



Research Paper

Optimizing Protection Settings at PT PLN (PERSERO) UP2D Lampung through User-Centered Design and Model-View-Controller Architecture

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Keywords

CodeIgniter 4, Model View Controller, Protection Setting System, User-Centered Design

Abstract

The rational basis for this research is the need to strengthen a Protection Management Information System in PT Perusahaan Listrik Negara (PLN) (Persero) UP2D Lampung so that it can implement monitoring and control systems or applications management protection settings quickly & accurately on electrical distribution system. Currently the company is using a manual process that uses Microsoft Excel, which is time-consuming and subject to human errors resulting in system reliability issues. In this paper, a new web-based system is developed based on the User-Centered Design (UCD) approach to provide an easy and friendly interface for field operators to handle filling process. Using the MVC (Model View Controller) architectural design pattern with CodeIgniter 4, it has structured and modularized code for easy maintenance and update. It automatically processes protection data, such as the Over Current Relay (OCR) and Ground Fault Relay (GFR) settings, its output to manager in a form easy to understand. The prototype was tested for usability via the User Equation Questionnaire (composed of Likert scale questions) with 19 respondents, allowing to determine a high usability score of 93.78% and validating the strong user satisfaction. The results of this study are expected to lead to the implementation of a reliable system with a user-friendly interface, ultimately enhancing the reliability of the electrical distribution system and speeding up responses to electrical issues in the Lampung region.

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1. INTRODUCTION

PT Perusahaan Listrik Negara (PLN), specifically the Distribution Control Implementation Unit (UP2D) of Lampung, plays a crucial role in ensuring a reliable and stable electricity supply across the Lampung region. PT PLN UP2D Lampung, as the main electricity distribution unit, still faces many challenges in carrying out the protection system to maintain grid stability. The proper configuration of protection settings is vital to preventing faults that could damage electrical equipment and to ensuring the continuity of the power supply. The protection management system at PT PLN UP2D Lampung, on the other hand, still employs manual processes through programs such as Microsoft Excel, leading to inefficient processing time and frequent human error along with inaccuracies in protection configuration

settings.

One of the critical aspects of protection management involves configuring protection relays, such as Over Current Relay (OCR) and Ground Fault Relay (GFR). Accurate relay settings are essential in preventing significant disturbances in the power distribution network [1]. However, the current configuration method at PT PLN UP2D Lampung is still fragmented and partial, making it difficult for real-time monitoring and having a slow response to disturbances in the system. Thus, the web-based protection setting information platform can be established as a primary step toward improving operating efficiency and reducing response time for faults in electrical distribution.

Research conducted by Gallegos et.al [2] demonstrates that the implementation of computer-based systems in protection

management significantly enhances the response time to electrical disturbances. According to the findings, by implementing integrated technology-based systems that allow a wider access from the user-level data inputs, they have reduced reliance on manually entering the data into a system historically responsible for significantly slowing down these fault detections and recovery processes. Electrical disturbances can thus be responded to faster through these automated systems leading to improved reliability of the system as human error is reduced. Similarly, a study by [3] suggests the incorporation of Internet of Things (IoT) technology to automate the monitoring and control of protection systems. Protection systems can function in real-time by utilizing IoT, enabling responsive monitoring and handling of electric faults. This technology is a solution to help reduce reliance on manual systems for more efficient and structured supervision. On the other hand, Indonesia’s electrical distribution businesses IoT adoption is still in its infancy and limited only to research and pilot projects.

In Indonesia, several studies related to electrical management for PT PLN have been conducted [4, 5, 6, 7]. Research [6] developed a web-based system to manage the protection settings of PLN’s transmission networks in East Java and Bali, with [5] also building the similar system in Garut, West Java. While these systems succeeded in improving the efficiency of protection management, it did not incorporate a User-Centered Design (UCD) approach, which could enhance usability and the overall user experience [8, 9]. Considering this, the current project presents the creation of a web-based protection setting information system using the Model-View-Controller (MVC) architecture for backend management with the use of UCD to guarantee an appropriate user experience—this means taking into account aspects referring in special to technicians and field operators who need an intuitive responsive interface [10]. The proposed system combines UCD of the user interface with MVC for backend structure which will help achieve reliable settings of protection, faster response to electrical faults and reduce human errors adversely affecting operations. This research aims to create a technology-based solution that will optimize the management and implementation of electrical distribution protection plans at PT PLN UP2D Lampung, thus providing a major contribution towards increasing the reliability of electricity distribution systems in the region of Lampung.

