Analysis of the 20 kV Distribution Network System Reliability Index Technically and Economically Using the Section Technique Method and RNEA at the Margorukun Feeder

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Abstract – The growing demand for electrical energy in line with Indonesia's economic growth and societal welfare requires a reliable distribution system. To support distribution in industrial, urban, business, and daily life contexts, a dependable system is needed to channel electrical energy to consumers. This study aims to analyze the reliability of the 20 kV distribution system using the Section Technique method and the RNEA method, from both technical and economic aspects. The assessment is conducted based on the SPLN 68-2:1986 and IEEE 1366-2003 standards, focusing on the Margorukun feeder in 2023. The calculations show that the SAIFI value using the Section Technique method is 1.14 times/customer/year, which meets the SPLN 68-2:1986 standard and is close to the IEEE 1366:2003 standard. Meanwhile, the RNEA method results in a SAIFI of 2.66 times/customer/year, which meets the SPLN 68-2:1986 standard but does not reach the IEEE 1366:2003 standard. For SAIDI, the value obtained from the Section Technique method is 4.47 hours/year, while the RNEA method reaches 6.84 hours/year; both meet the SPLN 68-2:1986 standard but do not meet the IEEE 1366-2003 standard. In terms of CAIDI, the Section Technique method shows a value of 3.92 hours/customer/year, better than the RNEA method at 2.57 hours/customer/year; however, both do not meet the IEEE 1366-2003 standard. The evaluation of ASAI and ASUI indicates that the Section Technique method is superior in service availability and reliability. Further analysis related to EENS and AENS shows that the Section Technique method is more effective, with EENS values of 49.842935 and AENS of 0.011431, compared to the RNEA method, which reaches 55.420674 and 0.012711, respectively. The economic losses calculated from the Section Technique method amount to IDR 72,008,089.35, while the RNEA method shows higher losses of IDR 80,068,247.50. The results of this study indicate that the Section Technique method is more reliable and effective in evaluating the reliability of the Margorukun feeder compared to the RNEA method, although both do not fully meet the IEEE 1366:2003 standard.

Keywords: Reliability Indices, 20 kV Distribution System, Section Technique Method, RNEA Method, Economic Reliability Indices, MATLAB 2023b

I. INTRODUCTION

The fulfillment of Indonesia's current electricity needs is a primary aspect. Additionally, the demand for electricity continues to increase each year in line with the economic growth and welfare of the Indonesian people. According to data from PT Perusahaan Listrik Negara (PLN) regarding the Electricity Supply Business Plan (RUPTL), the electricity demand from 2021 to 2030 is estimated to be 40,575 MW [1]. The reliability of the power distribution network system is determined by factors such as system configuration, the use of installed protective devices, and the effectiveness of the protection system. With the right configuration, reliable equipment, and automated system operation, the reliability of the distribution system can be enhanced [2]. The power distribution network system is responsible for the provision and distribution of electricity to end users [3]. The electricity distribution system plays a crucial role in the continuity of electricity delivery. It is responsible for a significant portion, even up to 90%, of the reliability issues experienced by customers. By focusing efforts on improving the reliability of the distribution system, it can serve as the primary means to ensure a better overall reliability level for customers [4].

The analytical techniques used to evaluate the reliability of power distribution network systems have undergone rapid development. Several methods can be used, including the Reliability Network Equivalent Approach (RNEA), the Reliability Index Assessment (RIA), the Section Technique, and the Shortest Path Method (SPM). In this study, only the Section

Technique and RNEA methods are used [5]. In the Section Technique method, the system is first divided into smaller sections, minimizing the likelihood of calculation errors and reducing costs. Additionally, this method evaluates the reliability of the distribution system based on the impact of equipment failure on system operation [6]. The RNEA method is used to simplify the analysis of complex distribution systems. The main principle of the RNEA method is to transform parts of the distribution network into equivalent elements, allowing the reorganization of the complex distribution system into a simpler series form [7].

The issues that arise on the Margorukun feeder are due to equipment malfunctions and deliberate human-caused damage. Consequently, disruptions or damages in the power distribution system affect the reliability of the distribution system and the untransmitted energy to customers. To support the distribution system in industrial, urban, business, and daily life sectors, a reliable system for delivering electrical energy to consumers is required. Therefore, in this study, the author applies the Section Technique and RNEA methods to evaluate disturbances and economic losses occurring over a one-year period on the Margorukun feeder [8].

II. LITERATURE

Power Distribution Network System

The distribution system is the provision of electricity to customers with minimal disruptions, higher reliability, and lower costs [9]. The power distribution network system starts from the distribution substation and extends to the consumer's service, including the distribution substation, primary feeder, distribution transformer, and secondary system. The current distribution network can only serve the needs and standards of the past few decades and cannot meet new tasks and upcoming challenges. The distribution system and load will undergo dramatic changes over the next 20 to 50 years. Based on this, the main goal of the distribution network is to ensure that power is effectively delivered to customers. To achieve continuity of electricity delivery, it is essential to maintain system stability and load balance [10]. Currently, the distribution system can be divided into three types: distribution substations, primary distribution often referred to as Medium Voltage Network System (JTM), and secondary distribution, often referred to as Low Voltage Network System (JTR) [11].

