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Evaluation of 20 KV Distribution System Using SAIDI and SAIFI Reliability Indices at PT PLN

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Abstract – *Currently, power outages in Tarakan City are still frequent, both planned and due to disturbances such as fallen trees, lightning strikes or damage to the distribution equipment itself. PT PLN (Persero) Tarakan continues to make improvements to improve the reliability of the distribution system in Tarakan City using standard values, the reliability index for duration of disturbance (SAIDI) and the number of blackouts (SAIFI) so that the distribution of electrical energy continues to be channeled to customers. SAIDI and SAIFI values will be calculated every month to find out corrective actions against disturbances or damage that occur. Reliability is a benchmark value to see the reliability of the distribution system. The reliability index of SAIDI and SAIFI of PT. PLN (Persero) Tarakan in 2020 was 2.81 hours/plg/month and 2.55 times/plg/month. In 2021, SAIDI and SAIFI received 1.72 hours/plg/month and 2.45 times/plg/month. Based on the reliability index, PT PLN (Persero) Tarakan is categorized as reliable because the SAIDI and SAIFI values obtained do not exceed the existing standard values based on SPLN 68-2: 1986.*

Keywords – *Reliability index; SAIDI; SAIFI; power outages; distribution system.*

I. Introduction

ELECTRIC energy has become a basic necessity for human life today. Electricity is highly essential for all layers of society, both in industrial activities and in daily life. With the increasing demand for electricity alongside the growing population utilizing this energy, the request for power capacity also continues to rise. This situation often leads to frequent power outages, whether caused by disturbances or planned outages, as well as outages due to the malfunction of electrical equipment itself [1].

The increasing demand for electricity, driven by population growth and industrial activities, has led to frequent power outages [2]. These outages are often caused by heavily loaded distribution systems [3], faults in the power distribution grid [4], and overloading of electrical equipment [5]. The situation is further exacerbated by the challenge of matching power supply with demand, particularly in developing countries [6]. The impact of these outages on society is significant, with potential economic and health implications [7]. To address these issues, innovative solutions such as reconfiguring distribution systems [2] and implementing integrated switching devices [3] have been proposed.

The distribution of electric power is a crucial aspect in ensuring the delivery of power to consumers. This distribution must meet two main aspects: service continuity and reliability index. Service continuity refers to the ability to deliver electric energy continuously to customers without significant interruptions. The reliability index, on the other hand, reflects the level of service or reliability of the distribution system based on a specified reliability value. To enhance the reliability of the distribution system, efforts are needed to quickly address disturbances and isolate affected areas to minimize the impact on other customers [8].

Efforts to enhance the reliability of distribution systems have been explored through various strategies. [9] and [10] both emphasize the importance of service restoration algorithms and fault management systems, with Mohagheghi specifically highlighting the potential of autonomous microgrids. Automation is a key theme in this area, with [11] and [12] both discussing the use of automated distribution schemes and high-speed network reconfiguration to speed up service restoration. [13] and [14] focus on the impact of dispersed generation and microgrids on system relia-

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bility, with Meneses proposing a mathematical model to analyze this impact. [15] introduces the concept of optimal restoration sequence and variable restoration times, further enhancing the reliability of distribution systems.

Currently, power outages in Tarakan City are still frequent. These outages can be caused by various factors, both planned and unplanned, such as fallen trees, lightning strikes, or damage to the distribution equipment itself. The frequent power outages have resulted in numerous complaints from the community, impacting various aspects of daily life and economic activities. In response, PT PLN (Persero) Tarakan continuously strives to make improvements to enhance the reliability of the distribution system in Tarakan City. One approach used is monitoring and analyzing the reliability index of interruption duration (SAIDI) and the number of outages (SAIFI) [16].

The SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) are crucial indicators in assessing the reliability of the power distribution system. SAIDI measures the average duration of interruptions per customer over a certain period, while SAIFI measures the average frequency of interruptions per customer in the same period. Optimal SAIDI and SAIFI values indicate a reliable and efficient distribution system [17]. A range of studies have explored the relationship between SAIDI and SAIFI values and the reliability and efficiency of distribution systems. [18] and [19] both found that reducing these values through system improvements, such as loop configurations and the use of distributed generation, can enhance reliability. [20] and [21] further demonstrated the positive impact of these improvements on system reliability and economic losses. [22] and [23] provided practical methods for optimizing maintenance and investment to achieve optimal SAIDI and SAIFI values. These findings collectively suggest that lower SAIDI and SAIFI values are indicative of a more reliable and efficient distribution system.

PT PLN (Persero) Tarakan calculates the SAIDI and SAIFI values every month to identify and analyze disturbances and take necessary corrective actions. Based on the available data, in 2020, the reliability indices of SAIDI and SAIFI for PT PLN (Persero) Tarakan were 2.81 hours/customer/month and 2.55 times/customer/month, respectively. In 2021, these values improved to 1.72 hours/customer/month and 2.45 times/customer/month. This improvement indicates enhancements in the distribution system implemented by PT PLN (Persero) Tarakan [24].

By continuously conducting evaluations and making ongoing improvements, PT PLN (Persero) Tarakan is expected to further enhance the reliability of the electric power distribution system, ensuring better delivery of electric energy to customers and reducing the frequency of outages. This effort is not only essential to meet the increasing demand for electricity but also to support economic stability and the quality of life of the community in Tarakan City.

II. Research Methods

This research will be conducted at PT PLN (Persero) Tarakan. The research will start from February to September to collect data, perform calculations, and analyze the data to complete this study.

The equipment used in processing the research data includes both hardware and software. The hardware used in this research includes a computer/laptop unit, printer, and calculator. The software used includes Microsoft Office 2010, specifically MS Word, MS Excel, and MS PowerPoint.

The research will be carried out at PT PLN (Persero) Tarakan by conducting observations to obtain data and information related to the SAIDI and SAIFI reliability indices and by conducting a literature study to gather information for problem-solving using references relevant to the title or literature study as a reference for completing this research.

The stages in completing this research include literature study, data collection, customer data recapitulation, SAIDI SAIFI value calculation, analysis, and conclusions. The literature study aims to collect several references related to the title taken by the author from various sources as a reference in the process of completing this research, such as journals, books, and other reference sources. Data collection necessary to complete this research includes the duration of interruptions, the number of interruptions, the number of customers served, the number of customers experiencing outages, and the data used from 2020 and 2021 at PT PLN (Persero) Tarakan. After obtaining the necessary data, customer data recapitulation will be carried out based on the duration of interruptions, the number of interruptions, the number of customers served, and the number of customers experiencing outages. Then, the causes of interruptions or outages will be grouped to determine the most frequent or common outages in power distribution, such as unplanned outages, planned outages, and outages due to natural disasters [25]. From the obtained data, SAIDI and SAIFI reliability indices will be calculated. To determine if the obtained values meet the standard, they will be compared with the predetermined standard values. The equations for SAIDI Equation (1) and SAIFI Equation (2) can be seen in the

equations below:

$$SAIDI = \frac{\sum(U_i \times N_i)}{N_T} \quad (1)$$

with U_i is the duration of interruptions (hours), N_i is the number of customers experiencing interruptions, and N_T is the total number of customers served.

$$SAIFI = \frac{\sum N_i}{N_T} \quad (2)$$

with N_i is the number of customers experiencing interruptions, and N_T is the total number of customers served.

After obtaining the SAIDI (outage duration) and SAIFI (number of outages) indices for a year, a comparison will be made to determine if the SAIDI and SAIFI indices meet the specified standards to assess the reliability of the distribution system at PT PLN (Persero) Tarakan. Analyzing the reliability of the distribution system in Tarakan City can be said to be reliable by comparing the reliability values obtained each year. The system is considered reliable if the obtained values do not exceed the existing standard values.