2. EXPERIMENTAL SECTION

Figure 1 shows the User Centered Design framework [8, 11, 12]. This method is able to recognize key issues and gather information that can improve the participant’s experience, potentially enhancing the quality of the study tools [13].

2.1 Understand Context of Use

System designers must have a thorough understanding of the context in which the application will be used, including who will use the system, their objectives in using the application, and under what circumstances or conditions the application will be utilized. A deep understanding of this context is crucial for

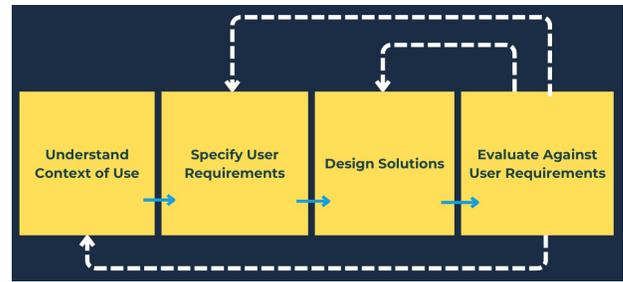


Figure 1. User Centered Design Framework

designers to create a system that is relevant and tailored to the diverse needs of the users.

2.2 Specify User Requirements

After understanding the context in which the application will be used, the next step is to define the user requirements. At this stage, the system designers must identify the users’ needs within the business context and the objectives they aim to achieve through the application. This includes the desired functionality, success criteria, and features necessary to support the users’ operational efficiency and effectiveness. During this phase, both functional and non-functional system requirements are identified based on the users’ needs. The functional requirements are viewed from two perspectives: admin users (UP2D) and non-admin users (non-UP2D).

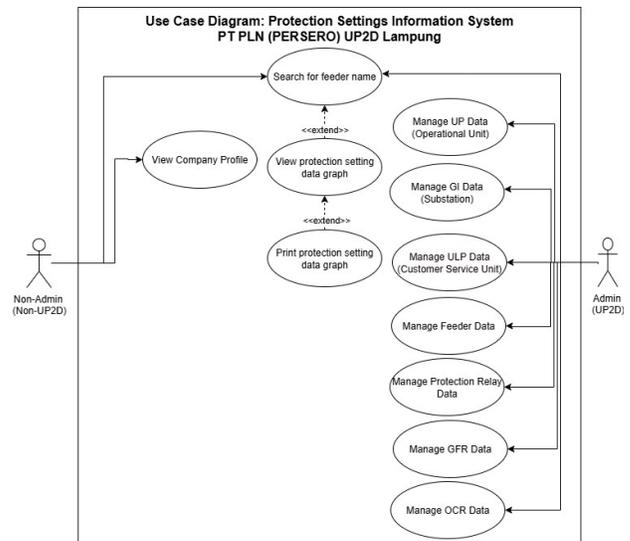


Figure 2. Use Case Diagram for the Protection Setting System of PLN UP2D Lampung

2.3 Design Solutions

This stage marks the initial phase, where each iteration involves selecting focus tasks and estimating the time required for each iteration. The iterations are planned to be conducted three times, with varying durations. During this phase, the UML diagrams

and the user interface design for the protection setting information system are created using Figma tools to design the system prototype that will be implemented. The interface design is based on the UML diagrams (use case diagram and activity diagram) and the Entity-Relationship Diagram (ERD) that have been developed. The ERD is used to model the tables and the required data for system development. The use case diagram is employed to model the features needed by the organization for the system design, while the activity diagram is used to illustrate the workflow and processes within the protection setting information system. The system is then implemented using CodeIgniter 4, a framework that supports the Model-View-Controller (MVC) architecture, which will be developed further.

