Journal of Engineering Science and Technology Review 14 (6) (2021) 201 - 210

JOURNAL OF
Engineering Science
and Technology Review

www.jestr.org

Research Article

Evaluation of the Maturity in the Management system of Maintenance of Electricity Distribution Networks – A Case Study

Lorenna Baptista de Oliveira[1], Nissia Carvalho Rosa Bergiante[1], Marcio Zamboti Fortes[1,*], Vitor Hugo Ferreira[1], Bernardo Salgado Moreira[2], Fernando Carvalho Cid de Araujo[3] and Gilson Brito Alves de Lima[1]

[1]Fluminense Federal University, Brazil
[2]Energisa, Brazil
[3]HOC Automação, Brazil

Received 4 August 2021; Accepted 21 December 2021

Abstract

The need for continuous improvement of corporate processes, several maturity models have been developed in recent years. As in industry, several studies have developed in the electric power sector. This work seeks to development of a maturity model applied in the maintenance of the Brazilian electric sector. Based in bibliographic research was build a maintenance maturity model, which evaluated three criteria: team positioning, work team sizing, and work schedule. It included five stages of maturity progression. To validate it in Brazilian scenarios, a company from the electricity distribution sector was evaluated to reach new levels of maturity of the corporation.

Keywords: Maturity model; management systems; maintenance process; Maintenance management models.

1. Introduction

The word maintenance derived from the Latin *manustenere* means "to keep what one has". According to Almeida [1], although its definition is presented in different ways by certification bodies, in all of them there is an emphasis on the concern with the proper functioning of machines and equipment, especially in the production system.

Characterized by high dependency on technology and systems, modern industries face the intense global competition that turns their equipment and its reliability and availability into crucial assets for business success [2-6].

Consequently, with the emergence of mechanization, industrialization, automation and technology development, maintenance has also evolved not only in practical procedures but also in maintenance management. These developments have helped improve product quality, increase reliability, and reduce accident risk and customer satisfaction [1].

Thus, the importance of maintenance management relies on the premise that poor performance of the machine, downtime and inefficient operation of the plant lead, among other consequences, to production losses, which may affect the profit and contribute to a loss of opportunities and market share [7]. Thus, enhancing the maintenance management becomes vital to ensure competitive advantage between firms.

Therefore, to guarantee that good practices will not only be implemented but also kept in the daily operations, the scope of maintenance management may include well-defined performance indicators. These metrics will support the maintenance management process and also will help the accomplishment of the long-term economic viability of the operations [8].

Despite the importance of maintenance for companies, this function has not always had been a strategic area. As pointed by Barbera et al. [9], the need for an integrated maintenance area within the organization is known since 1970s. However, a study showed that about 40% of the organizations investigated had not yet realized the importance of effective maintenance management [7]. In Fraser et al. [10], the authors also states that historically maintenance and its costs were considered a "necessary evil".

Although some companies have not realized the importance of maintenance management, the increasing pressures to obtain and retain competitive advantage are making maintenance management focus change, making maintenance increasingly proactive [7]. Therefore, identifying ways to cut costs, improve quality, and reduce time to market becomes increasingly important for corporate competitiveness [11].

Several models of maintenance maturity have been developed in view of the need for continuous improvement of the maintenance processes. These maturity models assess the strengths and opportunities for improved maintenance management practices in organizations. Thus, maturity becomes a measurement that can be used to provide decision-makers with information to formulate the right decision for the next step toward best practices in maintenance management, and to compare performance across [2-3].

In this work, a maintenance maturity model is proposed, and its validation is tested in a group of companies in the Brazilian electricity distribution sector. The proposed model evaluates the Electric power distribution system planning [12], in all its three levels known as strategic, tactical and operational which involves, among other characteristics, the operational bases allocation (strategic level), sizing and allocation of the operation teams (tactical level) and distribution of services and scales of operational crew

*E-mail address: mzamboti@id.uff.br
ISSN: 1791-2377
doi:10.25103/jestr.146.23

(operational level). The proposed methodology can be applied in other sectors and industries.

For its development, this document is divided into 4 parts. The second part has a literature review is conducted, addressing more deeply the topics of maintenance management and maturity models. Some models of maintenance maturity are also evaluated in this order to subsidize the approach proposed. In the third part there is an address the methodology of the work. In the sequence a model is presented and a case study in the electric power sector is conducted It is at this stage that the results from the application of the model are discussed. The final considerations are presented in last section.

2. Literature Review

2.1. Maintenance Management

According to Chemweno et al. [6], maintenance can be defined as a set of activities necessary to maintain an installation or equipment in an "as-built" condition and thus guarantee the original productive capacity. The general literature says that work states that the maintenance function is not only focused on the equipment or system, but also through its proper operation must ensure the safety and protection of the environment. In Stefanovic et al. [8] points out that the role of maintenance is also in controlling quantity, quality and cost, so it should not only ensure optimal operating conditions, but also its effectiveness.

As in maintenance, maintenance management has undergone several changes over time. With the increase in automation, mechanization, and evolution of production processes the role of the management has become increasingly important [8].

