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Analysis Of Saifi, Saidi, Caidi, And Ens Values As Reliability Indices In The 20 KV Distribution Network At PT. PLN (Persero) UP3 Bandung Ulp Cijawura

Dina Wulansari[1], Anira Marsha Wahyuni[2], Riska Mutiara Fitri[3]

[1,2,3]Electrical Engineering, National Institute of Technology, Bandung

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Abstract

The reliability of the electrical power distribution system is an important factor in ensuring continuity and quality of service to customers. This study aims to analyze the reliability level of the 20kV distribution network at PT. PLN (Persero) UP3 Bandung ULP Cijawura using the System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), and Energy Not Supplied (ENS) indices. The methods used include collecting data on outages, outage duration, the number of affected customers, and the load during the period from January to December 2024. The data was analyzed quantitatively and compared with the SPLN 68-2:1986 and IEEE Std 1366-2003 standards. The calculation results show a SAIFI value of 2.14 times/customer/year, a SAIDI of 2.34 hours/customer/year, a CAIDI of 1.09 hours/time, and an ENS of 84,657 kWh with an estimated economic loss of IDR 122,303,968 per year. Based on a comparison with the standards, the SAIFI and SAIDI values have met the SPLN standard but have not yet met the IEEE standard, while the CAIDI value has met the IEEE standard. The analysis results show that the high frequency and duration of disturbances are influenced by natural factors, third-party activities, animals, and network component conditions. Therefore, preventive and corrective maintenance needs to be improved in order to reduce the disturbance index values and increase the reliability of the distribution system.

Keywords: *System Reliability, Distribution System, SAIFI, SAIDI, CAIDI, ENS*

(*) Corresponding Author: *wulansaridina31@gmail.com, marshaanira51@gmail.com, riskamf@gmail.com*

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INTRODUCTION

Electricity demand is increasing every year in line with economic growth and community welfare. PT PLN (Persero)'s projected electricity demand from 2018 to 2027 is estimated to reach 56,024 MW, reflecting a significant increase in energy consumption in line with economic growth, industrial expansion, and rising household electrification rates. This growing demand requires a distribution system that is not only capable of delivering sufficient power capacity but also ensuring a high level of reliability in supply and distribution operations. A reliable distribution network is essential to maintain service continuity, minimize losses, and support national development. According to Ma'rifanto et al. (2022), the reliability of an electricity distribution system is strongly influenced by system configuration, installed safety devices, and the effectiveness of protection systems. They emphasize that appropriate network configuration,

dependable equipment, and automated operational control contribute substantially to improving overall distribution reliability.

Reliability in power systems is commonly defined as the ability of the system to deliver electricity to consumers in the required quantity and quality without interruption. Abdul, Emidiana, and Gagah (2023) explain that reliability can be measured by observing how frequently outages occur, how long they last, and how quickly the system can be restored to normal conditions. A high frequency of load interruptions indicates poor reliability performance, whereas a system with minimal and short-duration interruptions reflects strong reliability. In this context, reliability is not merely a technical indicator but also a measure of service quality. As Billinton and Allan (1996) argue in their fundamental work on power system reliability evaluation, reliability assessment provides a quantitative basis for decision-making in planning, operation, and maintenance, ensuring that utilities can balance cost efficiency with service performance.

In practice, many distribution networks still rely on overhead line systems, which are particularly vulnerable to both internal and external disturbances. Muliadi and Jamal (2022) highlight that overhead distribution lines are exposed to weather conditions, falling trees, lightning strikes, animal interference, and equipment aging, all of which significantly affect system reliability. From an engineering perspective, Gonen (2014) states that distribution systems are inherently more prone to disturbances compared to generation and transmission systems due to their wide geographical coverage and direct exposure to environmental factors. The immediate consequence of such disturbances is service interruption or blackout, which not only inconveniences customers but also results in financial losses for both consumers and the utility company. Furthermore, frequent outages can reduce public trust in the electricity provider and negatively impact industrial productivity.

To mitigate these disturbances, maintenance plays a crucial role in sustaining and improving system reliability. Rahmi, Rahmat, and Monice (2021) explain that maintenance activities can be categorized into preventive and corrective maintenance. Preventive maintenance aims to extend the lifespan of equipment and prevent unexpected failures, while corrective maintenance involves repairing or replacing damaged components to restore system functionality. According to Mobley (2002), an effective maintenance management strategy integrates condition monitoring, periodic inspection, and data-driven decision-making to reduce unplanned outages and optimize operational performance. Through systematic maintenance, utilities can minimize the Energy Not Supplied (ENS) value, which represents the amount of electrical energy that fails to be delivered to customers due to interruptions. A lower ENS value indicates better reliability performance and improved service quality.

