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Investigating Communication Failures in AMR Meter at PT PLN UP3 Bali Selatan: A Failure Mode and Effect Analysis Approach

I Komang Wijaya Kusuma Liska[1]*, Anak Agung Istri Sri Komala Dewi[2], Ni Luh Putu Lilis Sinta Setiawati[3]
[1,2,3] Industrial Engineering Study Program – Faculty of Engineering, Udayana University

***Corresponding Author**: wijaya.kusumaliska10@student.unud.ac.id[1]

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ABSTRACT

Automatic Meter Reading (AMR) is an automated system for reading electricity meter data that allows for remote monitoring and control of energy supply. This research addresses the high incidence of communication failures in the AMR system at PT PLN UP3 Bali Selatan, which significantly impacts the reliability of energy measurement and transaction processes. Using the Failure Mode and Effect Analysis (FMEA) method, this study identifies the primary causes of communication failures and prioritizes mitigation efforts based on Risk Priority Number (RPN) values. Data was collected through direct observation and interviews with the AMR team over two months, as well as historical data held by the AMR team. The analysis results indicate five critical communication failures in the Automatic Meter Reading (AMR) system. The most vital, “Can't connect to modem (1),” has an RPN of 225, followed by “Can't connect to modem (2)” (RPN 175) and “Modem no Answer” (RPN 125). Based on Pareto analysis, these failures account for over 80% of communication issues, highlighting the need for prioritized corrective actions. Recommendations include routine hardware maintenance, optimization of communication device placement, and technical training for the AMR team. The findings contribute to improving the reliability of AMR systems and offer a structured approach for mitigating communication failures.

INTRODUCTION

The need for electrical energy, economic growth, and community welfare constantly increases yearly. Improvements in power generation and existing infrastructure capabilities are needed to ensure the smooth distribution of electrical energy to consumers and meet standards [1]. The increase is also marked by several things, such as the development of increasingly advanced industries and businesses, the rise in population, which will automatically lead to an increase in electricity consumption and the increase in equipment that requires electric power.

PT PLN (Persero) is a State-Owned Enterprise (BUMN) engaged in electricity provider services for the people of Indonesia that constantly improves services by offering various programs for the convenience of the community [2]. In the energy transactions field, a sub-field of transaction meter maintenance that is in charge of maintaining the customer's kilowatt hour (kWh) Meter so that the transaction process or energy measurement can run properly. A kilowatt hour (kWh) meter is an active energy meter that uses the principle of induction to calculate the amount of electrical work in a given time [3].

Electrical energy measurement has a vital role in determining the income of electricity companies. Faulty energy measurement data is one of the most common customer complaints against electricity companies. In the process of recording electricity meters, PT PLN utilizes officers to visit customers' homes and record data on electrical energy consumption at kWh [4]. The recording process cannot be done if the customer's house is empty. To improve accuracy and efficiency, PT PLN (Persero) introduced the Automatic Meter Reading (AMR) system, which is an automatic system for reading electricity meter data that allows monitoring and controlling energy supply to customers using communication media such as Public Switched Telephone Network (PSTN), modem, Digital Power Line Carrier (DPLC), or Radio Packet that allows remote reading [5]. The AMR system makes monitoring customers' energy consumption easier and reduces manual meter reading errors to maintain customer trust in PT PLN UP3 Bali Selatan services.