Maintenance management has undergone several changes over time. Historically maintenance management models have gone through a few cycles. In Barberá et al. [9] can be thoroughly analysed the evolution of maintenance and maintenance management, since the pre-Industrial Revolution period, where artisans were responsible for the maintenance of buildings, primitive machines, and vehicles using their experience and observation to repair parts, to the present day where the reliability aspect of availability has become more important in relation to serviceability.

According to Fraser et al. [10] maintenance management can be divided into two main types of maintenance models: the corrective maintenance (CM) and the preventive maintenance (PM). While the corrective maintenance sought to correct, restore the productive capacity of equipment or installation that diminished its capacity to perform the functions for which it was designed, preventive maintenance seeks, according to a pre-established schedule, improve the quality of the products from the conditions of equipment. Thus, work such as changing parts and oil or cleaning, are performed periodically following the installation and operation manuals that accompany the equipment Bruin et al. [11].

Corrective maintenance is the simplest maintenance management model because its performance is based on equipment/system failure. For this reason, it is sometimes referred to as failure-based or unplanned maintenance. A disadvantage of this model is presented in Borba et al. [12], the author states that the failure of certain equipment can trigger other problems which can make this management model expensive. Also, in cases where subsequent part breaks occur on the same equipment, the time used for maintenance causes the plant to stop for long unscheduled periods.

According to Kans et al. [13], few companies actually use this maintenance model. This is because the corrective maintenance model is characterized by the high cost of spare parts inventory, high labour costs, high machine downtime, and low production availability. Thus, in almost all cases where the model is used, industries perform basic preventive tasks.

In order to reduce the limitations of the corrective maintenance management model, the preventive maintenance model has been proposed. In this sense, we sought to reduce the likelihood of failures by performing maintenance tasks at regular and fixed intervals.

According to Borba et al. [12], preventive maintenance has the advantage of early planning and scheduled execution, cost savings due to damage prevention and reduced downtime. In contrast, their execution is performed regardless of the condition of the elements, it's being performed on elements that could sometimes have remained in a safe and acceptable operating condition for a longer time. Or failing to repair the equipment that because they work exhaustively would need maintenance prior to the others. Also, in cases where during maintenance a human error occurs, equipment may end up worse than before maintenance. In this sense, preventive maintenance involves additional costs and is only worthwhile if the benefits exceed the costs Carvalho et al. [14].

Selecting a maintenance strategy depends on several factors, including the cost of downtime, redundancy, and reliability characteristics of items, for example Fraser et al. [10]. Therefore, deciding the optimal level of maintenance requires the construction of appropriate models and the use of optimization techniques [14].

Given the advantages and disadvantages of classic maintenance management models, new maintenance concepts have recently emerged, the main ones being predictive maintenance, total productive maintenance (TPM), reliability-centered maintenance (RCM), condition monitoring (CM)) and condition-based maintenance (CBM) [15-17].

The goal of predictive maintenance, classified as a branch of preventive maintenance, is to ensure the maximum interval between repairs and minimize the number and cost of unscheduled outages created by equipment/system failures under supervision. In this sense, it is necessary to regularly monitor the mechanical condition, efficiency and other indicators of the operational condition of the machines and processes for data acquisition for decision making. According to Kans et al. [13], this maintenance model can improve productivity, product quality, and overall plant efficiency.

The total productive maintenance, unlike the other models, seeks to go beyond a way of doing maintenance, acts in an organizational way, becoming a managerial philosophy [11]. Its conception, beginning in the 50's decade in Japan, encompasses preventive and predictive maintenance programs, as well as a training program for operators that help to monitor the machine during the activities and perform maintenance that does not require a lot of control. Its five pillars are efficiency, self-repair, planning, and training and life cycle [1].

The reliability-centered maintenance (RCM) had its emergence after World War II with the emergence of informatics, media, and industrial automation. Its goal is to maximize results with respect to system reliability or reduced interruption costs [18]. The methodology adopts a structured sequence consisting of seven steps that aim to eliminate and prevent defects by eliminating their causes, being indicated in cases in which faults or defects can cause tragedies and great damages [1].

According to the author, RCM is designed to balance costs and benefits for the most cost-effective preventive maintenance program. Nevertheless, the program does not prevent all failures, so the consequences of each failure must be identified and the probabilities of occurrence known [17].

Condition-based maintenance (CBM), classified as a model derived from predictive maintenance, aims to detect future failures before they occur. To this end, this model uses condition monitoring techniques to determine if there is a problem with the equipment, identify its severity, and estimate how long the equipment can function before failure. In addition, it can also be used to detect and identify specific components in equipment that are degrading. As with other models, different types of CBM are applied in practice. A review of the main differences in this model is presented in Kwak & Ibbs [19].

It is noteworthy that although common in academia, condition monitoring (CM) does not represent a comprehensive and integrated maintenance management model. In this sense, its application is centered on equipment or system, as can be observed in Ruschel et al. [20] and Kans et al. [13], for example.

In addition to the maintenance management models presented, Fraser et al. [21] also presents in their review 37 other models discussed in the literature, which by acting more or less comprehensively can work together in maintenance management.