Reliability of the Power Distribution System

Reliability is defined as the probability that a device or system will perform its intended function under specified operational conditions over time. The aspects of power system reliability include adequacy and security. Adequacy involves the availability of facilities within the system to meet consumer demand, including both scheduled and unscheduled outages. Meanwhile, security relates to the system's ability to handle sudden disturbances such as short circuits or the loss of components from contingencies that can be relied upon. Reliability analysis not only considers the existing infrastructure but also incorporates new facilities and predicts potential risks that could cause power outages, along with recovery strategies [12]. Based on component failure rates, repair times, and feeder configurations, basic reliability parameters such as the average failure rate (λ), mean outage time (r), and average annual unavailability (U) are expressed in the following equations [13]. Here are the equations:

1. Average Failure Rate (λ)

$$\lambda = \sum_{i=1}^{n} \lambda i \quad (1)$$

2. Mean Outage Time (r)

$$r = \frac{\sum_{i=1}^{n} ri * \lambda i}{\sum_{i=1}^{n} \lambda i} = \frac{U}{\lambda} \quad (2)$$

3. Average Annual Unavailability (U)

$$U = \sum_{i=1}^{n} ri * \lambda i \quad (3)$$

System Reliability Index

Reliability in a distribution network system refers to the level of service in providing electrical power from the system to users over a specific period. To assess the reliability of a service system or feeder, a reliability index is established to compare the reliability of a distribution system. These reliability indices include SAIFI, SAIDI, CAIDI, ASAI, and ASUI [14]. Below are the explanations and formulas for the SAIFI, SAIDI, CAIDI, ASAI, and ASUI indices:

1. SAIFI (*System Average Interruption Frequency Index*)

SAIFI is an estimate of the number of sustained interruptions experienced by the average customer in a year. The SAIFI value can range from 1 to 10, indicating how frequently interruptions occur. This value can be improved by reducing the frequency of interruptions experienced by customers [15].

$$SAIFI = \frac{\sum_{i=1}^{n} Ni * \lambda i}{\sum_{i=1}^{n} Nt} \quad (4)$$

Explanation:

λi = Frequency of equipment interruptions at the load point
Ni = Number of customers at the load point
Nt = Total number of customers in the system

2. SAIDI (*System Average Interruption Duration Index*)

SAIDI is an estimate of the total number of hours of interruptions experienced by the average customer in a year. The SAIDI value can range from a few minutes to several hours, indicating the duration of interruptions. This value can be improved by reducing the duration of interruptions experienced by customers [15].

$$SAIDI = \frac{\sum_{i=1}^{n} Ni * Ui}{\sum_{i=1}^{n} Nt} \quad (5)$$

Explanation:

Ui = Duration of equipment interruptions
Ni = Number of customers at the load point
Nt = Total number of customers in the system

3. CAIDI (*Customer Average Interruption Duration Index*)

CAIDI is an estimate of the average duration of interruptions and is used as a measure of the utility's response time to system contingencies. This index can be improved with faster response and shorter repair times for interruptions [15].

$$CAIDI = 1 - \frac{\sum_{i=1}^{n} Ni * Ui}{\sum_{i=1}^{n} Ni * \lambda i} \quad (6)$$

Explanation:

λi = Failure rate
Ui = Reapair time
Ni = Number of Customers
i = Load point

4. ASAI (*Average Service Availability Index*)

ASAI is the portion of time that customers have power availability during the reporting period. This index is also known as the "Service Reliability Index." A high ASAI value indicates a

(7)

high level of reliability [15].

$$ASAI = 1 - \frac{\sum N_{LP}\ x\ 8760 - (\sum N_{LP}\ x\ U_{LP})}{\sum N_{LP}\ x\ 8760} \quad (12)$$

Explanation:

U = Average failure time at the load point in one year

N_{LP} = Number of customers at the load point experiencing outages

Ni = Total number of hours in one year

5. ASUI (*Average Service Unavailability Index*)

ASUI is the ratio of the time customers are without power to the total time customers are supposed to be supplied with power during a specific period [15].

$$ASUI = 1 - ASAI \quad (8)$$

Economical Reliability Index

In the context of distribution system reliability analysis with economic calculations, a reliability index depends on the amount of electrical power supplied during outages from each load point and the applicable electricity tariff. To conduct this analysis, several data points are required, including network topology, load data, and customer/consumer data. These data allow for the evaluation of failure modes [16]. The equation used for calculating economic reliability is derived from the following system equations:

1. EENS (*Expected Energy Not Supplied*)

EENS is defined as the total amount of energy not delivered to customers due to outages over the span of one year [16].

$$EENS = \sum La\ x\ U \quad (9)$$

Explanation:

La = Average load connected to feeder i

U = Average annual outage time for feeder i

2. AENS (*Average Energy Not Supplied*)

AENS is the average index of energy that is not delivered due to outages [16].

$$AENS = \frac{EENS}{\sum n} \quad (10)$$

Explanation:

$\sum n$ = Number of customers served

Section Technique *Method*

The Section Technique method is a structured approach for analyzing a system. This method evaluates the reliability of the distribution system based on the impact of equipment failures on system operation. The effects of equipment disruptions are systematically identified by analyzing the consequences of each failure that occurs. Each equipment failure is then analyzed from the perspective of each load point within the distribution network. This approach is conducted in a bottom-up manner, where one failure mode is considered at a time [17].

