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Real-Time Monitoring System Of Energy Consumption Using Internet Of Things: A Solution To Anticipate Decision-Making To Prevent Overloads And Electrical Accidents

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Abstract: *In recent years much has been discussed about energy efficiency, with several factors in question, such as: the exacerbated use of energy and accidents involving electrical overload. Such findings are due to the lack of monitoring of the electrical network, directly impacting micro, small and medium-sized enterprises (MSMEs). Based on that, in this article we propose a real-time energy monitoring software: Vollti. The system receives data sent through a smart meter located on the control panel. Consumption information is presented in the form of dashboards, where these can be customized by time of day, week and month, in addition to being able to visualize by energy phases. At the moment the system is in the test phase in 60 local companies, where based on the feedback received, it is estimated that it can create new functionalities such as: more elaborate graphs based on the time interval that the user wants and preview values related to invoices monthly.*

Key Word: *Energy efficiency; Monitoring System; Internet of Things*

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I. Introduction

Energy efficiency is the term used for the practice of saving energy while maintaining the level of service (Olughu, 2021). Within an electrical network, several factors will influence energy consumption. The electrical load of a given location is composed of a combination of several loads, which are defined by the voltage of use and their powers. These loads can be divided into four main groups: Motors, Lighting, Heating, Refrigeration, and electronic devices (Fernandes, 2010). Energy consumption will depend on the combination of the use of these groups, including their simultaneous use, the frequency, necessity of use, and the time of day.

The lack of supervision regarding the use of the electrical network, both in consumption and in installations, affects everything from the value of the electricity bill to the possibility of an accident, which can generate even more unnecessary expenses. Substantial energy losses lead to a notable increase in electricity expenditures, which can harm various projects. According to Zancan (2007), the waste of electrical energy can often hinder a business's economic prosperity, impacting the sustainability of enterprises, reducing their competitiveness and productivity, and increasing costs. Therefore, reducing waste is essential for the success of companies and businesses, especially small ones that are heavily impacted by energy costs.

According to the 2021 Statistical Yearbook of Electrical Accidents, published by the Brazilian Association for Awareness of the Dangers of Electricity (ABRACOPEL), in 2021, there were a total of 1085 fatal accidents involving electricity. In 2022, an average of 15,460 fires caused by overload or short circuit were recorded, representing a 32.3% increase compared to 2021 (ABRACOPEL, 2023). Thus, it is evident that a significant proportion of electrical accidents are linked to electrical overload due to poorly sized and unchecked electrical installations. Faced with these challenges, there is a need for greater control over the use of the electrical network and the balance between phases.

Power overload occurs when there is an imbalance in the phase system, an occurrence that can lead to a range of problems, from increased energy losses to the overheating of cables. These issues can adversely affect power quality and cause damage to cables and equipment, particularly motors, which are susceptible to damage due to these imbalances (Fernandes, 2010).

A study conducted in Europe involving 574 multinational companies between 2008 and 2013 demonstrated that the adoption of energy efficiency measures necessitates the implementation of energy management systems. The impact of such systems on short-term corporate financial performance is notably positive (Martí-Ballester, 2017). By optimizing energy consumption in the operation of various equipment, it becomes possible to significantly enhance productivity, mitigate accidents resulting from overload, and reduce wastage, thereby fostering greater energy efficiency.

Smart meters play a pivotal role in assisting consumers with judicious energy use, as they enable remote monitoring of energy consumption to detect instances of excessive usage (Fortes et al., 2017). Building upon this premise, this article aims to present a case study of an energy efficiency monitoring system targeted at micro and small industries located in the city of Porto Velho, Rondônia. The primary objective is to generate real-time energy consumption data at different intervals, facilitating consumption optimization through efficient production planning.