2.2. Maturity Models

According to Bruin et al. [11], maturity models were designed to evaluate the maturity of a process or activity based on a comprehensive set of criteria. That is, these models aim to evaluate the competence, capacity, and level of sophistication of the process under analysis, besides serving as an evaluation and comparative basis for process improvement.

The maturity models assess the current level at which an organization is in relation to certain pre-established good practices. In this sense, by analysing the current level of the organization, improvement actions can be taken generating action plans to achieve full development, i.e. excellence in management.

Another important feature is that maturity models also help the decision-makers in the process management since they give the guidelines so that a certain area within an organization is developed and can reach higher levels of maturity.

There are several maturity models with applications in different sectors, for example in the IT sector of companies [13] and hospitals [14], production in industries [15], enterprise risks [16], project management [17-19] , maintenance [5], [13], [20], among others.

Although the applications of maturity models are diverse, their usefulness is essentially focused on the same purpose, that is, continuous process improvement through benchmarking. Establishing precise criteria for achieving different levels of maturity in each area, as well as recommending methods and techniques is key to ensuring the best organizational practices. Thus, excellence is achieved by reaching ever-higher levels in specific areas by means of a rational plan of an organization. By doing so, organizations can identify the focus area for their improvement efforts.

It should be noted, however, that there are several different types of maturity models, but that they generally share the common property of defining a number of dimensions or process areas in various stages or maturity levels, with a description of the characteristic performance in several levels of granularity [21].

According to Bruin et al. [11] the most popular way of assessing maturity is a five-point Likert scale. This scale allows the transformation of qualitative data into data that can be measured and evaluated by indicating the degree of agreement or disagreement with statements about the attitude being measured. Thus, high or positive numerical values are attributed to lower or negative concordances and values for disagreements [22]. In Jiang et al. [23] and Raber et al. [24] are examples of maturity models using a Likert scale.

In Fraser et al. [21], the author divides maturity models into three basic groups: Maturity grids, Hybrids, and Likert-like questionnaires, and CMM-like models.

Kohlegger et al. [25] present in their work the results of an in-depth analysis of 16 maturity models assessing their individual characteristics in order to obtain information on the nature of maturity and maturity modelling. The author found that on average the models have 5.5 levels, 40% based on CMM models and 47% do not have a conceptual parent model. In addition, most models have internal operations in the company and their data come from interviews.

In Helgesson et al. [26] a review of the literature on maturity models was also presented. In the paper, the author focused on process models by addressing the methodologies available in the literature to evaluate these models of maturity. The result of the mapping study shows that the most commonly used evaluation method is those where evaluation is conducted by actively using the maturity model in a process improvement effort. This evaluation becomes important as it allows the use of model results to evaluate the model being used.

In addition, Helgesson et al. [26] show that most published articles use the CCM model as a basis for creating new models. It is worth mentioning that CMM identifies five levels of maturity: initial, repeatable, defined, managed and optimizing. However, some alter suggest modifications, for example: explicitly defined, managed, measured, and continuously improved [21].

In Van Looy et al. [27], the author makes a classification of business process maturity models (BPMM). The review investigated 61 articles and found that in practice, BPMMs do not necessarily address all theoretical components of maturity models. Thus, in order to have a correct choice of the maturity model that is appropriate to the company's needs, professionals must observe two questions: (1) which components of BPMM are important to the organization? and, (2) which business processes should be evaluated and improved?

As in [27], in the review [28] the authors found that most business intelligence (BI) maturity models do not consider all factors that affect BI. Therefore, if organizations want to know exactly their maturity levels in business intelligence as a whole, they need to use multiple models or one integrated model to combine the different existing maturity models.

A paper from 2019 [29], conducted a review of the literature on maturity models and noted that despite the various areas of expertise of MM, most publications focus on software engineering and IT / IS management approaches, pointing to for the need for further studies in other areas.

The author also highlighted some improvement needs of the studied MMs. Therefore, for MMs to fulfil their role, they must help guide evolutionary improvements. In addition, because there are few procedures for defining maturity and sometimes these procedures are of a complex application, an MM should aim to identify the level of maturity so that it can be propagated to other organizations [29].

2.3. Maintenance Maturity Models

When maturity models are applied to maintenance management systems, reliability is increased, risks to workers are reduced and company profits are increased. This is because the maintenance of large investment equipment, once considered a necessary evil, is now considered fundamental to improving the cost-effectiveness of the operation, creating additional value by providing better and more innovative services to customers [4].

The key challenges facing organizations today are choosing the most efficient and effective strategies to continuously improve operational capabilities, reduce maintenance costs and achieve competitiveness in the industry. Therefore, maturity models, in addition to reflecting maintenance industry policies and strategies, are an important tool for evaluating the maturity of maintenance management [4].

It is worth mentioning that such models seek to offer improvement opportunities, detect problems and help find solutions for the areas identified as less mature [4].

In this sense, the model proposed in [30] seeks to monitor the effectiveness of lean practices, presenting in a visual way the results achieved. The model helps decision-makers to find the gaps between LEAN requirements and the results of their practices, helping them focus their efforts on those areas that require further improvement.