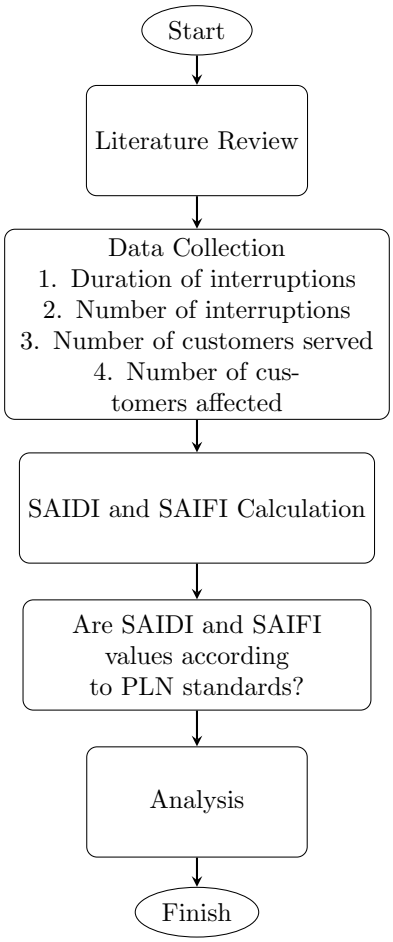

Figure 1: Flowchart

i. Data Analysis

The data analysis process in this research includes data processing, outage grouping, SAIDI and SAIFI calculation, analysis, and conclusions. Data processing is performed after obtaining the necessary data; the data will be separated based on the duration of interruptions, the number of interruptions, the number of customers served, and the number of customers experiencing outages. Outage grouping involves categorizing outages that occur due to planned outages, unplanned outages, and natural disasters. SAIDI and SAIFI calculation is performed by calculating the SAIDI and SAIFI reliability indices using the obtained data. Then, the obtained SAIDI and SAIFI values are compared to determine if they meet the desired standards. Analysis and conclusions involve analyzing the obtained values and then comparing if the obtained SAIDI and SAIFI indices meet the specified standards to assess the reliability of the distribution system at PT PLN (Persero) Tarakan. The reliability of the distribution system in Tarakan City can be said to be reliable if the obtained SAIDI and SAIFI values do not exceed the existing standard values.

Table 1: Reliability Index Standard Values

Reliability Index Standard	Standard Value
SAIDI	15.36
SAIFI	2.88

III. Results and Discussion

The recapitulation of customer monitoring data at PT PLN (Persero) Tarakan for the period 2020-2021 is shown below:

Table 2: Customer Data Recap at PT PLN (Persero) Tarakan 2020

No	Month	Cust. No.	Out. Cust.	Hrs x Out. Cust.
1	Jan	59,815	72,772	162,849.17
2	Feb	60,152	141,753	196,954.81
3	Mar	60,521	125,939	81,565.13
4	Apr	60,838	203,932	227,629.55
5	May	61,021	187,117	145,556.51
6	Jun	61,403	42,430	39,727.53
7	Jul	61,799	283,557	347,395.70
8	Aug	62,172	279,648	331,956.29
9	Sep	62,474	249,321	210,544.20
10	Oct	62,743	147,501	211,061.34
11	Nov	63,074	68,209	36,110.31
12	Dec	63,437	87,497	84,180.99

with: Cust. No. refers to the number of customers. Out. Cust. denotes the number of customers experiencing outages. Hrs x Out. Cust. represents the hours multiplied by the number of customers experiencing outages.