1. Failure Rate (λ_{LP})

The result of summing up the impact of each electrical equipment, such as transformers, circuit breakers (CB), and sectionalizers, on the load points [18].

$$\sum i = k\ \lambda_i \quad (11)$$

Explanation:

λ_i = Failure rate for equipment K

K = All equipment affecting the load point

2. Interruption Duration (U)

The total product of the failure rate (λ) and the repair time (r) of each piece of equipment affecting the load point [18].

$$U_{LP} = \sum_{i=k} U_i = \sum_{i=k} \lambda_i\ x\ r_j$$

Explanation:

r_j = Repair time

RNEA Method

The network reliability method with the RNEA approach is a simplification of the Failure Mode and Effect Analysis (FMEA) method. In the FMEA method, the probability of failure or malfunction of each component in the distribution system is identified and analyzed to assess its impact on the load point. RNEA adopts the basic principles of FMEA but with a simpler approach, allowing for more efficient evaluation of distribution system reliability. This method utilizes equivalent elements to represent parts of the distribution network, facilitating easier and faster analysis. Thus, RNEA provides a more effective solution for managing the complexity of distribution systems and understanding the impact of component failures on overall network reliability [19].

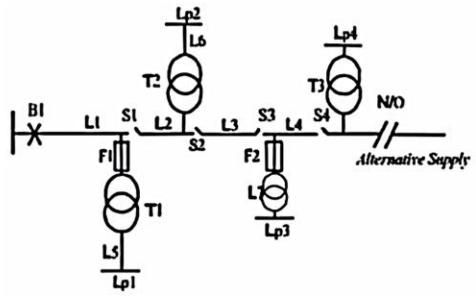

Figure 1. Radial Distribution System

Explanation:

S = Disconnecting switch

T = Transformator

F = Fuse

B = Breaker

In Figure 10, the distribution structure is shown to be radial, encompassing a disconnecting switch, transformer, line, fuse, and breaker. S1 and L1 are referred to as the main parts that transmit power to the usage location. Under normal conditions, the usage (load point) is directly connected to the transformer. Fuse F1 and the branch line T1 and L5 are known as branch parts [20]. The following equation is used to calculate the failure rate using the RNEA method:

$$\lambda_j = \lambda_{sj} + \sum_{i=1}^{n} \lambda_{ij} + \sum_{k=1}^{n} P_{kj}\lambda_{kj} \quad (13)$$

$$U_j = \lambda_{sj} + \sum_{i=1}^{n} \lambda_{ij} r_{sj} + \sum_{i=1}^{n} P_{kj}\lambda_{kj} r_{sj} \quad (14)$$

$$r_j = \frac{U_j}{\lambda j} \quad (15)$$

Explanation:

λ_{sj} = Failure rate at load point j

U_j = Average annual unavailability at the load point

r_j = Average outage duration at load point j

λ_{sj} = Failure rate of series components at the load point

λ_{ij} = Failure rate of main section i at the load point

λ_{kj} = Failure rate of branch section k at the load point

P_{kj} = Control parameter of branch section k at the load point

r_{ij} = Switching time or repair time of load point j on main section i

r_{sj} = Repair time for series element s at the load point j
r_{kj} = Switching time or repair time of load point j on lateral section k

MATLAB 2023b

Matlab is a commercial program created by The MathWorks, Inc., often used for mathematical calculations, data analysis, modeling, simulation, graphic creation, and computational development. Simply put, Matlab can be considered a tool for calculations and plotting in engineering fields. However, in practice, Matlab is much more complex than just an advanced scientific calculator. This program is widely used in numerical computation for data analysis, engineering system simulation, and code sharing with other users. Matlab was created by Cleve Moler, a mathematician and computer programmer, who developed the idea based on his doctoral thesis in the 1960s. Initially used by students at the University of New Mexico, Matlab has evolved into one of the most versatile and powerful computational software available today [21].

III. METHODS

Research Design and Approach

This research employs quantitative methods, which involve collecting numerical data for research purposes. The aim of this study is to calculate the technical and economic reliability of the 20 kV distribution network system on the Margorukun feeder using the Section Technique and RNEA methods. The results of the analysis are evaluated using the standards SPLN 68:2 1986 and IEEE 1366-2003.

Location and Time of Research

This research was conducted at PT. PLN UP3 Surabaya Utara, located at Jalan Gemblongan No. 64, Kelurahan Alun-Alun Contong, Kecamatan Bubutan, Kota Surabaya, Provinsi Jawa Timur 60174. The study took place from May 7 to May 21, 2024.

Data Analysis

The stages of this research design are illustrated in the flowchart in Figure 2.