Figure 1. AMR customer data at PT PLN UP3 Bali Selatan

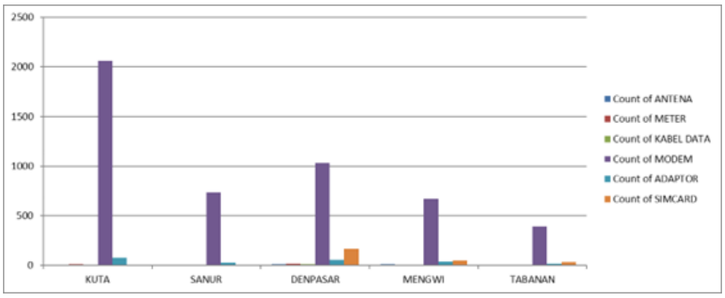

Figure 2. Graph of AMR failures at PT PLN UP3 Bali Selatan

Based on the registered Customer Data of the Centralized AMR Application and the AMR Disruption/Failure Graph at PT PLN UP3 Bali Selatan in Figures 1 and Figure 2, as of January 1, 2024, there were 8,019 active customers of the AMR system and 5,445 AMR failures that occurred in 2023 (period from February 1, 2023 to January 1, 2024). The graph shows the AMR failure that happened in PLN UP3 Bali Selatan based on the cause of only two groups of failures: failure in communication and failure in meters. Then, the failures that occurred were dominated by failures in AMR communication. From this data, it can be concluded that meter communication failures often occur in the AMR System at PT PLN UP3 Bali Selatan.

Looking at the conditions in the 2023 period, it is necessary to analyze the causes that most affect AMR meter communication failures. One of the methods used is Failure Mode and Effect Analysis (FMEA), which is expected to determine the level and highest risk estimate of the sources of communication failure in the AMR system at PT PLN UP3 Bali Selatan. Previous research, FMEA was carried out to determine the cause of the decline in electrical energy of PT PLN (Persero) Semarang area has the highest risk level of 4 types of failures that occur [6]. Failure analysis with the FMEA method to determine undercarriage maintenance in three-wheeled blue electric vehicles shows that one component is a critical component and efforts to prevent damage with routine maintenance are needed [7], so the use of FMEA applications continues to be developed in quality control analysis [8].

However, the application of FMEA in the context of communication failures in AMR systems is still rarely found. Therefore, this research provides a new contribution by applying FMEA to identify the sources of communication failures in the AMR system at PT PLN UP3 Bali Selatan, which serves as a basis for proposing risk-based priority improvement solutions.

This study has two main focuses. First, what are the main causes of communication failures in the AMR system at PT PLN UP3 Bali Selatan? Second, how can mitigation priorities be determined based on the Risk Priority Number (RPN) value generated from the FMEA analysis? By answering this question, the research is expected to provide in-depth insights into the causes and solutions to communication failures in AMR systems.

MATERIALS AND METHODS

Data collection was carried out at PT PLN UP3 Bali Selatan for two months in the Energy Transaction section; direct observation of the field and interviews do the data collection technique. Historical data collection and direct observation of the AMR system were carried out to collect data on AMR communication failures at PT PLN UP3 Bali Selatan. Data collection with interviews was carried out with the AMR team, team leader, and assistant manager to obtain data information on the causes and impacts of AMR meter communication failures using the FMEA method as well as for weighting severity, occurrence, and detection.

After collecting data, data analysis is carried out by determining the largest group of AMR failures. Determining the group causing the most significant AMR failure was carried out to determine the group to be analyzed into a process function in the FMEA method. Meanwhile, FMEA is used to obtain Risk Priority Number (RPN) values with the risk level of each cause of communication failure and to provide recommendations for improvement by the highest risk priority [9]. Furthermore, the RPN values are sorted based on the highest value to the lowest value to create a Pareto Diagram to help focus attention on the main problems that must be addressed in the improvement effort.

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a structured procedure to identify and eliminate the possibility of failure modes that occur in the future [10]. Potential failures are determined by assigning a value or score for each failure mode based on the occurrence, severity, and detection level [11]. FMEA is also used as a technique that identifies three things, includes (1) potential causes of failure of systems, designs, products, and processes during their life cycle, (2) the effects of the failure, and (3) the degree of criticality of the effect of failure on the functioning of systems, designs, products, and processes [12].