As shown in Fig. 1, it is possible to observe that the result achieved by each studied cell is presented in a visual way, assisting the managers in the definition of the strategies. Despite the simplification of the results, the model presents a certain mathematical complexity using resources such as fuzzy in its development.

The work [6] presented an evaluation model of asset maintenance maturity, considering the limitation of the applications of the several CMMs created in recent years. Thus, the work sought to incorporate the maintenance performance indicators (MPM) that are generally not considered during the maturity evaluation.

According to the author, the use of these indicators reduces the subjectivity of the benchmarking process, also reducing the challenge of assessing the maintenance maturity, since the use of subjective criteria can sometimes render the results of ambiguous performance evaluation [6].

Despite the benefits highlighted by Chemweno et al. [6], there are still many challenges to be overcome in order for these models to be implemented and their data incorporated into the maintenance maturity assessment models. This occurs because all modelling there are limitations, for example, the one cited by Alrabghi & Tiwari [31]. In the paper, the authors state that because of the development and consequent complexity of the current maintenance processes, the modelling techniques make analyses limited. One example is the need for simplifying assumptions, such as perfect inspections or immediate maintenance actions, which result in models that, according to him, cannot be implemented in real systems.

In addition, it is necessary to analyse the data available for the creation of complex models. In Nowakowski & Werbińka [32], the authors state that sufficient data rarely exists to estimate parameters in a complex model and, when they exist, are generally unreliable. This makes the application of mathematical models to support maintenance decisions less obvious. The author also emphasizes that, in general, the models of maintenance should be sufficiently simple and treatable so that they are accessible to the professionals of the area.

Although the approach proposed by Alrabghi & Tiwari [31], Nowakowski and S. Werbińka [32] approaches more closely the real situation existing in the industry than the simplified models, due to the unavailability of data such modelling was avoided in this work.

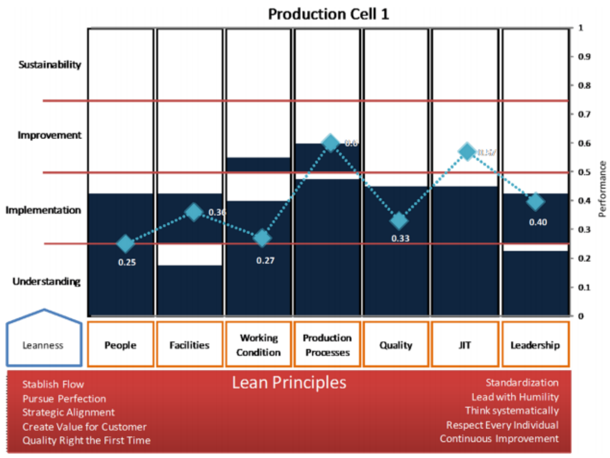

Fig. 1. Visual result of cell 1 maturity model [30].

A model for evaluating the maturity of a system Maintenance Management Information Technology (MMIT) is presented in Kans et al. [13]. The model employs several criteria that are used not only to assess the current status of the company but also to help mature information system in order to meet the future needs of the corporation.

According to the author, the meeting the needs of the company in the elaboration of a plan of improvement of maintenance can or not be reached because it is necessary that the level of maturity selected is compatible with the level of maturity of the IT of the corporation. Therefore, it can be said that the creation of a maturity evaluation model depends not only on the data but also on the infrastructure in order to obtain the desired result. Thus, if the system selection is adequate, it is possible to maximize the benefits derived from the use of the maturity model, increasing the profitability of the company [13].

3. Methodology

There are several applications of maturity models. However, few studies present the application of models to evaluate the maturity of workforce planning management processes. In this sense, this section seeks to describe the premises on which a model applicable to several companies that perform field maintenance services. Given the need to improve the performance of teams by reducing travel time, an appropriate choice of work team and a well-design work schedule that eliminate losses and increase productivity (value-added/man-hour) allowing higher revenues and increased profit margins the model will take into consideration all three levels of planning: strategic planning, tactic planning, and operational planning.

Through this maturity model, we expected that companies that offer services can improve the decision methods used in order to create a plan that leads them to reach maturity in their workforce planning. In this sense, the most important premise is that the model should be easily applied and its results effortlessly approachable, favouring its application specially for companies with a high degree of decentralized operations.

The conceptual model relies on three elements developed based on an action-research process conducted in three phases: methodological aspects are presented in this section, and includes phase 1 and 2 - the review of the literature and immersion in a different electric power companies. The conceptual model relies on three elements: Maturity Axis, Maturity Levels, and Performance Indicators. The maturity axes and levels were defined in phase 1 and the third one was built during phase 2. The third phase is a case study that will be presented in fourth part (see Figure 2).