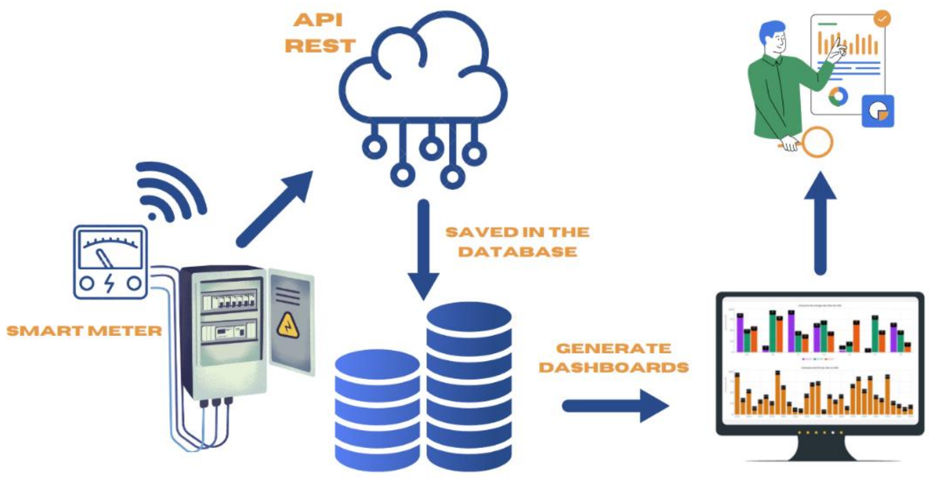
To achieve this goal, this work is divided into the following sections: Methodology, Results and Discussions, and Conclusions and Future Work. In the Methodology section, we will elucidate the tools employed in the construction of this study and the research methods applied. Subsequently, the subsequent section will delve more deeply into the specifics of our research findings, including the energy monitoring system, its operational mechanisms, and its potential contributions towards addressing this issue. Finally, in the Conclusion section, we will summarize the key points covered throughout the work and discuss prospective objectives.

II. Material And Methods

In order to establish a solid foundation for a deeper understanding of the significance of energy efficiency and the challenges necessitating the implementation of an energy monitoring system, a systematic literature review was conducted using reputable sources such as academic databases, scientific journals, and relevant publications. Keywords such as energy efficiency, energy waste, electrical accidents, and electrical overload were employed to refine the selection of research materials. Articles and works from 2007 to the current year were considered, with a focus on aligning their content with the research objectives.

Recognizing the paramount importance of providing an effective and secure solution for businesses, a real-time energy monitoring system has been developed. This system empowers entrepreneurs to continuously monitor energy consumption levels, granting them the capability to implement proactive or corrective measures. These actions result in reduced unnecessary expenses and the mitigation of electrical accident risks. The operational architecture of this system adheres to the scheme illustrated in Figure 1.

Figure 1: General schema of the application.



Data within the system is collected via a bidirectional energy meter installed within the establishment's energy panel. Communication between the meter and the server is established through Wi-Fi, utilizing an API developed in Laravel following the REST standard, which is responsible for data persistence in the system's database. Based on this available data, users can create personalized dashboards tailored to their specific visualization needs. Consequently, users gain intelligent real-time control over their energy consumption through the system.

The development of this system followed the XP methodology (Extreme Programming), with an emphasis on an incremental functionality development approach. Features were added incrementally as development progressed.

The medium fidelity prototype was crafted using the Figma platform. For development purposes, the following tools and technologies were selected: database – MySQL 8.0, backend programming language – PHP

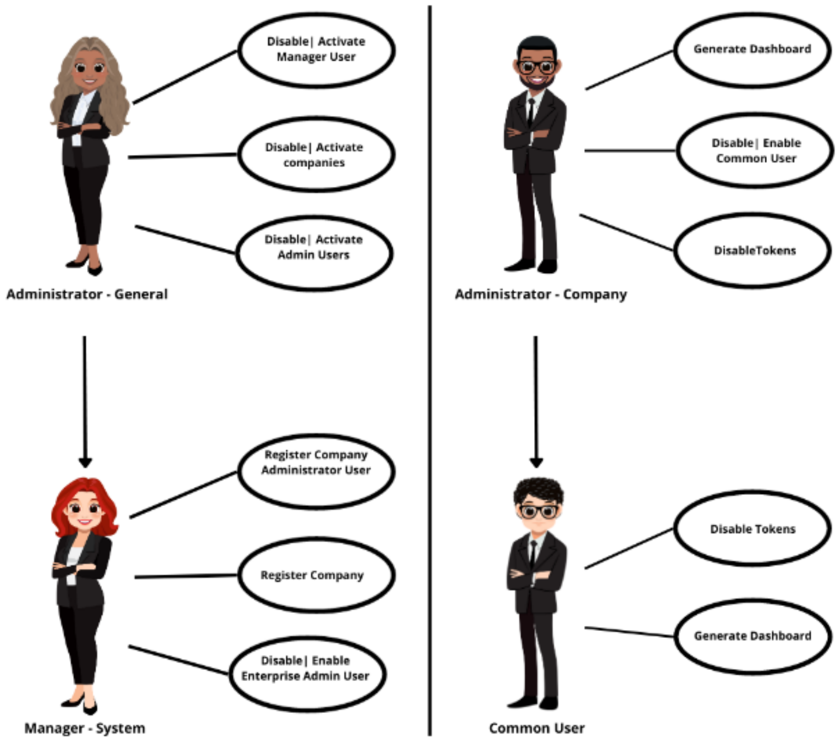
8.1 with the Laravel 9 framework, and frontend programming language – JavaScript, along with the ReactJS library.