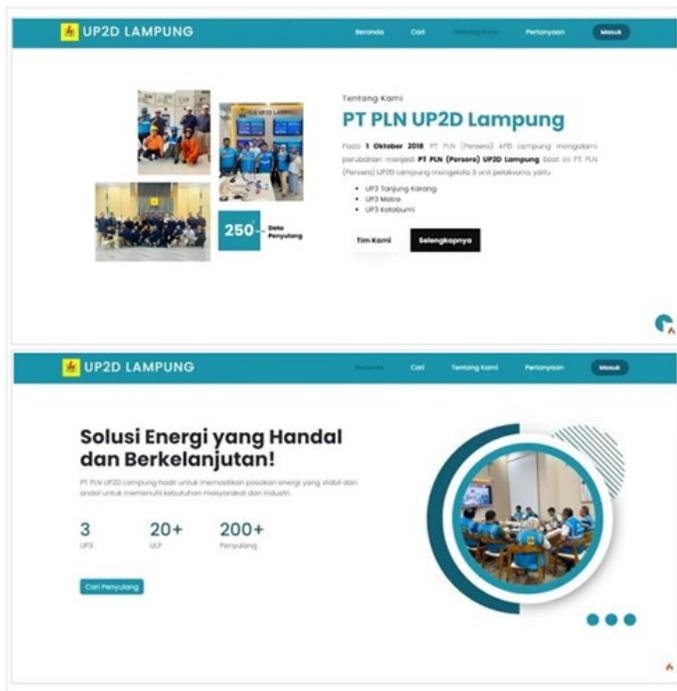


Figure 3. UI of Profile Protection Setting System PT PLN UP2D Lampung

2.4 Evaluate Against User Requirements

During this phase, feedback and analysis are gathered, and existing assumptions are validated against the results of the system design and implementation. This phase demonstrates that the system meets the planned objectives and user requirements [14]. The study employs the User Experience Questionnaire (UEQ) to assess whether the prototype design is suitable for use [15]. Usability testing, using the UEQ (which evaluates usability, satisfaction, and ease of use), measures learning ability, efficiency, retention, errors, and user satisfaction, with results calculated using the Likert scale [15, 16].

3. RESULTS AND DISCUSSION

In this section, the results from each stage of the research using the User-Centered Design (UCD) method are described.

