SIMTITS
Interdisciplinary School of Management and Technology
Institut Teknologi Sepuluh Nopember

JURNAL TEKNOBISNIS
2023 Vol. 9(2), 119-129

Received 29 Nov, 2022; Revised 10 Jan, 2023; Accepted 31 Jan, 2023 | DOI: 10.12962/j24609463.v9i2.1875

Design of Electrical Equipment Load Visualization to Improve the Availability of Peak Load Information Using the Line Chart Method

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ABSTRACT

The management of electrical equipment load in a national power company plays a crucial role in determining company policies. However, efficient data processing is hindered by the current use of spreadsheet formats. Therefore, this research aims to design a visualization of electrical equipment load using the line chart method to improve the availability of peak load information. The research process involves identifying customer needs, conducting literature analysis, designing, as well as testing and verifying the design. The findings of this study result in an attractive and effective visualization design that provides accurate information about peak load, analyzes load trends, and identifies load patterns. With this early design, it is expected to facilitate the next steps in the coding process for the dashboard.

KEYWORDS: Electrical Equipment Load, Visualization, Peak Load Information, Design Dashboard, Line Chart Method.

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1. INTRODUCTION

The Operations Evaluation field in a national power company plays a crucial role in managing and analyzing electrical equipment load data within its jurisdiction Kementrian ESDM (2020). This data is obtained through SCADA and AMR systems, which record equipment load every 30 minutes. To obtain the peak load of each electrical equipment on a daily, monthly, and annual basis, spreadsheets are used, which can lead to time-consuming processing. The peak load data is utilized by various departments for operational planning and future investment projects, requiring accurate validation (Upadhyay & Sampalli, 2020).

The challenge lies in the increasing demand for peak load data of electrical equipment from various departments within the national power company. However, the required data is still presented in spreadsheet format, resulting in time-consuming processes. Therefore, an innovative and efficient solution is needed to quickly present this data and meet the users' needs more optimally. In recent years, several systems have emerged for visualizing electricity consumption, providing real-time data through specialized applications for large-scale industrial and household settings. However, there is a lack of development for lightweight business-scale applications (Smith et al., 2019). By utilizing Energy Visualization (EV) and Energy Management System (EMS) connected to SCADA equipment, awareness of electricity consumption can be increased, and electricity management can be facilitated. In a journal article by (Chen & Chen, 2021) it is stated that the charts and graphs method can be used for data that refers to patterns or trends in data over a specific time period. The suggested type is using Point plot or Ladder Plot to demonstrate the relationship or comparison between two numerical variables.

At the end, this research aims to design a visualization of electrical equipment load to improve the availability of peak load information using the line chart method. With this design, it is expected to facilitate the coding process for the prototype and serve as the final reference for the dashboard to be created in the next steps.

2. LITERATURE REVIEW

Peak load refers to the maximum power consumed by a power plant during a specific time period (Alsaedi & Tularam, 2020). It can also be defined as the highest load borne by electrical equipment within a given period. In the context of planning, there are three periods of peak load: daily, monthly, and annual Kementrian ESDM (2020).The operator responsible for managing the operation of the power system in a national electricity company is called a Dispatcher. This personnel records all operational communications, whether written in a book or through other permanent and verifiable methods Kementrian ESDM (2020). In addition to communication records, the Dispatcher also notes significant events in the power system and summarizes the load profile of electrical equipment in their work sheets, obtained from various sources Figure 1.

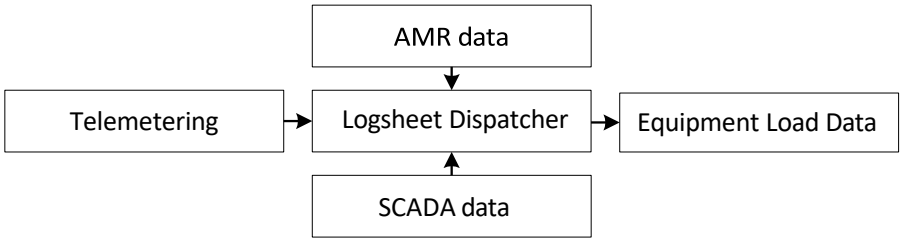

FIGURE 1. Source of equipment load data.