III. Results and Discussions

As a result, an energy monitoring system named Vollti was developed, as part of the Mais Rondônia project. This initiative was carried out by the National Industrial Learning Service of Rondônia (SENAI – RO) in collaboration with the Federal Institute of Rondônia (IFRO) and the State Secretariat for Economic Development of Rondônia (SEDEC – RO). Funding for the Vollti system was provided through the digital transformation program, a partnership between DigitalBR and the Brazilian Association of Industrial Development – ABDI, with the goal of optimizing companies' electrical consumption. The system can be accessed via the following link: http://vollti.com.br.

The system accommodates four distinct types of users, as represented in the use case diagram depicted in Figure 2. In summary, there are two usage scenarios. The first pertains to system management, where users include the general administrator and systems manager. These roles have the capability to add company administrators and system managers, view their profiles, and adapt permissions as necessary. The second scenario involves industry users, where there are Company and Common users. These users can create and edit dashboards and add other members within their respective companies.

Figure 2: Use Cases Diagram.



Graphics have been integrated into the system, allowing companies to monitor energy consumption. These graphical representations can be accessed through customizable Dashboards, which can be adjusted in terms of layout, size, and the number of graphs displayed on the screen.

Each Dashboard can be tailored and personalized based on the specific analysis objectives. Upon creating a Dashboard, the system generates an access token. This token enables access to the Dashboard without the need to log in to the website, making it more convenient for viewing. Your Dashboards can be adapted to suit your requirements, and you have the flexibility to select the presentation format, as illustrated in Figures 3 and 4.

Once the formatting is defined, you can choose the type of graph to generate. The graphs are categorized into general consumption and consumption by energy phase, with presentation options including:

- Per hour of the day
- Per day of the week
- Per week in the month
- Per day of the month

Furthermore, an index has been developed to display the proportion of phases in use. This graph allows for a clear visualization of which phase is being used, as well as the ability to determine whether the phases are in balance. Typically, in a business electrical installation, there are three phases. The system will issue a red alert for overuse, a yellow alert for attention, and a green signal if all phases are balanced.

In this manner, companies will have the capacity to create multiple Dashboards that cater to various requirements. Figure 5 depicts the layout of a Dashboard, where it is possible to observe weekly consumption, the phase utilization proportion, and hourly consumption throughout the day, providing a basis for comparison with the weekly consumption measurement.

Figure 3: Add Lines and Save Dashboard.