The FMEA calculation will result in the RPN value of each failure mode. The value obtained for the FMEA calculation is from interviews and discussions with company respondents. The most considerable RPN value is a mode that must be prioritized to be improved [13]. The formula for calculating RPN is as follows.

$$RPN = Occurance \times Severity \times Detection$$

Pareto Diagrams

Pareto diagrams are a method of managing errors, problems, or defects to help focus on problem-solving efforts, according to Heizer and Render [14]. This Pareto diagram is an illustration that sorts the classification of data from left to right in order of ranking from highest to lowest, according to Besterfield [15]. This approach can help identify the most urgent problems that need immediate attention (highest ranking) and those that can be addressed later (lowest ranking). Additionally, Pareto charts can highlight the most significant issues impacting quality improvement initiatives.

RESULTS AND DISCUSSIONS

Analyzing the Causes of Failure in the Largest AMR Systems

In this research, the data used is AMR system disturbances in 2023 (period February 1, 2023, to January 1, 2024); there are 5,445 disturbances in the system. The failure of the AMR System at PT PLN UP3 Bali Selatan is grouped based on the following causes:

Table 1. Determination data on the cause of failure in the largest AMR system

Causes of AMR Failure	Total Number (Failure)	Percentage (%)
Failure in AMR Application	0	-
Failure in Communication	5402	99,2 %
Failure on kWh Meter	43	0,8 %

Based on the data above (Table 1), it can be seen that the largest cause of Automatic Meter Reading (AMR) failure occurred in Communication Failures, which was 5,402 or 99.2% in the period from February 1, 2023, to January 1, 2024, at PT PLN (Persero) UP3 Bali Selatan.

Failure Mode and Effect Analysis (FMEA)

Further research was conducted using the FMEA method to identify the causes of AMR communication failures based on the causes of the largest failures. The table below (Table 2) shows the analysis results obtained with severity, occurrence, and detection values from interviews with Team AMR, the Team Leader, and the Assistant Energy Transaction Manager.

Table 2. Results of worksheet failure mode and effect analysis of AMR meter communication failure

Function	Failure Type	Potential Impact	S	Potential Causes	O	Detection Mode	D	RPN	Recommended
Failure in Communication	Can't connect to modem (1)	Meter reading failure	5	Damage to the Modem	9	Regular inspections / checks	5	225	Replacing the Modem
	Can't connect to modem (2)	Meter reading failure	5	Hang on the Modem	7	Regular inspections / checks	5	175	Modem Restart Maintenance
	Modem no Answer	Meter reading failure	5	Damage to Adapters, Antennas, and Data Cables	5	Regular inspections / checks	5	125	Replacing Adapters, Antennas, and Data Cables
	No carrier	Meter reading failure	2	Communication signal is weak/is in a blank spot	1	Regular inspections / checks	5	10	Maintenance of Antenna Relocation
	No Dial Tone	Meter reading failure	4	Damage to GSM, GSM Card blocked or gateway shutdown	5	Regular inspections / checks	5	100	Performing a Replacement on GSM

The RPN value shows how important a type of failure should be prioritized based on severity, occurrence, and detection values. Based on the data above (Table 2), of the five types of failures, one type has the largest RPN value compared to other types of failures. The type of failure is can't connect to modem (1) due to damage to the modem with an RPN value of 225. The severity value greatly influences the high RPN value of this type of damage, and the occurrence is relatively higher. This value is high because the failure has an effect and is a more significant cause than other failures.

Pareto Diagrams

Based on the sequencing of RPN values and based on the Pareto diagram in Figure 3, it is obtained that can't connect to modem (1), can't connect to modem (2), modem no answer, no dial tone, and no carrier which have a major failure rate and have an essential role in AMR meter communication failure. The impact of these five types of failures greatly influences quality degradation. This indicates that a failure mode must be repaired in each type of failure. Repairs that will be made for the five types of failures are carried out based on the causes of failure that have been analyzed based on Failure Mode and Effect Analysis (FMEA) so that the problems that occur are known for repairs to be made. To resolve the “Can't Connect to Modem (1)” issue, implement a routine maintenance schedule to check for damage and ensure optimal operation. Additionally, improve environmental conditions, such as controlling humidity and temperature, to prevent corrosion. These measures will enhance the reliability of the AMR meter communication system.