In a database, there is a large amount of data that needs to be organized according to specific criteria. When users require certain data, the system processes it until the relevant data is found and ready to be presented to the users. The process of transforming data from its raw form to a readable format, as designed, is called data projection. In practice, data projection, or data visualization, is understood as presenting data in a way that is easily understood by users. In the paper by (Chen & Chen, 2021), the use of visualization techniques for projecting different types of data is discussed, as shown in Table 1.

TABLE 1. Types of data visualization methods

	Visualization Methods	Data Types
Charts and graphs	Bar Chart/Area Chart/Bubble Chart/Heat Map	Comparative data
	Venn Diagram/Rectangle Tree Diagram/Node Relation Diagram/Sankey Diagram	Relational data
	Histogram/Stem and Leaf Plot/Box Plot/Probability Density Plot	Distributed data
	Point Plot/Ladder Plot	Trend data
	Pie Chart/Ring Chart	Proportion data
Map	GIS Map	Geographic data
	3D Map	Geographic data
Emulation	3D models	Scene/Object
Effect	Animation	Scene/Object/All data types
Technology	VR (virtual reality)	Scene/Object/All data types
Technology	AR (Augmented Reality)	Scene/Object/All data types

The electrical equipment load data used in this study consists of measurements taken every 30 minutes from the installed equipment, thus categorizing it as Time Series data. Line charts are often considered as the preferred choice for visualizing time series data and displaying the main trends (Wang et al., 2018).

3. METHODS

In a conceptual context, this study aims to optimize the management and regulation of electrical equipment load. The visualization of equipment load generated through the Dashboard design has the potential to provide valuable information to users, enabling them to make informed decisions in managing peak equipment loads. Thus,

this research contributes to efforts in improving the overall efficiency and availability of electrical energy. The methodological steps of the research are explained in Figure 2.