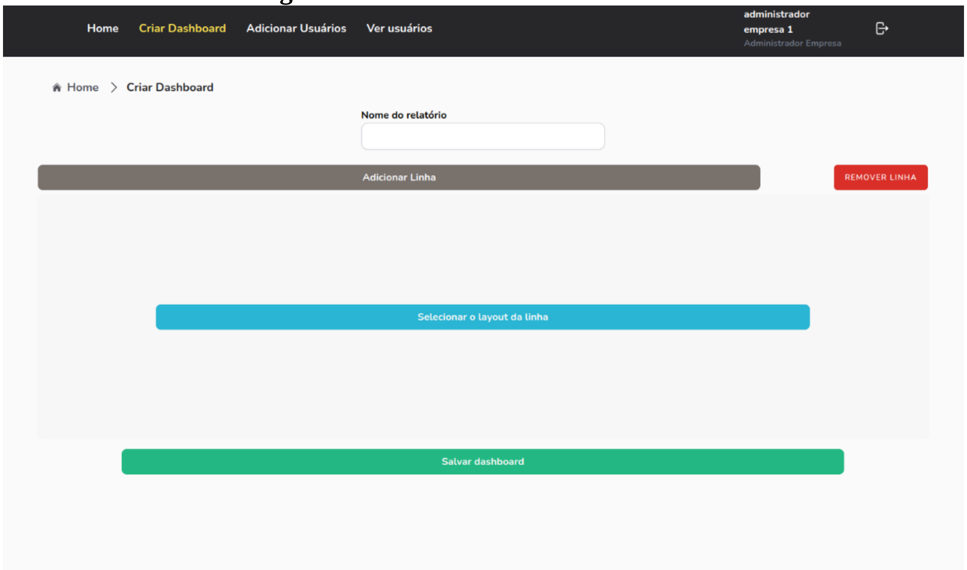


Figure 4: Dashboard Layout Selection

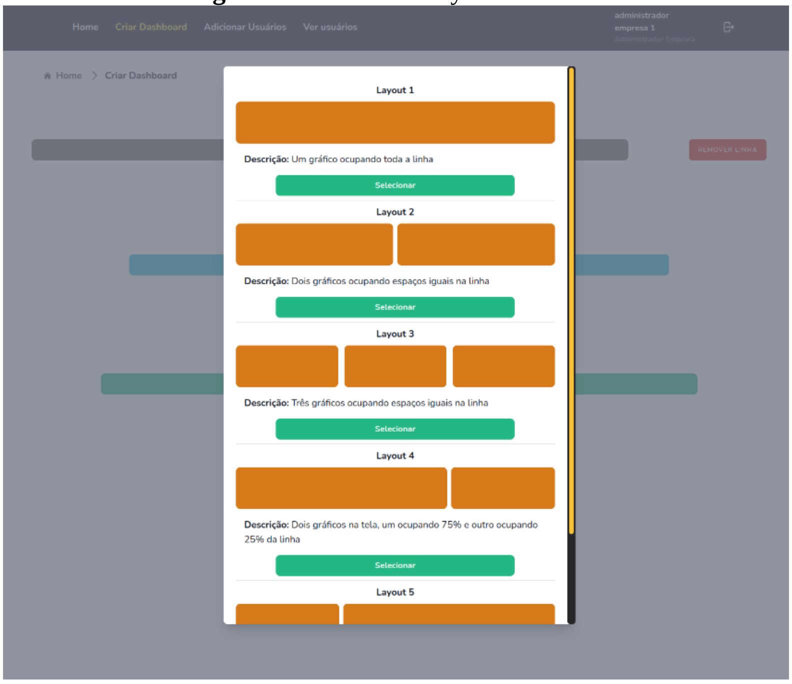
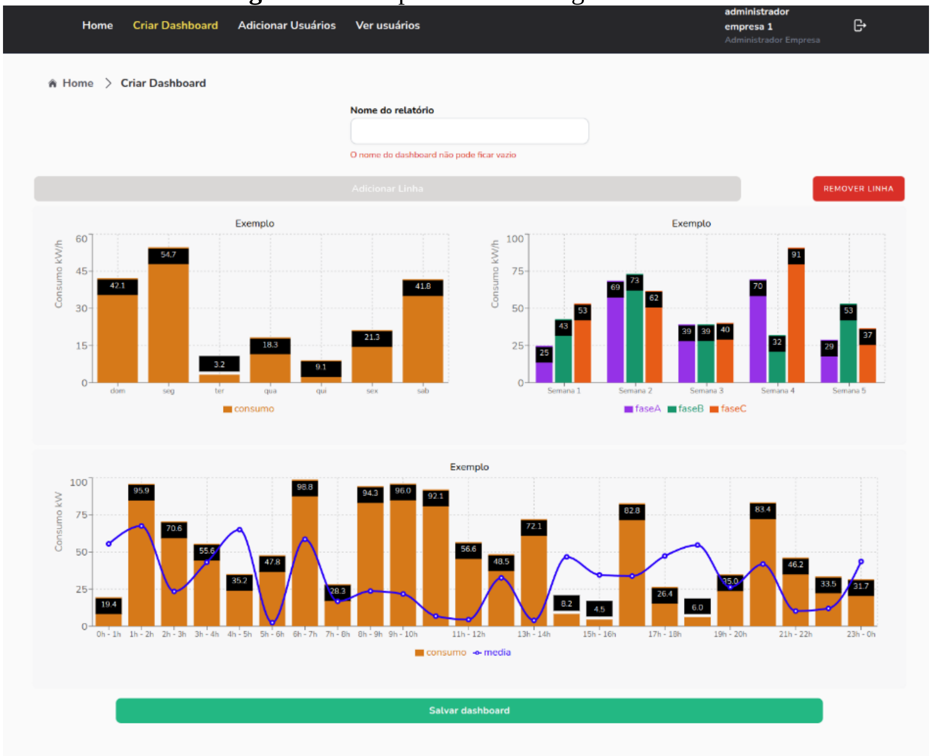