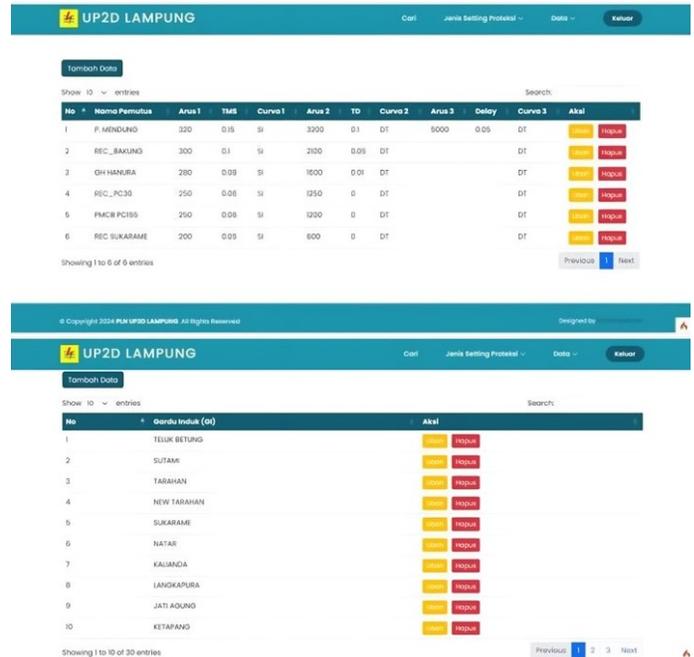


Figure 4. UI of Manage Feeder and GI Data

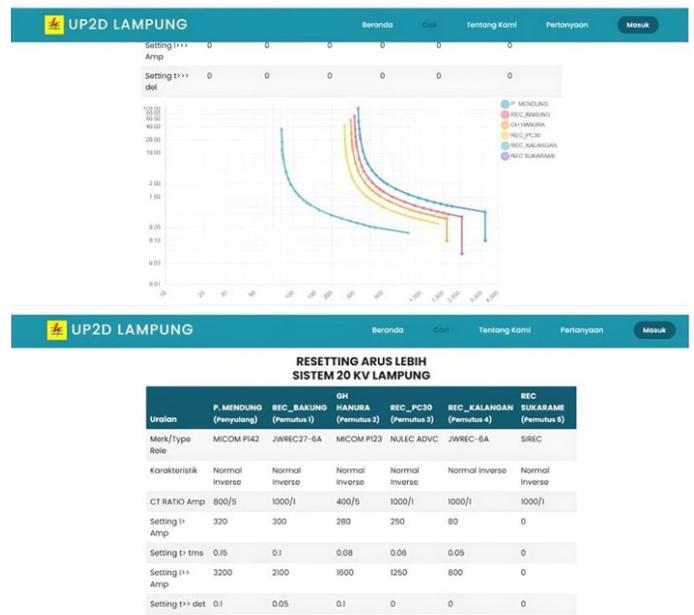


Figure 5. UI of Manage OCR/GFR

3.1 Understand Context of Use

This phase carried out several data collection methods on the Protection Setting Information System development at PT PLN (Persero) UP2D Lampung, which included observation and interviews. This study evaluated the protection setting processes in the electricity distribution network through direct observation of business operations at the organization, where Microsoft

Excel remains as the primary reporting tool. Based on these observations some problems were identified and shared with stakeholders in order to look for opportunities to create a new system that would be able to solve the issues uncovered.

Direct interviews were conducted by asking several staff on duty about existing problems, expected system needs, and business processes that occur at PT PLN (Persero) UP2D Lampung. Currently, the organization administers protection settings in the power distribution network using a manual system (Microsoft Excel), which is not an efficient way of tracking protection settings and introduces human errors. The two main groups of users accessing the system are admins (UP2D) and non-admins (Non-UP2D). Administrators are designed to configure and monitor the protection system in real-time, whereas non-admin users only receive high-level data (for example, raw feeder information).

Table 1. The User Satisfaction Index

Index	User Satisfaction Result
0% – 19.99%	Very dissatisfied
20% – 39.99%	Dissatisfied
40% – 59.99%	Uncertain
60% – 79.99%	Satisfied
80% – 100%	Very satisfied

This context highlights the need for a system that enables fast response times to disturbances, better organization of protection data, and streamlined operations to improve system reliability. Insights from user research, including both interviews and observations, revealed that admins require a user-friendly interface that reduces complexity and allows easy access to protection system data.

3.2 Specify User Requirements

At this stage, the identification of both functional and non-functional system requirements is conducted based on user needs. The functional requirements are viewed from two perspectives: the admin (UP2D) and non-admin (non-UP2D) users. The admin (UP2D) requirements include: managing UP (Implementation Unit) data, managing GI (Substation) data, managing ULP (Customer Service Unit) data, managing feeder data, managing protection relay data, managing OCR (Over Current Relay) data, managing GFR (Ground Fault Relay) data, searching for feeder names, viewing protection setting data graphs, and printing protection setting data graphs. The non-admin (non-UP2D) requirements include: viewing the company profile, searching for feeder names, viewing protection setting data graphs, and printing protection setting data graphs. These functional requirements are represented in the form of a use case diagram, as shown in Figure 2.

In addition, the users have several non-functional requirements, as follows:

a. A user-friendly interface that requires minimal training for field technicians.

- b. The system must be secure, ensuring that only authorized personnel can access sensitive data.
- c. The system must be scalable to accommodate future updates and improvements.
- d. Easy access to data and real-time updates for quick decision-making.

3.3 Design Solutions

This study designs the mockup interface using FIGMA and implements the design in the system development using CodeIgniter 4 [17]. The CodeIgniter 4 framework is chosen because it facilitates the Model-View-Controller (MVC) architecture. This architecture is modular and easy to maintain, making it suitable for future scalability and system upgrades. The system is designed and implemented using Bahasa Indonesia. Figure 3 Shows the UI of Profile Protection Setting System PT PLN UP2D Lampung, Figure 4 displays UI of Manage Feeder and GI Data, and Figure 5. UI of Manage OCR/GFR.

3.4 Evaluate Against User Requirements

User acceptance assessment is being performed on the system using Likert scale. The testing method is designed to reflect the level of satisfaction obtained by the user and includes a questionnaire containing questions on the created system [18]. Each question offers respondents five response options, each associated with specific Likert scores: strongly agree (5), agree (4), uncertain (3), disagree (2), and strongly disagree (1). By assigning Likert scores to these responses, user feedback can be quantitatively analyzed [18, 19]. The satisfaction index can then be calculated through Equation (1) after getting the total score. Subsequently, the derived satisfaction index data is juxtaposed against the defined index intervals, as outlined in Table 1 [18].

$$\%Index = \frac{\text{Total Score}}{\text{Maximum Score}} \times 100 \quad (1)$$

The questionnaire was completed by PT PLN UP2D Lampung employees who had prior exposure to and experience with the FIGMA prototype [20] of the developed system. Surveys were collected from 19 participants (administrators and leaders), potentially representative of users within the system. Table 2 provides a brief overview of the responses to the questionnaire. In the analysis, questionnaire results are first calculated in total (Likert score) based on the answers provided by each respondent, as shown in Table 3.