Stages of Calculation for the Section Technique Method

The flowchart for the calculations using the Section Technique method in figure 3. The calculation stages using the Section Technique method are as follows:

a) Divide the Margorukun feeder into several sections based on Load Break Switch (LBS).
b) Identify failures for each feeder section.
c) Determine the repair time.
d) Calculate failure frequency and duration of interruption.
e) Sum the failure rate and duration of interruption for each load point.
f) Calculate the SAIFI, SAIDI, and CAIDI indices for each section.

Stages of Calculation for the RNEA Method

The flowchart for the calculation of the RNEA method in figure 4.

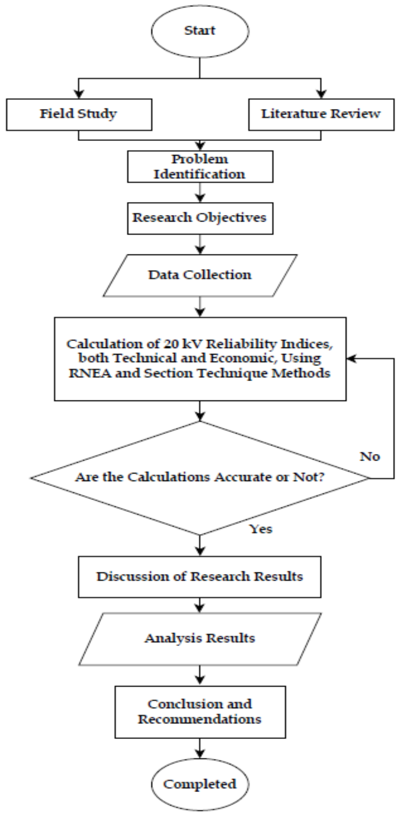

Figure 2. Research Design Flowchart

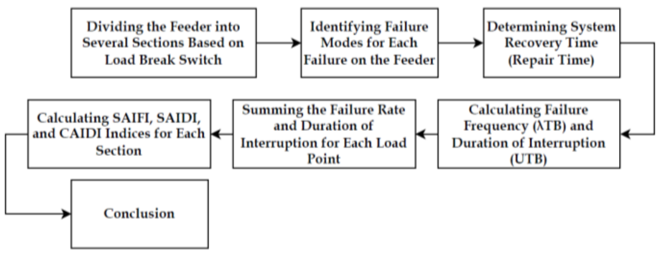

Figure 3. Calculation Flowchart for the Section Technique Method

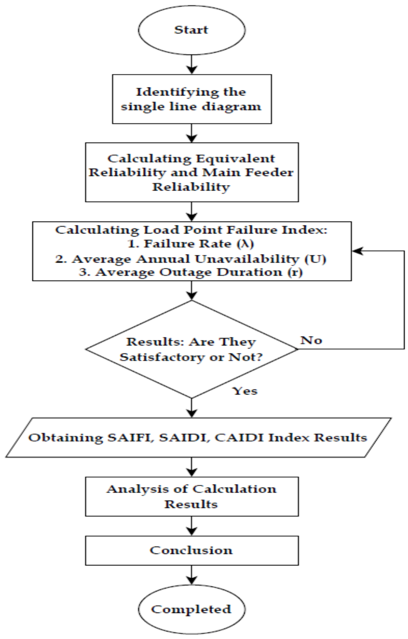

Figure 4. Block Diagram of the RNEA Method Calculation

Here is the translation of the stages of calculation for the RNEA method:

a) Identify the single-line diagram of the network on the Margorukun feeder for the year 2023. From this step, the feeder branches are reduced to form an equivalent network.
b) Calculate the equivalent reliability for the branch sections to obtain the values of λ_e and U_e.
c) Calculate the load point failure index, and
d) Obtain the SAIFI and SAIDI indices.

IV. RESULTS AND DISCUSSION

Feeder Topology

For the Margorukun feeder, there is system topology data as shown in the diagram in figure 5.