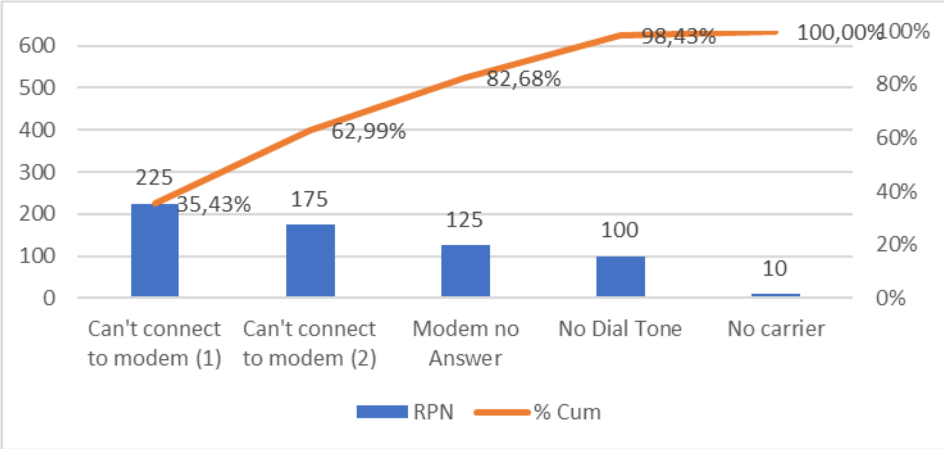

Figure 3. Diagram of the communication failure of the AMR meter based on the RPN

The results of this study indicate that communication failures in the Automatic Meter Reading (AMR) system at PT PLN UP3 South Bali are primarily attributed to modem damage, which has the highest Risk Priority Number (RPN) value of 225. This finding aligns with the research conducted by Hasanah [5], which asserts that communication disruptions in AMR systems are frequently caused by faulty or suboptimal hardware. Additionally, Hariyati [16] and Siswanto [17] identifies that SMS modems often lead to unstable communication signals, further supporting the emphasis on modem damage as a primary cause of disruptions. This highlights the critical role of modem reliability in ensuring effective communication within AMR systems.

CONCLUSION

The research was conducted in the Energy Transaction Department of PT PLN UP3 Bali Selatan identified five primary sources of communication failures in the Automatic Meter Reading (AMR) system. The most critical failure type is “Can't connect to modem (1),” attributed to damage to the modem, which has an RPN value of 225. Following this, “Can't connect to modem (2)” occurs due to the modem hanging, with an RPN value of 175. Another significant issue is the “Modem no Answer,” caused by damage to the Adapter, Antenna, and Data Cable, resulting in an RPN value of 125. The “No Carrier” failure is also linked to weak communication signals or being in a blank spot, with an RPN value of 10. Lastly, the “No Dial Tone” failure arises from damage to the GSM, blocked GSM cards, or gateway shutdown, carrying an RPN value of 100.

Mitigation priorities based on RPN values indicate that "Can't connect to modem (1)" failures with RPN values of 225 require primary attention, followed by "Can't connect to modem (2)" (RPN 175) and "Modem no Answer" (RPN 125). Based on the Pareto diagram, these failures accounted for more than 80% of the total risks identified, making them a major focus for corrective actions. This Pareto diagram shows that by resolving the first two failures, most communication problems on the AMR system can be effectively resolved.

To address communication issues in the AMR system at PT PLN UP3 Bali Selatan, the primary priority is to handle malfunctioning and hanging modems through routine inspections, replacement stock, automatic restart systems, and firmware updates. Hardware failures such as adapters, antennas, and data cables are addressed through audits and immediate replacements. Optimization of modem locations and management of GSM cards are necessary to tackle weak signal and gateway issues. Focusing on the two main problems based on Pareto analysis can reduce over 80% of risks, supported by technical training for quicker and more effective responses.

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