Figure 5: Example of monitoring Dashboard



IV. Conclusions and Future Work

This study aimed to provide context regarding the primary factors contributing to damages within the electrical grid, emphasizing the significance of implementing continuous monitoring of companies' electrical consumption and the potential for enhanced energy efficiency as a result. As discussed in earlier sections, companies encounter significant challenges related to the cost of electricity, which is typically high and escalates further due to excessive consumption, inadequate facility inspection, and phase imbalances. The importance of energy efficiency and real-time monitoring has been underscored as a pivotal approach to mitigate wastage, lower costs, and prevent accidents.

Presently, the system is undergoing implementation in 60 local companies, with monitoring scheduled to span over a 6-month period. During this phase, it is anticipated that entrepreneurs, utilizing the software, will be able to cultivate more informed electrical consumption practices and identify potential issues within their electrical installations, thereby reducing the risk of accidents.

To facilitate the ongoing research in this field, there are plans to create more sophisticated graphs that incorporate additional time-related data. These enhancements will consider the specific time intervals users wish to analyze and introduce the functionality of estimating monthly electrical costs based on energy consumption.

References

[1]. Associação Brasileira De Distribuidores De Energia Elétrica – Abradee. Estudo Comparativo De Tarifas. 2011. Disponível Em: Https://Abradee.Org.Br/Wp-Content/Uploads/2018/09/Estudo_Comparativo_De_Tarifas_Abradee-2011.Zip.

[2]. De Souza, Danilo Ferreira; Martinho, Edson; Martinho, Meire Biudes; Martins Jr. Walter Aguiar (Org.). Anuário Estatístico De Acidentes De Origem Elétrica 2023 – Ano Base 2022. Salto-Sp: Abracopel, 2023. Doi: 10.29327/5194308.

[3]. Fernandes, Carlos. Eficiência Energética Em Edifícios De Serviços: Estudo De Caso. 2014. 105 F. Dissertação (Mestrado Em Engenharia Mecânica) - Faculdade De Engenharia, Universidade Do Porto, Porto, 2010. Disponível Em: Https://Www.Voltimum.Pt/Sites/Www.Voltimum.Pt/Files/Pdflibrary/Dissertacao_Final_Carlos_Fernandes.Pdf.

[4]. Fortes, M. Z., Ribeiro, A. T., Gonçalves, D. A. V., Schaefer, M. A. R., & Flores, M. M. (2017). Análise Da Adoção De Medidores Inteligentes Como Instrumento Da Política Pública De Eficiência Energética. Engevista, 19(2), 316–327. Disponível Em: Https://Periodicos.Uff.Br/Engevista/Article/View/9104/6577. Acesso Em: 08 De Maio De 2017.

[5]. Martí-Ballester, C.P., 2017. Sustainable Energy Systems And Company Performance: Does The Implementation Of Sustainable Energy Systems Improve Companies' Financial Performance? J. Clean. Prod. 162, S35–S50. Disponível Em: Https://Www.Sciencedirect.Com/Science/Article/Pii/S0959652616320613/Pdfft?Casa_Token=Td1y5qd9yjuaaaaa:Tkyvetau38nx69ooqqcdt77mwiqjq9bvaillh5dekbmj2edfwtvzzfvvlamo6azgvhunsylmuvnvg&Md5=0d1efe980b4b6a5886dc9cca0f0e67a5&Pid=1-S2.0-S0959652616320613-Main.Pdf.

[6]. Montenegro, Bianca De Paula; Gomes, Leonardo Lima. Custo De Capital Do Setor De Distribuição Elétrico Brasileiro. Rio De Janeiro, 2014. 71p. Dissertação De Mestrado – Departamento De Administração, Pontifícia Universidade Católica Do Rio De Janeiro.

[7]. Santos, Gustavo Antônio Galvão Dos Et Al. Por Que As Tarifas Foram Para Os Céus? Propostas Para O Setor Elétrico Brasileiro. Revista Do Bndes, Rio De Janeiro, V. 14, N. 29, P. 435-474, Jun. 2008.