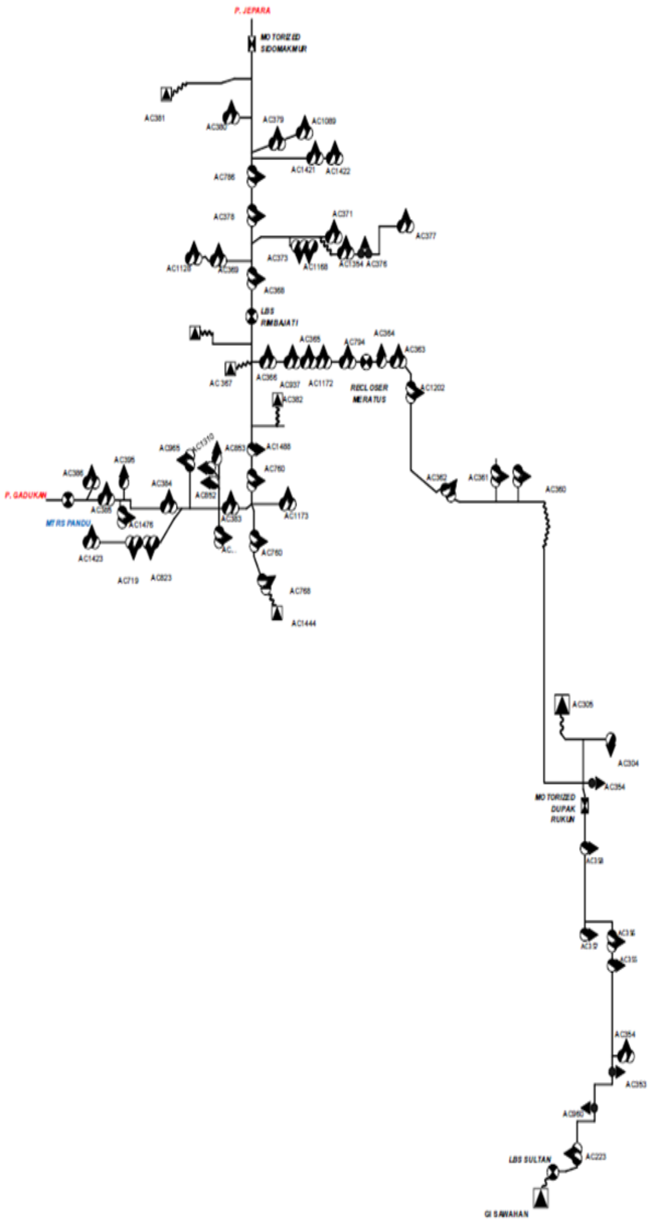

Figure 5. Single Line Diagram of the Margorukun Feeder

Margorukun Feeder Network Data

The transformer and customer data for the Margorukun feeder are explained in Table 1, which shows a total of 55 transformers and 4,360 customers shown on data in Table 2.

Table 1. Transformer Data and Number of Customers

LP	Transformers	Power 20 kV	Number of Customers
1	AC768	200	1
2	AC1256	100	1
3	AC760	200	1
4	AC1173	100	1
5	AC383	200	19
6	AC823	160	28
7	AC384	200	103
8	AC719	200	1
9	AC1310	200	1
10	AC1202	160	422
11	AC382	100	1
12	AC853	160	1
13	AC1476	160	1
14	AC363	250	33
15	AC1249	100	1
16	AC395	100	1
17	AC385	160	1
18	AC794	160	1
19	AC1172	100	2
20	AC365	160	1
21	AC366	100	16
22	AC1147	200	1
23	AC092	200	1
24	AC1147	200	1
25	AC092	160	112
26	AC1366	100	1
27	AC1147	100	1
28	AC092	200	1
29	AC768	160	1
30	AC223	200	126
31	AC1147	250	1
32	AC1488	100	16
33	AC817	200	46
34	AC937	250	1
35	AC364	160	1
36	AC092	250	1
37	AC1147	100	1
38	AC092	200	1
39	AC1147	250	1
40	AC1147	250	1
41	AC359	150	334
42	AC092	160	2
43	AC1147	100	1
44	AC1147	200	610
45	AC360	160	304
46	AC361	250	530
47	AC362	250	668
48	AC1423	250	1
49	AC304	160	233
50	AC358	160	309
51	AC357	200	1
52	AC356	160	189
53	AC355	100	151
54	AC354	200	1
55	AC960	100	74
Total Number of Customers			4360

Table 2. Network Line Data for the Margorukun Feeder

LP	Length (km)	LP	Length (km)
LP1	0,9	LP29	0,067
LP2	0,124	LP30	0,072
LP3	0,054	LP31	0,125
LP4	0,052	LP32	0,067
LP5	0,068	LP33	0,161
LP6	0,044	LP34	0,121
LP7	0,045	LP35	0,145
LP8	0,045	LP36	0,255
LP9	0,102	LP37	0,155
LP10	0,033	LP38	0,138
LP11	0,98	LP39	0,013
LP12	0,012	LP40	0,052
LP13	0,104	LP49	0,041
LP14	0,051	LP50	0,013
LP15	0,312	LP51	0,054
LP16	0,025	LP52	0,034
LP17	0,025	LP53	0,082
LP18	0,011	LP54	0,021
LP19	0,077	LP55	0,025
LP20	0,098	LP40	0,052
LP21	0,081	LP49	0,041
LP22	0,028	LP50	0,013
LP23	0,109	LP51	0,054
LP24	0,106	LP52	0,034
LP25	0,103	LP53	0,082
LP26	0,124	LP54	0,021
LP27	0,58	LP55	0,025
LP28	0,044	Total Customers	10,068

Matlab Calculation Results of the Margorukun Feeder

The Matlab calculation results of the Margorukun feeder can be seen in the table 3.

. From the calculations using the Section Technique method, the SAIFI value obtained is 1.14 times/customer/year, SAIDI is 4.47 hours/year, CAIDI is 3.92 hours/year, ASAI is 0.999490, and ASUI is 0.000509.

Next, the Matlab calculation results using the RNEA method are explained in the table 4

From the calculations using the RNEA method, the obtained values are SAIFI of 2.66 times/customer/year, SAIDI of 6.84 hours/year, CAIDI of 2.57 hours/year, ASAI of 0.999218, and ASUI of 0.000781 shown in table 4.

Matlab Calculation of Economic Losses

Table 5 shows the calculation results of the undelivered energy index for sections 1-4.

