial and regulatory scope, so the objective was met, noting that this item became input in the characterization of the scenarios before and after the implementation of SCR.

Regarding the second specific objective, comparing the scenarios before and after the implementation of the tool, it was observed that in 2019 as a whole, the use of the "Top 10 Feeders" project implied a mapping of the main offending feeders of the indicators. However, its use implied a high rate of recidivism and a considerably higher expenditure of labor, based on the premise that the feeder, as a whole, was inspected. The state of Rondônia has long and radial circuits, of inter-municipal extension, like few seen in the country. These are mainly rural circuits, which are even on private properties, implying longer inspection times.

After the implementation of the tool, there was a change in the scenario, and there was no waste of labor, as before the application of the tool. These scenarios were studied in the Results and Discussions chapter.

Therefore, from a managerial point of view, there is greater man-hour savings, and in the case of the distributor, this fact means greater availability of field teams to attend to emergency interruptions, and also the managerial gains to the reduction of OPEX directed to the teams maintenance, associated with greater effectiveness of interventions, thus meeting the second specific objective.

The third objective, to address the importance of adopting BI as a decision-making support tool, through the analyzed results, being positive and evidenced from the reduction of repeated equipment, thus incurring in the reduction of the indicators of continuity of supply, thus inferring greater availability of electricity supply. Contributing to resource management in addition to the contributions described above further reduces the volume of discontinuation compensation by retaining capital for the organization.

To meet the fourth specific objective, to verify how the BI system can support the process of total quality and continuous improvement, it was possible to infer indirectly, through the other specific objectives, observing the precision applied in the management of priorities, reduction of indicators and expenses.

Contributions to the managerial vision are of high impact, delivering the information necessary for decision making, thus providing input for the reallocation of resources previously used in new priorities and/or retaining capital for the organization's investment. The use of BI promotes decision making in scenarios of constant change and also in control scenarios, allowing long-term decisions through forecasts that are based on several factors and variables such as frequencies and seasonality.

As for the general objective, to analyze the impact of the tool in Business Intelligence (BI) on the collective continuity indicators of a power utility, the expressive result achieved throughout this research, clearly evidenced the effectiveness and precision in the indication of the most offending points of the network. distribution system as a whole, with a direct impact on service quality indicators, which focus on the availability of electric energy.

Therefore, it becomes highly functional, considering that the results obtained through this study demonstrate a high impact on managerial views, especially in the area of maintenance management, including opening possibilities of application in different work fronts and scopes, which will be pointed out further. The main contribution is sight management and managerial views both macro and micro, allowing the management of the most diverse hierarchical functions, including the exchange of resources between regional and/or service centers in order to minimize any contingency.

After achieving the objectives proposed for this work, it was possible to generate information that will serve to reinforce the perpetuation of the monitoring tool and also as subsidies for new monitoring perspectives, in addition to contributing to the dissemination of the use of Business Intelligence in organizations, given that according to evidence by the IBGE (2010), the number of companies that use the tool is low.

It should be noted that the reduction achieved in DEC, in a total of 12 hours and 52 minutes, was the most significant achieved by the country's business units, being a national record.

This study was heavily impacted by the following events, the cyberattack that took place in April 2020, the high-impact interventions in the distribution network through scheduled shutdowns and, finally, the corona virus pandemic.

From future research, it is of high contributory potential for society and organization, in-depth research on individual continuity, therefore, allowing an analysis involving compensation for discontinuity and also violations. A study involving the applicability of BI in the predictability of compensation would also be of great contribution, through the occurrence of interruptions in the current month and, finally, a study involving the perceived satisfaction of customers observing the improvement of continuity indicators.

Such accompaniments allow a managerial vision, at the organizational level and points of weakness of the OPEX, allowing the manager a multidisciplinary accompaniment in the organization. It is inferred that the application of Business Intelligence, in these items, will contribute to the reduction of compensations, improvement in the customer satisfaction index and consequently to the lower occurrence of complaints with the company's Ombudsman and, consequently, reduction of the incidence of legal proceedings.

References

Berkan. (2020). Energia. Retrieved 13 February 2021, from https://berkan.com.br/atuacao/energia

Bispo, C. A. F. (2006). *Um novo modelo de pesquisa de Clima Organizacional.* São Carlos.

Costa, R. L. de C. (2007). *SQL Guia Prático-2a edição*. Brasport.

Da Silva, R. A., Silva, F. C. A., & Gomes, C. F. S. (2016). O uso do Business Intelligence (BI) em sistema de apoio à tomada de decisão estratégica. *Revista GEINTEC-Gestão, Inovação e Tecnologias, 6*(1), 2780-2798.

De Mast, J., & Lokkerbol, J. (2012). An analysis of the Six Sigma DMAIC method from the perspective of problem solving. *International Journal of Production Economics, 139*(2), 604-614.