In electrical power distribution systems, reliability is widely recognized as one of the most critical factors in ensuring continuous, high-quality service throughout the year. Muliadi and Jamal (2022) state that the reliability level of a distribution system can be assessed using standard reliability indices, namely the System Average Interruption Duration Index (SAIDI), the System Average Interruption Frequency Index (SAIFI), and the Customer Average Interruption Duration Index (CAIDI). SAIFI measures the average frequency of interruptions experienced by customers, SAIDI measures the average total duration of interruptions, and CAIDI reflects the average restoration time per interruption event. According to IEEE Std 1366-2012, these indices provide standardized benchmarks for evaluating and comparing reliability performance across different utilities and regions. By analyzing these indices, utilities can identify weaknesses in network performance and develop targeted improvement strategies.

Based on the background described above, this study focuses on analyzing the SAIFI, SAIDI, CAIDI, and ENS values as reliability indicators in the 20 kV distribution network at PT PLN (Persero) UP3 Bandung ULP Cijawura. Through this analysis, it can be determined whether the

reliability performance of the ULP meets established standards and whether further technical or operational improvements are required to enhance service continuity and customer satisfaction.

METHOD

This research was conducted at PT. PLN (Persero) UP3 Bandung ULP Cijawura with the research object being a 20 kV medium voltage distribution network. The research method used was a quantitative descriptive method, namely by processing and analyzing network disturbance data to determine the reliability level of the distribution system.

The data used in this study is secondary data obtained from PT. PLN (Persero) UP3 Bandung ULP Cijawura, including data on the number of disruptions, duration of outages, number of affected customers, and the amount of load disrupted during the period from January to December 2024. The data was collected through operational disruption reports and internal recording systems used by the relevant units.

The research began with the collection of data on 20 kV distribution network disturbances over a period of one year. The data obtained was then summarized and processed to calculate the system reliability indices, namely the System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), and Energy Not Supplied (ENS). The calculation of the reliability level of the distribution system was carried out using several indices, namely the System Average Interruption Frequency Index (SAIFI), which was calculated using the equation shown in equation (1).

$$\text{SAIFI} = \frac{\text{Number of Customers Affected by Outages}}{\text{otal Number of Customers}} \qquad (1)$$

System Average Interruption Duration Index (SAIDI) calculated using the equation shown in equation (2).

$$\text{SAIDI} = \frac{\text{Duration of Outage x Customers Affected}}{\text{Total Number of Customers}} \qquad (2)$$

Customer Average Interruption Duration Index (CAIDI) calculated using the equation shown in equation (3).

$$\text{CAIDI} = \frac{SAIDI}{SAIFI} \qquad (3)$$

Energy Not Supplied (ENS) calculated using the equation shown in equation (4).

$$\text{ENS} = Interruption\ (kW)\ x\ Duration\ (h) \qquad (4)$$

The reliability index calculation results were then compared with the SPLN 68-2:1986 and IEEE Std 1366-2003 standards to determine the reliability level of the distribution network being analyzed. In addition, the data on the causes of disturbances was grouped to identify the dominant factors affecting power outages. All analysis results were used as a basis for the discussion, conclusions, and recommendations for improvements to the distribution system in the Cijawura ULP working area.

RESULTS AND DISCUSSION

This section discusses the results of processing data on disturbances and analyzing the reliability level of the 20 kV distribution system at PT. PLN (Persero) UP3 Bandung ULP

Cijawura during the period from January to December 2024. The analysis was conducted based on calculations of the SAIFI, SAIDI, CAIDI, and ENS indices.

The results of the System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), Customer Average Interruption Duration Index (CAIDI), and Energy Not Supplied (ENS) calculations are shown in Table 1.

Table 1. Summary of Reliability Index Values for 2024

No	Month	SAIDI	SAIFI	CAIDI	ENS
1	January	0,49	0,27	1,84	17.073
2	February	0,2	0,37	0,54	7.073
3	March	0,11	0,11	0,96	3.977
4	April	0,09	0,08	1,22	3.660
5	May	0,06	0,05	1,15	2.029
6	June	0,03	0,02	1,38	1.316
7	July	0,21	0,15	1,42	8.098
8	August	0,23	0,15	1,58	7.941
9	September	0,22	0,27	0,83	8.160
10	October	0,34	0,28	1,19	12.306
11	November	0,3	0,35	0,86	11.145
12	December	0,05	0,04	1,12	1.879
1-Year Calculation Value		2,34	2,14	1,09	84.657

Based on the data in Table 1, the annual SAIFI value is 2.14 times/customer/year. This value indicates that, on average, each customer experiences 2.14 outages per year. The annual SAIDI value is 2.34 hours/customer/year. This value indicates that the average total duration of outages experienced by customers in one year is 2.34 hours. The CAIDI calculation results in a value of 1.09 hours/outage. This value indicates that the average time required to restore one outage is relatively fast, reflecting the performance of the operational team in handling outages and the readiness of supporting facilities and infrastructure in the field. The ENS calculation results in a total value of 84,657 kWh. This ENS value indicates that outages in the distribution network have a significant impact on the continuity of electricity supply.