The table shows the calculation results with EENS of 49.842935 MWh/year and AENS of 0.011431 MWh/customer/year. Thus, the following economic losses are obtained:

Then, the calculation results of the undelivered energy index using the RNEA method shown in table 6 and table 7

The table 8 shows the calculation results with EENS of 55.420674 MWh/year and AENS of 0.012711 MWh/customer/year. Thus, the following economic losses shown in table 8

Table 3. Matlab Calculation Results of the Margorukun Feeder Using the Section Technique Method

LP	SAIFI	SAIDI	CAIDI	ASAI	ASUI
1	0.02	0.05	3.50	0.999789	0.000210
2	0.01	0.03	3.50	0.999789	0.000210
3	0.00	0.00	3.50	0.999789	0.000210
4	0.02	0.06	3.50	0.999789	0.000210
5	0.02	0.08	3.50	0.999789	0.000210
6	0.00	0.00	3.50	0.999789	0.000210
7	0.04	0.13	3.50	0.999789	0.000210
8	0.07	0.29	4.05	0.999560	0.000439
9	0.05	0.21	4.05	0.999560	0.000439
10	0.00	0.00	4.05	0.999560	0.000439
11	0.07	0.27	4.05	0.999560	0.000439
12	0.12	0.47	4.05	0.999560	0.000439
13	0.15	0.59	4.05	0.999560	0.000439
14	0.00	0.00	4.05	0.999560	0.000439
15	0.09	0.37	4.05	0.999560	0.000439
16	0.00	0.03	4.05	0.999560	0.000439
17	0.00	0.00	4.05	0.999560	0.000439
18	0.00	0.00	3.84	0.999252	0.000747
19	0.00	0.00	3.84	0.999252	0.000747
20	0.00	0.00	3.84	0.999252	0.000747
21	0.00	0.00	3.84	0.999252	0.000747
22	0.01	0.02	3.84	0.999252	0.000747
23	0.00	0.00	3.84	0.999252	0.000747
24	0.01	0.02	3.84	0.999252	0.000747
25	0.02	0.07	3.84	0.999252	0.000747
26	0.00	0.00	3.84	0.999252	0.000747
27	0.00	0.00	3.84	0.999252	0.000747
28	0.00	0.00	3.84	0.999252	0.000747
29	0.01	0.03	3.84	0.999252	0.000747
30	0.00	0.00	3.84	0.999252	0.000747
31	0.00	0.00	3.84	0.999252	0.000747
32	0.01	0.04	3.84	0.999252	0.000747
33	0.00	0.00	3.84	0.999252	0.000747
34	0.00	0.00	3.84	0.999252	0.000747
35	0.04	0.15	3.84	0.999252	0.000747
36	0.00	0.00	3.84	0.999252	0.000747
37	0.00	0.00	3.84	0.999252	0.000747
38	0.00	0.00	3.84	0.999252	0.000747
39	0.00	0.00	3.84	0.999252	0.000747
40	0.00	0.00	3.87	0.998982	0.001017
41	0.00	0.00	3.87	0.998982	0.001017
42	0.00	0.00	3.87	0.998982	0.001017
43	0.06	0.23	3.87	0.998982	0.001017
44	0.00	0.00	3.87	0.998982	0.001017
45	0.00	0.00	3.87	0.998982	0.001017
46	0.00	0.00	3.87	0.998982	0.001017
47	0.00	0.00	3.87	0.998982	0.001017
48	0.00	0.00	3.87	0.998982	0.001017
49	0.00	0.00	3.87	0.998982	0.001017
50	0.00	0.00	3.87	0.998982	0.001017
51	0.00	0.00	3.87	0.998982	0.001017
52	0.00	0.00	3.87	0.998982	0.001017
53	0.00	0.00	3.87	0.998982	0.001017
54	0.32	1.25	3.87	0.998982	0.001017
55	0.00	0.00	3.87	0.998982	0.001017
TTL	1.14	4.47	3.92	0.999490	0.000509

Table 4. Matlab Calculation Results of the Margorukun Feeder Using the RNEA Method