Once the total score has been acquired, this value can be employed to ascertain the user satisfaction index. This determination involves utilizing an equation to identify the index within the Likert scale intervals, as demonstrated in the following illustration. This process aids in assessing the overall satisfaction of users based on their responses.

$$\%Index = \frac{\text{Total Score}}{\text{Maximum Score}} \times 100$$

Table 2. The Questionnaire Outcomes

No	Question	Percentage of Respondent Answers*				
		VS	S	U	D	VD
1	The arrangement of information on the system screens was evident and coherent.	10 (52.63%)	9 (47.37%)	0 (0%)	0 (0%)	0 (0%)
2	The system’s interface design is engaging.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
3	The system is easy to comprehend.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
4	The system is user-friendly.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
5	The features present on the system are in accordance with the requirements.	6 (31.58%)	12 (63.16%)	1 (5.26%)	0 (0%)	0 (0%)
6	I am content when using the system.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
7	It was easy to find the information I needed.	13 (68.42%)	6 (31.58%)	0 (0%)	0 (0%)	0 (0%)
8	I managed to efficiently accomplish the tasks and scenarios using this system.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
9	Whenever I encountered errors while utilizing the system, I was able to recover quickly and easily.	13 (68.42%)	6 (31.58%)	0 (0%)	0 (0%)	0 (0%)
10	Overall, I find this system satisfactory.	15 (78.95%)	4 (21.05%)	0 (0%)	0 (0%)	0 (0%)
Total		132 (69.47%)	57 (30%)	1 (0.53%)	0 (0%)	0 (0%)

*VS: Very Satisfied; S: Satisfied; U: Uncertain; D: Dissatisfied; VD: Very Dissatisfied

$$\%Index = \frac{891}{(19 \times 5 \times 10)} \times 100$$

$$\%Index = \frac{891}{950} \times 100$$

$$\%Index = 93.79\%$$

Table 3. The Results Total Score Using Likert Scale

Answer	Score
Very satisfied	132 × 5 = 660
Satisfied	57 × 4 = 228
Uncertain	1 × 3 = 3
Dissatisfied	0 × 2 = 0
Very dissatisfied	0 × 1 = 0
Total	891

According to the data presented in Table 2, the outcomes of the questionnaire, derived from the respondents, particularly the sample comprising employees of PT PLN UP2D Lampung, are demonstrated. Out of the 10 questions, 9 were answered with satisfactory or very satisfactory. For one of the questions, a single respondent provided an ambivalent answer: were features in-line with what we specified as requirements. The system lacks other features, such as automatic notification integration, which contributes to this uncertainty. From the quantitative aspect, we obtain a Likert type index of 93.79 %. Referring to the

user satisfaction index shown in Table 1, we can conclude that overall all respondents rate the developed system with "Very Satisfied or Highly Satisfactory" category, which fits the criteria predetermined by PT PLN (Persero) UP2D Lampung.

4. CONCLUSIONS

PLN (Persero) UP2D Lampung significantly facilitates data access and provides graphical representations of protection setting disturbances across Lampung Province, while integrating seamlessly with the company profile. User-Centered Design (UCD) improves the productivity and operational efficiency of a system by ensuring that it is aligned with the needs and preferences of users. Additionally, the use of Model-View-Controller (MVC) architecture by CodeIgniter 4 for back-end development makes the system modularized and maintainable as well as scalable in case of future enhancement. All 50 functional tests conducted through black-box testing were successful and met the expected outcomes, while usability testing with 19 respondents using the User Experience Questionnaire (UEQ) yielded an overall Likert score of 93.79%, reflecting a high level of system acceptance. Future work may also explore the performance of the system under high-load and security evaluation, as this can give deeper insights into how well it performs while managing large-scale data, along with its risks. Moreover, results from usability testing indicate that further research could identify additional features to improve user experience; one such feature might be an interactive dashboard, and another an automated alert system to receive faster notifications regarding protection disturbances.

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