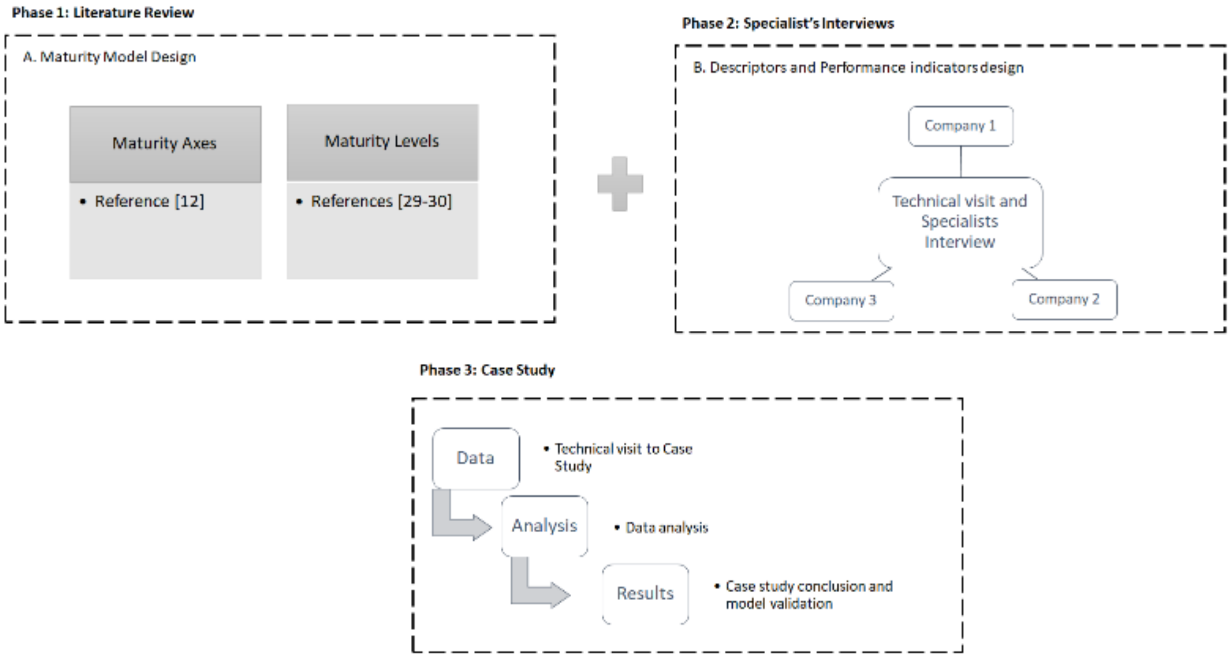

Fig. 2. Research process.

3.1. Phase 1: Maturity Model Design

In phase 1, the literature review allowed to draft the elements of the maturity model must. To do so we used as main approaches three references (1) the electric power distribution system planning [12]; (2) the Hayes and Wheelwright four-stage model [33] and (3) the maturity model proposed by [30].

The first step was defining Maturity Axes. From Borba et al. [12], we grounded the development of Maturity axes that would be evaluated in a maturity model applied to electrical companies.

In this sense, the model, called Workforce Planning Maturity Model (WPMM) was concerned to consider, specifically, the evolution of complexity in the allocation of activities for positioning, sizing and work scale, as well as the projection of service demand. To construct the maturity assessment model, therefore, three criteria/axes were evaluated: Team Positioning (operational base allocation), Work Team Sizing and Allocation and Scale of the operational crew.

Based on Borba et al. [12], we concluded that all the three levels mentioned before are deemed by the Operation and Maintenance (O&M) area of these electric companies as reasonable to fulfil clients' expectations through the optimization of the attendance of occurrences, lower costs and service order time. This previous work provided the categories hereafter presented. They are shown in Figure 3.

Another aspect that was included in the WPMM was the task of service demand forecasting. We opted to evaluate, for each axis, i.e., the workforce planning stages, whether it performed a service demand forecast and in which level this task is achieved.

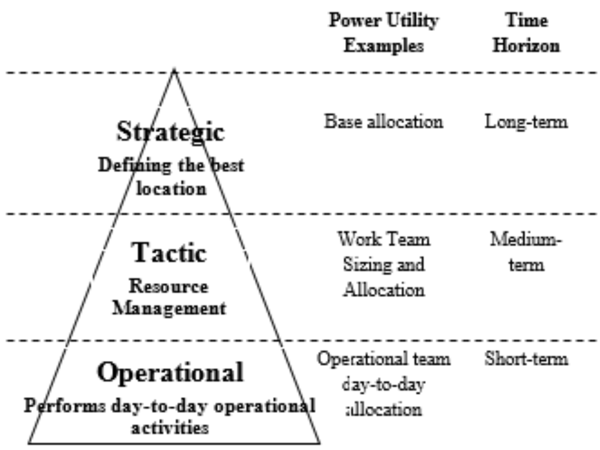

Fig. 3. Categories of Workforce Planning in O&M. Source: Authors.

The second step was the Maturity Levels. In this study, the scope of the Maturity levels was understood as a way to measure how the maturity axes support the strategy of the organizations. From this understanding, the approach found in work [33] was grounded theory. This four-stage model describes the strategic role of manufacturing area within organizations. From our perspective, companies located in steps 1 and 2 have their manufacturing adopting reactive strategies aiming to catch up to their competitors. Manufacturing area from companies in step 3 provides good support to company's business strategy. Those in step 4 pursue innovation by adopting initiatives that promote a competitive advantage [34].