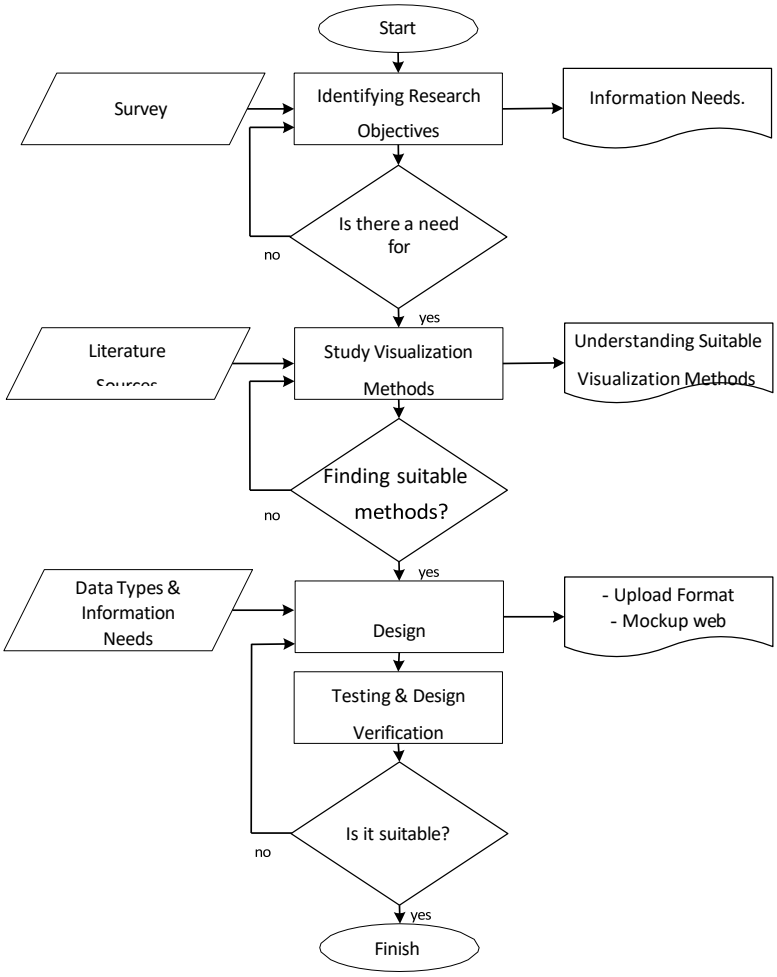

FIGURE 2. Research methodology.

Research Objective Identification

To identify the research objective regarding the provision of better equipment load peak information, the initial step is to conduct a survey among users of electrical equipment data within the scope of the national electricity company. This survey is conducted using previously researched methods (Agrawal et al., 2016) and the results are analyzed to gain a deep understanding of customer needs. Discussions with experts are also carried out to identify gaps in the services that need improvement. If necessary, the survey will be repeated with a more suitable approach. The purpose of this step is to gain a better understanding of customer needs regarding equipment load peak information. By conducting this comprehensive identification process, it is expected to establish specific and relevant research objectives in enhancing the equipment load peak information service.

Literature Review Related to the Research

In the literature review related to this research, the researcher analyzes relevant previous studies on the design of electrical equipment load visualization, such as (Chen & Chen, 2021), (Herrmann et al., 2021), (Smith et al., 2019), (Fan et al., 2017), (Lee et al., 2016), and (Rathod & Garg, 2016). This literature review provides an understanding of the challenges and opportunities in implementing visualization designs and identifies existing knowledge gaps. The literature review process is conducted by comparing research methods from previous studies with visualization methods that are suitable for this research, as presented in Table 1. The results of the literature review indicate that the suitable visualization method is using line diagrams (point plot/ladder plot), with careful attention to data validation due to specific conditions in this research. With a strong theoretical foundation from the literature review, this research has the potential to make significant contributions to the development of solutions for enhancing understanding and availability of equipment load peak information for electrical equipment.

Design

In the design process, the identification of reliable data sources is used as a strong foundation for creating an intuitive interface following principles of good design, such as simplicity, consistency, and clarity. Effective placement of visual elements in the layout ensures that the Dashboard mockup can visualize the load clearly and informatively, which is then evaluated to ensure optimal functionality, ease of reading information, and good interface responsiveness.

Identification of Data Sources.

In the process of identifying electrical equipment data sources, information about the equipment types, capacities, and other attributes is collected and analyzed. The goal is to understand the types of equipment to be used in the visualization. A relevant list of equipment is compiled based on characteristics and relevant units. This process is important to ensure that the used equipment load data has been properly obtained through careful analysis. The result is a Spreadsheet format that allows users to enter the equipment load history into the visualization data center for further analysis Guion et al. (2015). The Spreadsheet plays a crucial role in connecting users with the visualization data center and ensuring the accuracy and consistency of the entered data.

Layout and Interface Design.

In the layout and interface design stage, it is important to use the results of the data source identification and literature review as a strong foundation. This process involves the effort to create an intuitive interface following principles of good design, such as simplicity, consistency, and clarity. Special attention is given to the effective placement of visual elements in the layout, resulting in a Dashboard mockup capable of visualizing the load clearly and informatively. The mockup is then thoroughly evaluated to ensure optimal functionality, ease of reading information, and good interface responsiveness. Through the evaluation stage, users and stakeholders are given the opportunity to provide valuable feedback, allowing for a significant improvement in user

experience. This process is an essential step in ensuring that the generated interface design meets the expectations and needs of users to the best possible extent. The mockup is used to generate domain models, navigation models, and presentation models. This approach enables active user participation in the development cycle and reduces the effort of translating requirements into software Rivero et al. (2014).