Endeavor. (2015). Kaizen: a sabedoria milenar a serviço da sua melhor gestão. Retrieved 3 July 2015, from https://endeavor.org.br/operacoes/kaizen

Energisa (2021c). Nossa história. Retrieved from http://holding.grupoenergisa.com.br/paginas/grupo-energisa/nossa-historia.aspx

Energisa. (2021a). Base histórica de dados do Grupo Energisa até mar/21- em Excel. Kit do Investidor. Retrieved 12 March 2021, from https://api.mziq.com/mzfilemanager/v2/d/60f49a2d-bd8c-4fd9-95abbdf833097a83/647a2be1-28ea-b961-129a-3af9e7bde2a4?origin=1

Energisa. (2021b). Sobre o grupo. 2021. Retrieved from http://holding.grupoenergisa.com.br/paginas/grupo-energisa/sobre-o-grupo.aspx

Evans, J. R., & Lindsay, W. R. (2001). *The Management and Control of Quality.* Australia: South Western.

Gates, B. (2005). *Unleashing the power of creativity.* Edited by Jay Alison and Dan Gediman. NPR.

Han, J.-W., Kamber, M., & Pei, J. (2011). Data mining concepts and techniques third edition. *The Morgan Kaufmann Series in Data Management Systems, 5*(4), 83-124.

Ilssi. (2020). Everyday, Everybody, Everywhere …definition of Kaizen. Retrieved 19 April 2021, from https://ilssi.org/everyday-everybody-everywhere-definition-of-kaizen

Instituto Brasileiro de Geografia e Estatística [IBGE]. (2010). Pesquisa TIC-Empresa. Pesquisa TIC-Empresa. 2010. Retrieved 13 February 2021, from https://ftp.ibge.gov.br/Tecnologias_de_Informacao_e_Comunicacao_nas_Empresas/2010/pdf/tab_2_informacoes_gerais.pdf

Kladis, C. M., & Freitas, H. M. (1995). O processo decisório: modelos e dificuldades. *Revista Decidir, 2*(8), 30-34.

Marconi, M. de A., & Lakatos, E. M. (2003). *Fundamentos de metodologia cientfica* (5th ed.). São Paulo: Atlas.

Martins, R., & Ramos, D. (2012). Kaizen – muito mais que Melhoria Contínua, *Blog da qualidade*. 21 de jun. de 2012. Retrieved 12 November 2019, from https://blogdaqualidade.com.br/kaizen/

Microsoft. (2019). Microsoft Power BI Desktop. Retrieved 13 February 2021, from https://powerbi.microsoft.com/pt-br/downloads/

National Electric Energy Agency (ANEEL). (2010). Resolução Normativa nº414/2010, de 09 de setembro de 2010. Estabelece as Condições Gerais de Fornecimento de Energia Elétrica de forma atualizada e consolidada. Retrieved 20 January 2021, from https://www.aneel.gov.br/documents/656877/14486448/bren2010414.pdf/3bd33297-26f9-4ddf-94c3-f01d76d6f14a?version=1.0

National Electric Energy Agency (ANEEL). (2016). Resolução Normativa nº506, de 4 de setembro de 2012. Dispõe sobre as condições de acesso ao sistema de distribuição por meio de conexão a instalações de propriedade de distribuidora e dá outras providências. Retrieved 20 February 2021, from http://www2.aneel.gov.br/cedoc/ren2012506.pdf

National Electric Energy Agency (ANEEL). (2021). Indicadores Coletivos de Continuidade. Retrieved 13 April 2021, from https://www2.aneel.gov.br/aplicacoes/indicadores_de_qualidade/

Pereira, B. A. D., Lobler, M. L., & De Oliveira Simonetto, E. (2010). Análise dos modelos de tomada decisão sob o enfoque cognitivo. *Revista de Administração da Universidade Federal de Santa Maria, 3*(2), 260-268.

Procedures for Electricitiy Distribution in the National Electric System [PRODIST]. (2018). Módulo 1: Introdução. Retrieved 8 February 2021, from https://www.aneel.gov.br/documents/656827/14866914/M%C3%B3dulo1_Revis%C3%A3o10/f6c63d9a-62e9-af35-591e-5fb020b84c13

Prodanov, C. C., & Freitas, E. C. De. (2013). *Metodologia do Trabalho Cientfico: Métodos e Técnicas da Pesquisa e do Trabalho Acadêmico* (2nd ed.) Universidade FEEVALE. Novo Hamburgo – Rio Grande do Sul – Brasil.

Silva, A. F. Da. (2010). *Business Intelligence:* auxílio na tomada de decisão.

Sokovic, M., Pavletic, D., & Pipan, K. K. (2010). Quality improvement methodologies–PDCA cycle, RADAR matrix, DMAIC and DFSS. *Journal of Achievements in Materials and Manufacturing Engineering, 43*(1), 476-483.

Spejo, J. M. R., & Bueno, A. F. G. M. (2019). O Avanço Da Metodologia Lean Manufacturing No Mundo Globalizado. *Revista Interface Tecnológica, 16*(1), 302-313.

Structure Query Language [SQL]. (2016). SQL Server 2016. Retrieved 13 February 2021, from https://www.microsoft.com/pt-br/sql-server/sql-server-2016