We adopted the same concept to evaluate workforce planning actions. The WPMM maturity model was conceived to measure whether the maintenance management area goes beyond its traditional role by supporting the company's business strategy. Also, from Maasouman & Demirli [30], five maturity levels were defined, namely:

L1 - Understanding;
L2 - Implementation;
L3 - Updating;
L4 - Optimization;
L5 - Continuous Improvement.

For each level, a descriptor was established in order to facilitate the understanding of the conditions that guarantee or not the permanence of a determined team in the analysed level.

3.2. Phase 2: Specialists' interviews

To define performance indicators, we conducted non-structured interviews with managers of different Brazilian companies. As a result, descriptors and indicators for each of the five levels were proposed in terms of workforce planning actions and the type of service demand forecast performed.

Level L1 (Understanding) assumes that the team is aware of the importance of proper activity sizing (base allocation, team distribution by the base, and work scale by team and base) but does not use projection of service.

At L2 level (Implementation), it is expected that the team will use some method for sizing activities (base allocation, team distribution by base and work scale per team and base) and use the service demand projection developed by another company department.

For L3 (Updating) level to be reached, the team must periodically update its activity sizing methods (base allocation, base team distribution, and team and base work schedule) and service demand projection refine received from another department.

In the case of level L4 (Optimization), the team should use mathematical optimization methods for activity sizing (base allocation, team distribution by base and work scale by team and base) and propose projected service demand.

To reach Level L5 (Continuous Improvement), the team must use the company's standardized optimization methods for sizing activities (base allocation, team distribution by base and work scale by team and base), acting in conjunction with senior management to improve them and project service demand in line with the goals of senior management.

Figure 4 shows the maturity grid created for maturity assessment. As can be seen, for each Maturity axes (lines), two aspects were evaluated. In the first case (team positioning), the evaluations considered the allocation of activities and the projection of service demand. In the second case (work team sizing), the evaluation observed the quantification of the team size and the projected service demand. In the third case (work scale), the work scale and activities allocation were evaluated.

MATURITY LEVEL / MATURITY AXIS	UNDERSTANDING L1	IMPLEMENTATION L2	UPDATING L3	OPTIMIZATION L4	CONTINUOUS IMPROVEMENT L5
Base allocation	The team has knowledge of the importance of proper allocation of activities	The team uses some method to perform the allocation of activities.	The team periodically updates its activity allocation methods.	The team uses Mathematical Optimization Models to define the allocation of activities.	The team uses the Company's standard Optimization Model and works with company's business strategy team to improve it.
	The team does not make use of Service Demand Projection.	The team uses the Service Demand Projection from another department of the Company.	The team refines the Service Demand Projection received from another department	The team proposes Service Demand Projection.	The team performs Service Demand Projection align with the goals of company's business strategy.
Work Team Sizing and Allocation	The team has knowledge of the importance of proper allocation of activities	The team uses some method to perform the allocation of activities.	The team periodically updates its activity allocation methods.	The team uses Mathematical Optimization Models to define the allocation of activities.	The team uses the Company's standard Optimization Model and works with company's business strategy team to improve it.
	The team does not make use of Service Demand Projection.	The team uses the Service Demand Projection from another department of the Company.	The team refines the Service Demand Projection received from another department	The team proposes Service Demand Projection.	The team performs Service Demand Projection align with the goals of company's business strategy.
Operational team day-to-day allocation	The team has knowledge of the importance of proper allocation of activities	The team uses some method to perform the allocation of activities.	The team periodically updates its activity allocation methods.	The team uses Mathematical Optimization Models to define the allocation of activities.	The team uses the Company's standard Optimization Model and works with company's business strategy team to improve it.
	The team has knowledge of the importance of proper allocation of activities	The team uses some method to perform the allocation of activities.	The team periodically updates its activity allocation methods.	The team uses Mathematical Optimization Models to define the allocation of activities.	The team uses the Company's standard Optimization Model and works with company's business strategy team to improve it.

Fig. 4. Maturity grid proposed.

In order to identify the maintenance sector' maturity of the different organizational levels of the company, it was proposed questionnaires to evaluate the corporation processes. For each axis/criteria, an evaluated should be performed by choosing only one box. Also, in the second line, the task of service demand forecasting should also be evaluated. Exhibit 5 shows an excerpt of the assessment performed to the strategic planning level, i.e., an analysis of how companies determine their base allocation.

One can note that it is possible to be classified in Level L3, for example, in the base allocation planning but in Level L1 to the demand forecast. It is also noteworthy that the data from each work unit should be treated separately in order to identify the possible benchmarking in each evaluated criterion. Thus, it is expected that the use of the maturity model can point directions, prioritize improvement opportunities and guide organizational changes.

Table 1. Excerpt strategic level - Base allocation assessment

Level	Descriptor	x
Level L1	The team has knowledge of the importance of proper allocation of activities.	
	The team does not make use of Service Demand Projection.	
Level L2	The team uses some method to perform the allocation of activities.	
	The team uses the Service Demand Projection from another department of the Company.	
Level L3	The team periodically updates its activity allocation methods.	
	The team refines the Service Demand Projection received from another department.	
Level L4	The team uses Mathematical Optimization Models to define the allocation of activities.	
	The team proposes Service Demand Projection.	
Level L5	The team uses the Company's standard Optimization Model and works with the company's business strategy team to improve it.	
	The team performs Service Demand Projection align with the goals of the company's business strategy.	