Testing and Design Verification.

In this stage, design testing and verification are conducted to ensure that the visual interface design for electrical equipment load visualization meets the needs and expectations of data users. Design reviews need to be conducted to align the created design with available resources (Russo & Graham, 1999). The testing process involves preparation based on the results of the data user survey as a basis for appropriate testing. Testing is conducted by involving senior staff as end users to test the design and provide feedback. The obtained feedback is then analyzed to identify the strengths and weaknesses of the design. Based on this analysis, appropriate design improvements and adjustments are made. The verification and validation stage is carried out to ensure that the design meets the established requirements and evaluation criteria. By conducting comprehensive testing and verification, it is expected that the generated interface design can provide an optimal user experience and enhance the understanding of equipment load peaks for data users in operational evaluation.

4. RESULTS

In the visualization design using the line diagram method, the data source used is the historical record of equipment load changes over time, as recorded in the Dispatcher's worksheet Kementrian ESDM (2020). This data depicts the trends in equipment load changes over time. It should be noted that the data used is not Realtime data as in previous studies. In the context of this research, it is important to consider the specific conditions of electrical load measurements in the national electricity company, where equipment outages can occur due to maintenance or disturbances, leading to data deviations in other equipment. Therefore, the data validation process becomes a critical step in designing the dashboard to distinguish between normal and abnormal loadings caused by equipment outage conditions. Validation is performed by assigning statuses to the affected equipment based on their loadings resulting from the outage of a specific electrical equipment. By conducting careful validation, the dashboard can present accurate visualizations of peak load data and provide valuable information to users. The basis used in the design stage is to translate the desires of customers within the scope of the national electricity company, with a total of 48 data users in the operational evaluation field.

FIGURE 3. Survey results of equipment to be visualized

FIGURE 4. Measurement units for equipment load.

FIGURE 5. Desired types of load data.

The results of the survey shown in Figure 3, Figure 4, Figure 5 are summarized in Table 2

TABLE 2. Summary of survey results

	The presented data	Equipment types	Equipment units
1	24-hour Load	Distribution Transformers	Mega Watts
2	Highest monthly data	Interbus Transformer (IBT)	Mega Vars
3	Highest annual data	Conductors	Percentage
4		Generators	Kilo Volts
5		Subsystems	Amperes
6		Voltage	

The result of this research is the design of a visualization of electrical equipment loads in the form of a dashboard, which is implemented through a mockup web. The

design allows users to visually see the electrical equipment loads and obtain useful information regarding the availability of peak loads, according to the preferences expressed by the users in the survey on equipment load data. The visualization design utilizes an intuitive and interactive line diagram method, enabling users to easily understand and analyze the equipment load data.

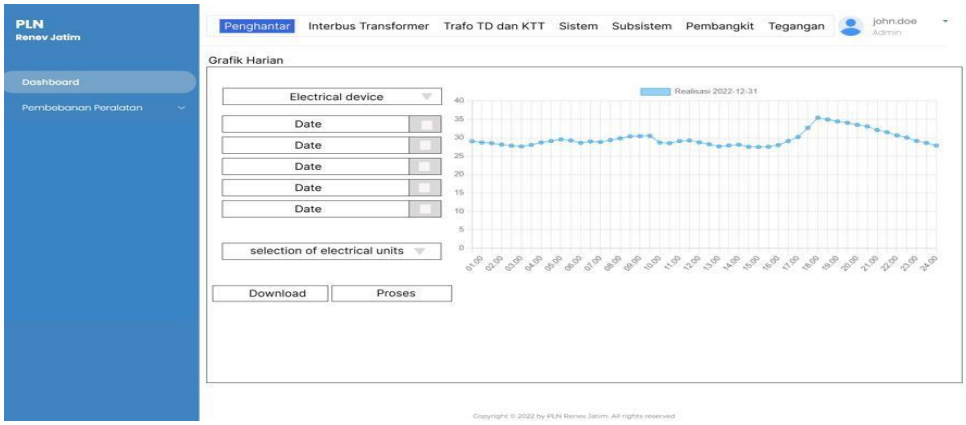

FIGURE 6. Daily load dashboard design.