Table 3: Customer Data Recap at PT PLN (Persero) Tarakan 2021

No	Month	Cust. No.	Out. Cust.	Hrs x Out. Cust.
1	Jan	63,738	233,447	227,190.76
2	Feb	63,981	180,721	130,657.61
3	Mar	64,222	219,539	174,696.77
4	Apr	64,563	164,717	123,845.24
5	May	64,794	239,056	205,353.96
6	Jun	65,094	98,211	65,971.14
7	Jul	65,364	154,000	80,868.59
8	Aug	65,722	254,020	150,780.32
9	Sep	66,041	65,053	16,382.84
10	Oct	66,345	57,062	26,560.74
11	Nov	66,684	192,999	104,768.27
12	Dec	66,930	56,453	35,448.72

with: Cust. No. refers to the number of customers. Out. Cust. denotes the number of customers experiencing outages. Hrs x Out. Cust. represents the hours multiplied by the number of customers experiencing outages.

i. Calculation of SAIDI and SAIFI for the year 2020

Calculation of SAIDI for January:

$$\text{SAIDI} = \frac{\text{Hours} \times \text{Number of Customers Outage}}{\text{Number of Customers Served}}$$

$$\text{SAIDI} = \frac{162,849.17}{59,815}$$

$$\text{SAIDI} = 2.722\,\text{hours/customer/month}$$

Calculation of SAIFI for January:

$$\text{SAIFI} = \frac{\text{Number of Customers Outage}}{\text{Number of Customers Served}}$$

$$\text{SAIFI} = \frac{72,772}{59,815}$$

$$\text{SAIFI} = 1.217\,\text{times/customer/month}$$

with: SAIDI (hrs/cust/mo) represents the System Average Interruption Duration Index in hours per customer per month. SAIFI (times/cust/mo) represents the System Average Interruption Frequency Index in times per customer per month.

From Figure 2 above, it can be seen that the values vary from January to December. The highest SAIDI value is in July at 5.621 hours/customer/month, and the lowest SAIDI value is in November at 0.572 hours/customer/month. The highest SAIFI value in 2020 occurred in July at 4.588 times/customer/month, and the lowest SAIFI value occurred in June at 0.691 times/customer/month.

Table 4: SAIDI and SAIFI Index Calculation Results for January-December 2020

No	Month	SAIDI (hrs/cust/mo)	SAIFI (times/cust/mo)
1	Jan	2.72	1.22
2	Feb	3.27	2.36
3	Mar	1.35	2.08
4	Apr	3.74	3.35
5	May	2.38	3.07
6	Jun	0.65	0.69
7	Jul	5.62	4.59
8	Aug	5.34	4.50
9	Sep	3.37	3.99
10	Oct	3.36	2.35
11	Nov	0.57	1.08
12	Dec	1.33	1.38
13	Avg	2.81	2.55

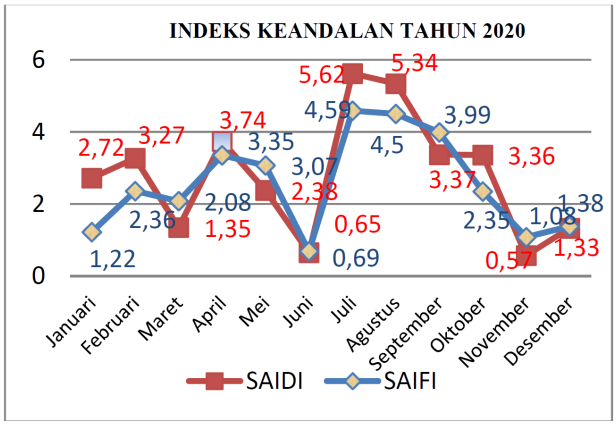

Figure 2: SAIDI and SAIFI Graph for the Year 2020

ii. Calculation of SAIDI and SAIFI for the year 2021

Calculation of SAIDI for January:

$$\text{SAIDI} = \frac{\text{Hours} \times \text{Number of Customers Outage}}{\text{Number of Customers Served}}$$

$$\text{SAIDI} = \frac{227,190.76}{63,738}$$

$$\text{SAIDI} = 3.564\,\text{hours/customer/month}$$

Calculation of SAIFI for January 2021:

$$\text{SAIFI} = \frac{\text{Number of Customers Outage}}{\text{Number of Customers Served}}$$

$$\text{SAIFI} = \frac{233,447}{63,738}$$

$$\text{SAIFI} = 3.663\,\text{times/customer/month}$$

Table 5: SAIDI and SAIFI Index Calculation Results for January-December 2021

No	Month	SAIDI (hrs/cust/mo)	SAIFI (times/cust/mo)
1	Jan	3.56	3.66
2	Feb	2.04	2.83
3	Mar	2.72	3.42
4	Apr	1.92	2.55
5	May	3.17	3.69
6	Jun	1.01	1.51
7	Jul	1.24	2.36
8	Aug	2.29	3.86
9	Sep	0.25	0.98
10	Oct	0.40	0.86
11	Nov	1.57	2.89
12	Dec	0.53	0.84
13	Avg	1.72	2.45

with: SAIDI (hrs/cust/mo) represents the System Average Interruption Duration Index in hours per customer per month. SAIFI (times/cust/mo) represents the System Average Interruption Frequency Index in times per customer per month.

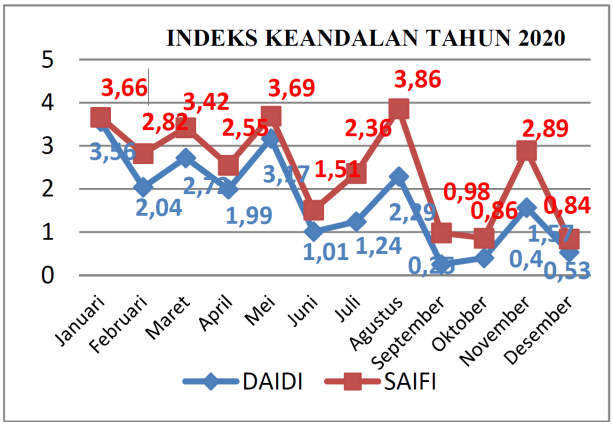

Figure 3: SAIDI and SAIFI Graph for the Year 2021

From Figure 3 above, it can be seen that the values vary from January to December. The highest SAIDI value is in January at 3.564 hours/customer/month, and the lowest SAIDI value is in December at 0.53 hours/customer/month. The highest SAIFI value in 2020 occurred in August at 3.865 times/customer/month, and the lowest SAIFI value occurred in December at 0.843 times/customer/month.

IV. Conclusion

Based on the monthly outage recapitulation data for 2020 and 2021, the most frequent outages occurred in the distribution group, with 2,411 outages in 2020 and 3,014 outages in 2021, while the generation group experienced 1,028 outages in 2020 and 957 outages in 2021. The highest SAIDI value in 2020 occurred in July at 5.62 hours/customer/month, and the lowest SAIDI value was in November at 0.57 hours/customer/month. The highest SAIDI value in 2021 occurred in January at 3.56 hours/customer/month, and the lowest SAIDI value was in December at 0.53 hours/customer/month. The highest SAIFI value in 2020 occurred in July at 4.59 times/customer/month, and the lowest SAIFI value was in June at 0.69 times/customer/month. The highest SAIFI value in 2021 occurred in August at 3.86 times/customer/month, and the lowest SAIFI value was in December at 0.84 times/customer/month. The reliability indices SAIDI and SAIFI of PT PLN (Persero) Tarakan in 2020 were 2.81 hours/customer/year and 2.55 times/customer/year, respectively. In 2021, the values were 1.72 hours/customer/year and 2.45 times/customer/year. Based on the reliability index, PT PLN (Persero) Tarakan is categorized as reliable because the obtained SAIDI and SAIFI values do not exceed the established reliability standards according to SPLN 66-2: 1986 with a SAIDI value of 15.36 hours/customer/year and a SAIFI value of 2.88 times/customer/year.

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