It was decided to build a WPMM model that would allow a quick and consistent assessment of the different business units of a company. The proposed was concerned with the evolution of complexity in the allocation of activities (for base positioning, team sizing by base and work scale by base) and the projection of service demand.

The final conceptual WKMM model can be seen in Figure 5.

4. Case Study

4.1. Company description

To validate the proposed maintenance maturity model, a case study was conducted with 11 electricity distribution companies that participate in the Energisa Group. Given the size of the company's distribution networks and a large amount of equipment it manages, strict maintenance planning is necessary in order to avoid the lack of customers service, since interruptions in service lead to large volumes of financial compensation paid [35].

The Group is composed of companies that act in the generation, transmission, and distribution of electric energy in Brazil. In addition to meeting part of the country's electricity demand, the group also has Energisa Soluções, which seeks to meet the need of customers with operation and maintenance services for electric projects [36]. The Figure 6 shows the Midwest region of Brazil with the respective concessionaries' areas.

It has the main base of the business the distribution of electric power where it controls 11 companies in several Brazilian municipalities. It has 538,613 thousand km of distribution networks and 603 substations with a total capacity of 12,916 MVA, reaching about 8% of the Brazilian population [36-37].

According to ANEEL (National Agency for Electric Energy) [38], the company Energisa Mato Grosso paid in 2018 a total of R$ 8,059,069.67 due to 826,496 compensations. It is worth noting that this is not a characteristic only this company. As can be seen in Exhibit 8 and Exhibit 9, interruptions in the service of the concessionaires are recurrent and show that such companies have great potential of reducing costs in their maintenance sectors.

5, Results, and Discussion

In order to validate the model, the proposed maturity assessment method was used to evaluate the maintenance sector of the distribution company Energisa. To this end, several visits were made to survey and evaluate the management characteristics of the maintenance used in each business unit of the organization.

As presented in the model, the three workforce planning levels of the organization's management were analysed. Through the allocation of bases, team sizing by base and definition of service scale by team and base, the strategic, tactical and operational module, respectively, were evaluated.

Through questionnaires and technical visits, we identified the criteria used, the decision variables considered, restrictions to be met and assumptions considered, as well as the main data sources considered by the various teams for sizing the field team. Suggestions for improvements to this process were also identified, with the main focus being the interest in reducing the number of hours spent by professionals to carry out the studies, highlighting the need for a corporate system for data consolidation, standardization of assumptions and process optimization aiming at continuous improvement of the sizing process.