In Figure 6, an informative and interactive design is shown with a graph of daily equipment load. The horizontal axis displays time with data sampling intervals every 30 minutes over a 24- hour period, while the vertical axis indicates the amount of equipment load adjustable with desired units. The menu beside the graph allows users to select specific date ranges, facilitating practical comparison of daily load trends in a single view for easy evaluation. There is also a download button that enables users to download the graph data in spreadsheet format, allowing for further data processing. The menu at the top of the dashboard provides flexibility for users to choose the type of equipment they want to visualize, enabling specific exploration of equipment load data.

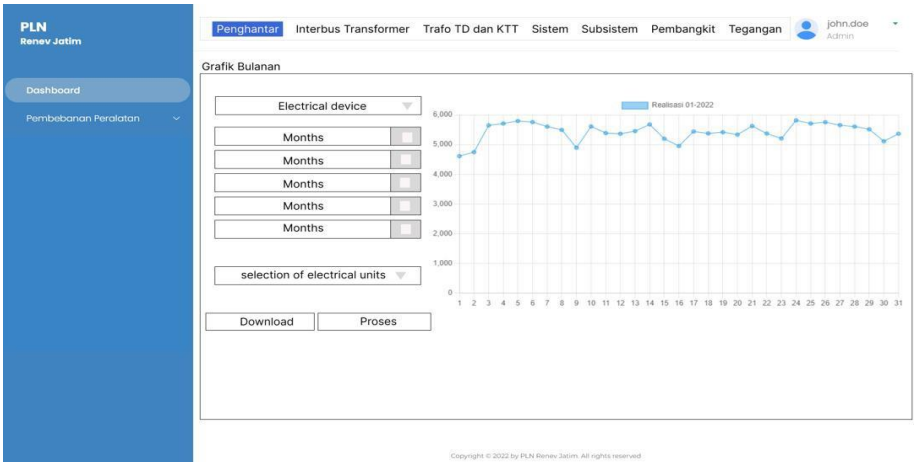

FIGURE 7. Monthly peak load dashboard design.

The dashboard interface design for monthly load graph is shown in Figure 7. In this design, the horizontal axis represents the time period in the form of dates within a specific month, while the vertical axis displays the peak load values of the equipment for each visualized date period. This dashboard incorporates important features such as period selection menu, unit options, and the ability to choose specific equipment for visualization. With an appealing and systematic layout, users can easily observe and compare the monthly equipment loadings in an intuitive display.

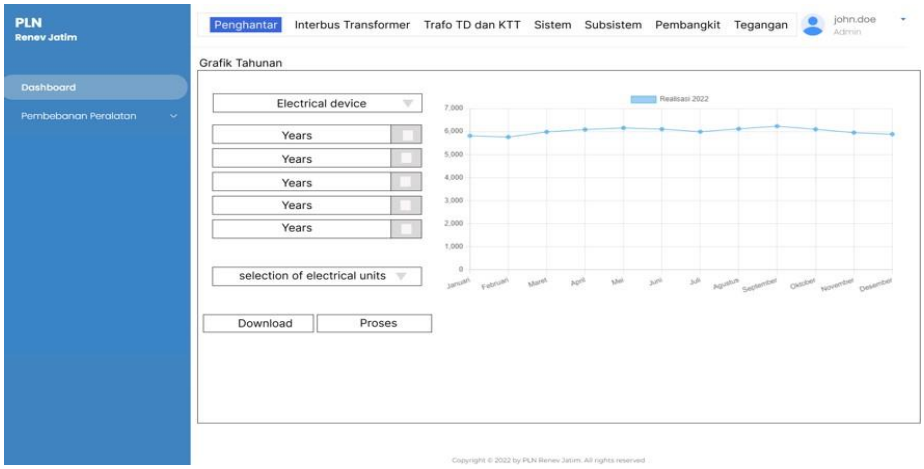

FIGURE 8. Monthly peak load dashboard design.