LP	SAIFI	SAIDI	CAIDI	ASAI	ASUI
1	334.50	851.50	2.55	0.999229	0.000771
2	196.46	500.09	2.55	0.999229	0.000771
3	2.65	6.76	2.55	0.999229	0.000771
4	400.87	1020.45	2.55	0.999229	0.000771
5	501.76	1277.26	2.55	0.999229	0.000771
6	2.65	6.76	2.55	0.999229	0.000771
7	820.33	2088.21	2.55	0.999229	0.000771
8	886.70	2257.16	2.55	0.999229	0.000771
9	618.57	1574.61	2.55	0.999229	0.000771
10	2.65	6.76	2.55	0.999229	0.000771
11	807.06	2054.42	2.55	0.999229	0.000771
12	1407.04	3581.73	2.55	0.999229	0.000771
13	1773.41	4514.33	2.55	0.999229	0.000771
14	2.65	6.76	2.55	0.999229	0.000771
15	1120.30	2851.86	2.55	0.999229	0.000771
16	87.61	223.01	2.55	0.999229	0.000771
17	2.65	6.76	2.55	0.999229	0.000771
18	2.65	6.76	2.55	0.999229	0.000771
19	5.31	13.52	2.55	0.999229	0.000771
20	2.65	6.76	2.55	0.999229	0.000771
21	2.65	6.76	2.55	0.999229	0.000771
22	42.48	108.13	2.55	0.999229	0.000771
23	2.65	6.76	2.55	0.999229	0.000771
24	42.48	108.13	2.55	0.999229	0.000771
25	122.12	310.87	2.55	0.999229	0.000771
26	2.65	6.76	2.55	0.999229	0.000771
27	2.68	6.99	2.61	0.999202	0.000798
28	2.68	6.99	2.61	0.999202	0.000798
29	50.44	128.40	2.55	0.999229	0.000771
30	2.73	7.40	2.71	0.999155	0.000845
31	2.73	7.40	2.71	0.999155	0.000845
32	75.82	202.30	2.67	0.999175	0.000825
33	2.71	7.23	2.67	0.999175	0.000825
34	2.71	7.23	2.67	0.999175	0.000825
35	273.44	696.07	2.55	0.999229	0.000771
36	2.65	6.76	2.55	0.999229	0.000771
37	2.65	6.76	2.55	0.999229	0.000771
38	2.65	6.76	2.55	0.999229	0.000771
39	2.65	6.76	2.55	0.999229	0.000771
40	2.65	6.76	2.55	0.999229	0.000771
41	2.69	7.07	2.63	0.999192	0.000808
42	2.69	7.07	2.63	0.999192	0.000808
43	305.83	831.43	2.72	0.999153	0.000847
44	2.73	7.42	2.72	0.999153	0.000847
45	2.73	7.42	2.72	0.999153	0.000847
46	2.73	7.42	2.72	0.999153	0.000847
47	2.73	7.42	2.72	0.999153	0.000847
48	2.73	7.42	2.72	0.999153	0.000847
49	2.65	6.76	2.55	0.999229	0.000771
50	5.31	13.52	2.55	0.999229	0.000771
51	2.68	6.96	2.60	0.999206	0.000794
52	2.68	6.96	2.60	0.999206	0.000794
53	2.71	7.21	2.66	0.999177	0.000823
54	1650.54	4395.51	2.66	0.999177	0.000823
55	2.65	6.76	2.55	0.999229	0.000771
TTL	2.66	6.84	2.57	0.999218	0.000781

Table 5. Calculation Results of EENS and AENS

Section	EENS	AENS
1	1.759486	-
2	5.691487	-
3	19.820905	-
4	22.571056	-
Total	49.842935	0.011431

Table 6. Economic Losses Results Using the Section Technique Method

Section	EENS	Economic Losses
1	1.759486	Rp. 2.541.930,00
2	5.691487	Rp. 8.222.492,42
3	19.820905	Rp. 28.635.261,74
4	22.571056	Rp. 32.608.405,18
Total	49.842935	Rp. 72.008.089,35

Table 7. Calculation Results of EENS and AENS

Section	EENS	AENS
1	55.420674	0.012711
Total	55.420674	0,012711

Table 8. Economic Losses Results Using the RNEA Method

Section	EENS	Economic Losses
1	55.420674	Rp. 80.066.247,75
Total	55.420674	Rp. 80.066.247,75

Evaluation of the Section Technique and RNEA Methods Calculations

In this study, the reliability index of the 20kV distribution system is evaluated using the SPLN 68-2:1986 and IEEE 1366:2003 standards shon in table 9

:

Table 9. Evaluation of Reliability Indices Using the Section Technique Method with SPLN 68-2:1986 and IEEE 1366-2003 Standards

Index	Section Technique	SPLN 68-2:1986	difference	IEEE 1366-2003	difference
SAIFI	1.14	3.20	2.06 (64.4%)	1.45	0.31 (21.4%)
SAIDI	4.47	21.09	16.62 (78.8%)	2.30	-2.17 (-94.3%)
CAIDI	3.92	6.56	2.64 (40.2%)	1.47	-2.47 (-166.7%)

Based on the presented table, the comparison results between the Section Technique method with SPLN 68-2:1986 and IEEE 1366-2003 show several values: for SAIFI, the obtained difference is 2.06 (64.4%), while the comparison value from IEEE 1366-2003 is 0.31 (21.4%). For the SAIDI index, the difference reaches 16.62 (78.8%), while IEEE 1366-2003 records a value of -2.17 (-94.3%). Finally, for CAIDI, the obtained difference is 2.64 (40.2%), and IEEE 1366-2003 shows a difference of -2.47 (-166.7%). This comparison indicates that under the SPLN 68-2:1986 standard, the reliability indices SAIFI, SAIDI, and CAIDI demonstrate reliable results for the reliability of the 20 kV distribution system. However, under the IEEE 1366-2003 standard, it shows that SAIFI presents a reliable value, while SAIDI and CAIDI show unreliable values. This indicates that IEEE 1366-2003 is stricter in assessing reliability and the impact of disturbances on the distribution system. Meanwhile, the RNEA Method obtained the following calculation evaluation results shown in table 10:

Table 10. Evaluation of Reliability Indices Using the RNEA Method with SPLN 68-2:1986 and IEEE 1366-2003

Index	Section Technique	SPLN 68-2:1986	difference	IEEE 1366-2003	difference
SAIFI	2.66	3.20	0.54 (16.9%)	1.45	-1.21 (-83.4%)
SAIDI	6.84	21.09	14.25 (67.6%)	2.30	-4.54 (-197.4%)
CAIDI	2.57	6.56	3.99 (60.8%)	1.47	-1.10 (-74.8%)

The comparison results between the RNEA method and SPLN 68-2:1986 and IEEE 1366-2003 show the following differences: for SAIFI, the obtained difference is 0.54 (16.9%), while the comparison value from IEEE 1366-2003 is -1.21 (-83.4%). For the SAIDI index, the difference reaches 14.25 (67.6%), while IEEE 1366-2003 records a value of -4.54 (-197.4%). Finally, for CAIDI, the obtained difference is 3.99 (60.8%), and IEEE 1366-2003 shows a difference of -1.10 (-74.8%). It can be concluded that the RNEA method, when compared to the SPLN 68-2:1986 standard, shows reliable values, whereas with the IEEE 1366-2003 standard, it yields unreliable values. The evaluation graph results shown in figure 6.

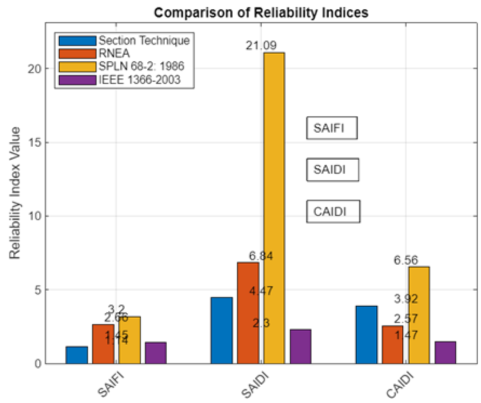

Figure 6. Evaluation Graph of Reliability Indices Using SPLN 68-2:1986 and IEEE 1366-2003

V. CONCLUSION

Based on the evaluation results obtained from the technical and economic analysis of the reliability index calculations, the following conclusions can be drawn:

1. Based on the reliability calculations for the Margorukun feeder using the Section Technique method, a SAIFI value of 1.14 interruptions/customer/year was obtained. This value aligns with the SPLN 68-2:1986 standard, which records 3.20 interruptions/customer/year with a percentage of 64.4%, as well as the IEEE 1366:2003 standard, which records 1.45 interruptions/customer/year with a percentage of 21.4%. On the other hand, the RNEA method yields a SAIFI of 2.66 interruptions/customer/year with a percentage of 16.9%, meeting the SPLN 68-2:1986 standard but not meeting the IEEE 1366:2003 standard with a percentage of -83.4%. Furthermore, the SAIDI calculated using the Section Technique method results in a value of 4.47 hours/year with a percentage of 78.8%, while the RNEA method yields 6.84 hours/year with a percentage of 67.6%. Both methods meet the SPLN 68-2:1986 standard (21.09 hours/year) but do not meet the IEEE 1366:2003 standard, which sets the limit at 2.30 hours/year, with the Section Technique method reaching a percentage of -94.3% and the RNEA method at -197.4%. For CAIDI, the Section Technique method produces a value of 3.92 hours/customer/year, while the RNEA method gives 2.57 hours/customer/year. Both are compliant with the SPLN 68-2:1986 standard, with the Section Technique method showing a percentage of 40.2% and the RNEA method at 60.8%. However, both methods do not meet the IEEE 1366:2003 standard, with the Section Technique method showing a percentage of -166.7% and the RNEA method at -74.8%. Overall, although the Section Technique and RNEA methods meet several criteria of the SPLN 68-2:1986 standard, neither fully meets the IEEE 1366:2003 standard. This indicates the need for improvements in the distribution system to enhance the reliability of the Margorukun feeder. Additionally, the evaluation of ASAI and ASUI shows that the Section Technique method is superior to the RNEA method in terms of availability and service reliability. The ASAI for the Section Technique method (0.999490) is higher than that of the RNEA method (0.999218) by 0.02%, while the ASUI for the Section Technique method (0.000509) is lower than that of the RNEA method (0.000781) by 34.8%. This indicates that the Section Technique method is more reliable in evaluating the reliability of electric distribution compared to the RNEA method.
2. Based on the calculations of EENS, AENS, and total economic losses, the Section Technique method proves to be more effective compared to the RNEA method. The Section Technique method shows a lower EENS value of 49.842935, while the RNEA method records a value of 55.420674, with a percentage difference of 10.1%. In terms of AENS, the Section Technique method yields a value of 0.011431, while the RNEA method shows 0.012711, also with a percentage difference of 10.1%. Additionally, the losses incurred from the Section Technique method amount to Rp 72,008,089.35, whereas the RNEA method results in higher economic losses of Rp 80,068,247.50, with a percentage difference of 10.1%.

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