The ENS value obtained is then used to calculate the estimated economic loss due to unsupplied electricity. The results of the economic loss calculation are shown in Table 2.

Table 2. Calculation of Economic Losses in 2024

No	Month	ENS (kWh)	Basic Electricity Rates (IDR)	Economic Crisis (IDR)
1	January	17.073	1444,7	24.665.363
2	February	7.073	1444,7	10.218.363
3	March	3.977	1444,7	5.745.572
4	April	3.660	1444,7	5.287.602
5	May	2.029	1444,7	2.931.296
6	June	1.316	1444,7	1.901.225
7	July	8.098	1444,7	11.699.181
8	August	7.941	1444,7	11.472.363
9	September	8.160	1444,7	11.788.752
10	October	12.306	1444,7	17.778.478
11	November	11.145	1444,7	16.101.182
12	December	1.879	1444,7	2.714.591
Total		84.657	1444,7	122.303.968

Based on Table 2, the economic loss amounts to a total of Rp122,303,968 per year. This value shows that improving the reliability of the distribution system not only has an impact on service quality, but also has the potential to reduce financial losses for companies and customers.

To evaluate the reliability level of the distribution system, the SAIFI and SAIDI values were compared with the SPLN 68-2:1986 and IEEE Std 1366-2003 standards. The results of the comparison are shown in Table 3.

Table 3. Table 5.6. Comparison of SAIFI, SAIDI, and CAIDI Calculation Results for 2024

No	Reliability Index	Results Calculations	Standard Index Reliability	
			SPLN	IEEE
1	SAIFI	2,14	3,2	1,45
2	SAIDI	2,34	21	2,30
3	CAIDI	1,09	-	1,47

Based on the comparison results shown in Table 3, the SAIFI and SAIDI values have met the SPLN national standards, indicating that the interruption frequency and duration experienced by customers are still within the acceptable limits set at the national level. This shows that, from a regulatory compliance perspective, the operational performance of the 20 kV distribution network at ULP Cijawura can be categorized as adequate. However, when compared to IEEE standard limits, both SAIFI and SAIDI values remain higher than the recommended benchmarks. This condition suggests that although the system performs satisfactorily according to national criteria, there is still a performance gap when evaluated against international reliability standards. In contrast, the CAIDI value has met the IEEE standard, indicating that the average restoration time per interruption is relatively efficient and aligns with internationally recognized performance expectations.

Overall, the analysis results demonstrate that the reliability level of the 20 kV distribution network at ULP Cijawura falls into the fairly good category based on national standards. The system is capable of maintaining service continuity at a level deemed acceptable within the domestic regulatory framework. Nevertheless, achieving compliance with international standards requires further performance improvement, particularly in reducing the frequency and total duration of interruptions. The fact that CAIDI has already met the IEEE benchmark indicates that restoration processes are relatively effective once a disturbance occurs. Therefore, the primary area for enhancement lies in minimizing the occurrence of disturbances and limiting their overall impact on customers.

Several improvement efforts can be undertaken to enhance system reliability. Strengthening preventive and corrective maintenance is essential to ensure that network components remain in optimal operating condition and that potential failures are detected before they develop into major disturbances. Optimizing the protection system can also help in isolating faulted sections more quickly and accurately, thereby preventing widespread outages. In addition, effective vegetation management around the distribution network is necessary to reduce the risk of contact between tree branches and overhead lines, especially during adverse weather conditions. Improving the speed and accuracy of disturbance response, including better coordination among operational teams, can further reduce interruption duration and contribute to lower SAIDI and SAIFI values.

Furthermore, during the observation period, disturbances occurred with varying frequencies and outage durations each month. These fluctuations indicate that reliability performance is dynamic and influenced by multiple operational and environmental factors. Weather conditions, such as heavy rain and strong winds, contributed to an increased likelihood of faults in overhead lines. Animal disturbances and third-party activities near the network infrastructure also played a role in causing interruptions. In addition, the physical condition and aging of network equipment affected the system's vulnerability to failure. These factors collectively explain the monthly variations in reliability indices and highlight the importance of continuous monitoring and systematic maintenance to maintain and further improve the reliability performance of the distribution network.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that the reliability level of the 20 kV distribution system at PT. PLN (Persero) UP3 Bandung ULP Cijawura during the period from January to December 2024 showed fairly good performance based on national standards. The reliability index calculations yielded a SAIFI value of 2.14 times/customer/year, a SAIDI value of 2.34 hours/customer/year, a CAIDI value of 1.09 hours/outage, and an ENS value of 84,657 kWh with an estimated economic loss of IDR 122,303,968 per year. Based on a comparison with the SPLN 68-2:1986 and IEEE Std 1366-2003 standards, the SAIFI and SAIDI values have met the SPLN standard but have not met the IEEE standard, while the CAIDI value has met the IEEE standard. These results show that although the reliability performance of the distribution network has been quite good, efforts are still needed to improve it in order to meet international standards.

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