The annual graph design depicts the comparison of monthly durations in a year, displayed on the horizontal axis, with the monthly peak load values of the equipment shown on the vertical axis Figure 8. The annual graph design is also equipped with additional menus that allow users to meet their specific needs, as shown in Table 2. With a well-designed layout and comprehensive menus, users can easily explore and analyze annual equipment load data efficiently and according to their needs.

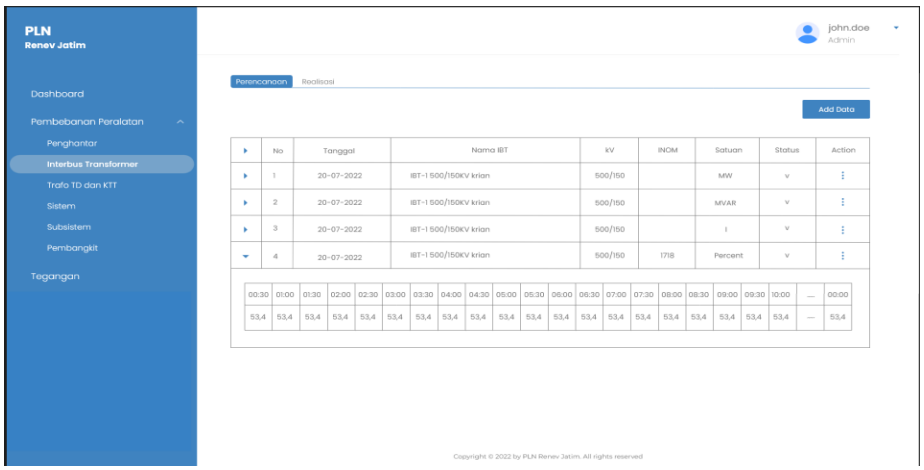

FIGURE 9. Data upload design in the dashboard.

Users have the ability to view and modify data if any discrepancies are found in the uploaded data, without the need to re-upload the data. Figure 9, there is a status column that functions to mark equipment values in peak load calculations that are deemed abnormal. Users can provide or remove specific marks in that column to indicate the

status of the equipment. This feature allows users to easily identify and manage abnormal data, thereby improving the accuracy and quality of peak load calculations.

5. CONCLUSIONS

In this study, the steps taken include identifying the research objectives, conducting a literature review on equipment load visualization, designing a dashboard that includes daily, monthly, and annual graphs, and testing and evaluating the design. The findings of this study successfully resulted in the design of equipment load visualization using the line chart method to enhance the availability of peak load information. The dashboard design allows users to easily view equipment load trends over different time ranges and provides a clear representation of the type of equipment, presented data, and units of equipment load. The evaluation results indicate that the design meets user needs and provides the expected information availability.

The dashboard design for equipment load visualization using the line chart method offers improved availability of peak load information. Users can easily view and analyze equipment load trends on a daily, monthly, and annual basis. This design also provides a clear and informative representation of the type of equipment, presented data, and units of equipment load. In the next steps, future work can involve implementing the design into a more comprehensive prototype and involving coding to create a practical visualization dashboard. From this study, it can be concluded that the visualization design of equipment load using the line chart method can make a positive contribution to enhancing the availability of peak load information. The developed dashboard design shows potential to provide valuable information to users and facilitate the analysis of equipment load data. Therefore, the subsequent implementation of this design into a dashboard will allow the real benefits of improving peak load information to be experienced.

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How to cite this article:

Sidqi, F., & Mudjahidin. (2023). Design of Electrical Equipment Load Visualization to Improve the Availability of Peak Load Information Using the Line Chart Method. *Jurnal Teknobisnis, 9*(2): 119-129. DOI: 10.12962/j24609463.v9i2.1875