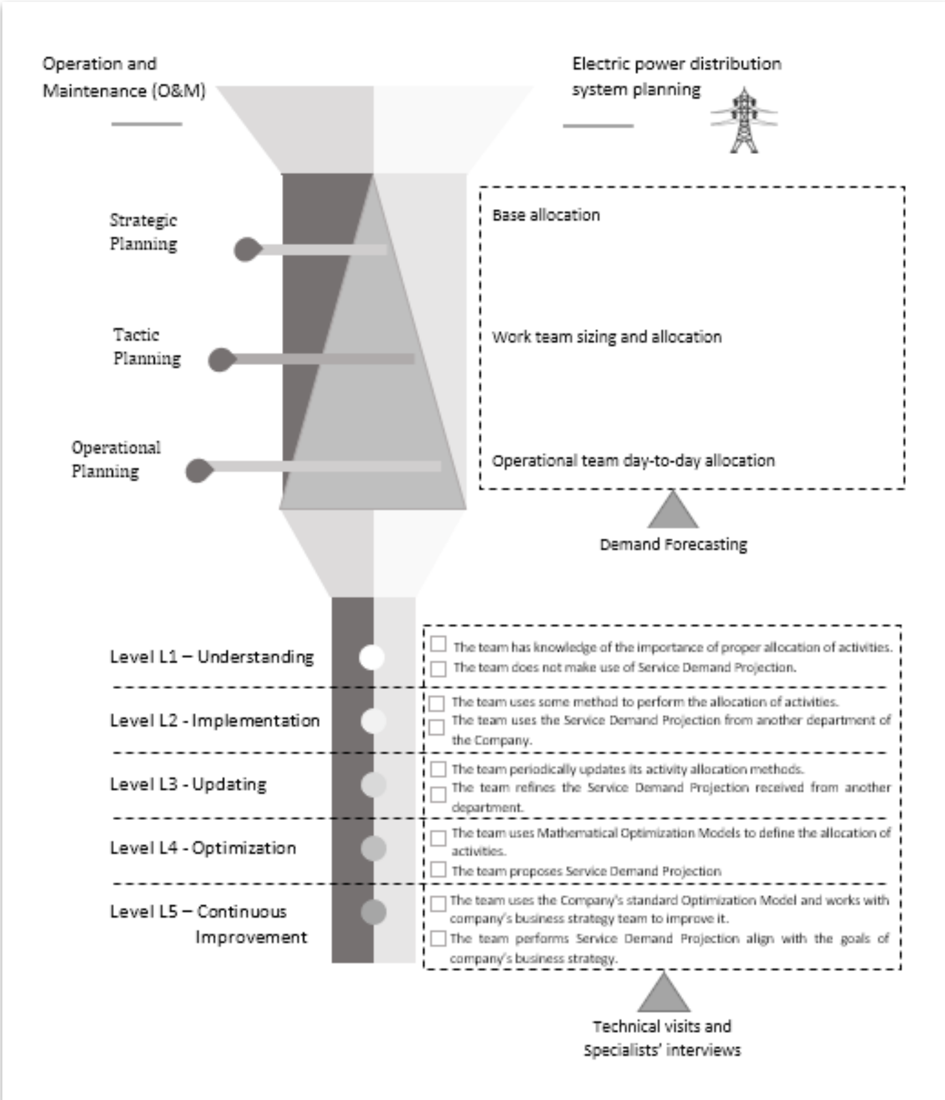

Fig. 5. WPMM Conceptual Model.

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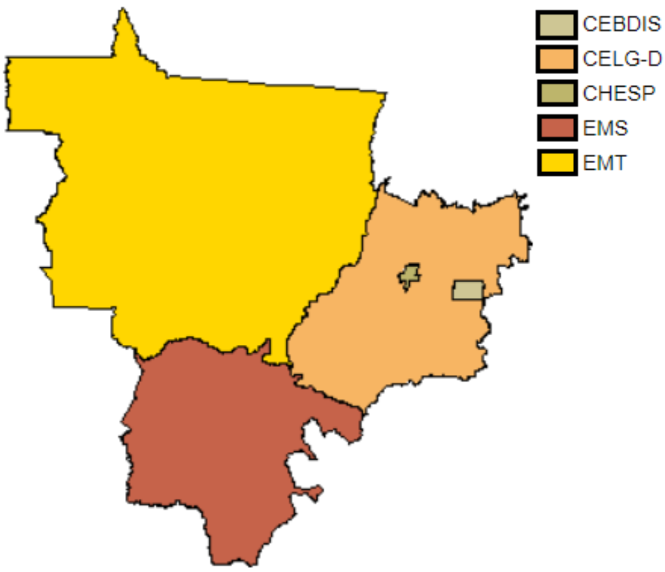

Fig. 6. Electric power concessionaires in the Midwest [38].

Table 2. Continuity Compensation Indices of Midwest Concessionaires - Number of Compensations [38].

Company	Compensations (R$)				
	DIC, FIC, DMIC			DICRI	Total
	Month	Trimester	Year	Month	
CEBDIS	6,5E+05	1,8E+05	1,1E+05	1,4E+03	9,4E+05
CELG-D	5,9E+06	2,0E+06	1,4E+06	9,3E+04	9,5E+06
CHESP	3,4E+04	2,0E+03	2,4E+02	3,3E+01	3,8E+04
SEM	6,3E+05	1,5E+05	8,1E+04	1,7E+04	8,8E+05
EMT	8,4E+05	2,1E+05	2,1E+05	5,5E+04	1,3E+06

Table 3. Continuity Compensation Indices of Midwest Concessionaires - Compensation Amount [38].

Company	Compensations (R$)				
	DIC, FIC, DMIC			DICRI	Total
	Month	Trimester	Year	Month	
CEBDIS	3,6E+06	4,8E+05	5,6E+05	1,4E+04	4,6E+06
CELG-D	5,4E+07	6,3E+06	5,3E+06	1,3E+06	6,7E+07
CHESP	1,0E+05	5,1E+03	2,3E+04	1,3E+02	1,3E+05
SEM	7,0E+06	9,4E+05	1,0E+06	2,6E+05	9,3E+06
EMT	9,0E+06	1,3E+06	4,5E+06	1,0E+06	1,6E+07

From the results of the model, it was possible to identify the maturity level of all business units of the organization, as well as to identify the limitations and competitive advantages as well as detecting the company's benchmark in terms of field maintenance management. Finally, it was possible to set the goals to be achieved in view of the ultimate goal of achieving continuous management improvement.

5. Conclusion

The industry maintenance sector is growing importance in the last years because the correct maintenance can reduce the machines downtime, making more profits and better confiability. So, ensuring proper management of the maintenance has become vital for businesses.

In this sense, this work sought to address the maturity of field maintenance management, considering the high annual costs caused by the discontinuity of energy service in the Brazilian electricity sector.

To this end, a maturity assessment model was proposed and tested in a company in the sector aiming at identifying improvements as well as presenting the path for the growing development of each business unit in a company.

The result reaffirmed the importance of studies such as this one and its application in the electric sector in order to improve the service provided and guarantee the minimum quality of service according to ANEEL regulations.

The authors suggest that the proposed maturity model should be used for other companies in order to verify the need to include more evaluation criteria specific to other industrial sectors.

For companies with more subsidiaries evaluated, the use of more robust statistical analysis methods is also suggested in order to obtain more precise conclusions.

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