ANALYSIS OF THE RELIABILITY OF ELECTRICAL DISTRIBUTION SYSTEMS USING THE TECHNIQUE SECTION METHOD AND RNEA FEDDER GIBP-MESIR

TUGAS AKHIR

Diajukan sebagai salah satu syarat untuk memperoleh Gelar Sarjana Teknik pada Program Studi Teknik Elektro Fakultas Sains dan Teknologi

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PROGRAM STUDI TEKNIK ELEKTRO
FAKULTAS SAINS DAN TEKNOLOGI
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
PEKANBARU
2023

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ANALISIS KEANDALAN SISTEM DISTRIBUSI LISTRIK DENGAN MENGGUNAKAN METODE *SECTION TECHNIQUE* DAN RNEA PENYULANG GIBP-MESIR

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Judul Jurnal :

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Volume 07, No. 02, November 2023, pages 133 - 145

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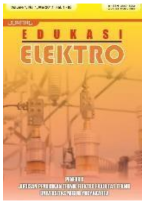
Jurnal Edukasi Elektro

https://journal.uny.ac.id/index.php/jee



ANALYSIS OF THE RELIABILITY OF ELECTRICAL DISTRIBUTION SYSTEMS USING THE TECHNIQUE SECTION METHOD AND RNEA FEDDER GIBP-MESIR

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Abstract— Electricity distribution systems are reliable if delivering electricity to the customer does not experience significant interruptions in the PT. PLN (Persero) ULP Duri found a variety of disturbances in one year. The resulting impact is energy that needs to be channelled during disruption, thus making the reliability value of the electricity distribution system unreliable. The study aims to analyze the system's reliability on the GIBP-MESIR fedder, using the Technique Section Method and RNEA Method, and calculate the economic losses over a year. System reliability index results using Section Technique Method SAIFI 1,258 times/customer/year, SAIDI 5,324 hours/customer/year and CAIDI 4,232 hours/customer/year. The RNEA method SAIFI 1,844 times/customer/year, SAIDI 7,819 hours/customer/year, and CAIDI 4,239 hours/customer/year. For both ways, the SAIFI, SAIDI, and CAIDI values are below SPLN 88-2 1986, and then it can be said to be reliable. Economic fulfillment of Section Technique Method with ENS value 59.194.677,96kWh, AENS 3.453,39 kWh/customer, and Rp 85.518.551.248. RNEA method values ENS 86.933.685,93 kWh, AENS 5.071,681 kWh/customer, and Rp. 125.593.096.063 for one year.

Keywords: Section Technique, RNEA, SAIFI, SAIDI, CAIDI

Article submitted June 23rd, 2023. Resubmitted July 22nd, 2023. Final acceptance August 24th, 2023. Final version published as submitted by the authors.

1 Introduction

Electricity distribution system is essential in delivering electric energy to the customer. This system must have good quality and a high level of reliability, with no significant interference or shutdown [1]. This is unavoidable because several factors affect the reliability of the list distribution system. Factors affecting the reliability of the system are external and internal disturbances [2]. External disturbances include lightning, tree branches, and failure to isolate. If left unchecked, these disturbances will lead to a decrease in the reliability of the electricity distribution system [3].

PT.PLN (Persero) ULP Duri is a company that distributes electricity in the Duri region. The generated electricity comes from two Mother guards, the Main Guard of the Hall of Pungut and Duri's Head Guard. The Main Guard had eleven fighters from Cameroon, Congo, Morocco, and Mesir. While Argentina, Bolivia, Brazil, Cuba, Panama, Venezuela, and Chile were supplied by the Duri Mother Guard.

Based on the results of interviews through the Technical Supervisor, PT.PLN (Persero) ULP Duri, there are disruptions in the entire recurrence, totaling 363 times/year. From the total disturbance of all these repetitions, one of the fedder that have the highest value of disruption is taken namely, the fedder of GIBP-MESIR. GIBP-MESIR fedder have 51 times/year, causing interference by 2%, isolator slowness by 3%, SUTM components by 13%, animals by 5%, and trees by 10%. The reliability value of System Average Interruption Frequency Index (SAIFI) was 16,303 times/customer/year, and System Average Interruption Duration Index (SAIDI) 22,881 hours/customer/year. In addition, the economic losses generated were an ENS value of 25.439.607,28 kWh, an AENS of 14.841,378 kWh/customer, and Rp. 367.526.005.622 for one year. It can be seen that PT.PLN (Persero) ULP Duri on the fedder GIBP-MESIR has a system reliability value that exceeds SPLN No. 68-2 1986, so the losses experienced are huge. Therefore, the GIBP-MESIR retreat is said to be unreliable.

The research discusses the reliability of electrical distribution systems, i.e., network reliability analysis, by comparing RIA and FMEA Methods using the parameters SAIDI, SAIFI, CAIDI, and MAIFI. Other research also discussed the reliability of electrical distribution systems, namely comparing the Section Technique Method and FMEA using the parameters SAIFI, SAIDI, and CAIDI [4][5][6]. Next, after research on the reliability of electricity distribution systems using the Section Technique Method, the study adds an analysis of the calculation of economic losses [7]. Another study on the reliability of the electricity distribution system using the RNEA Method said an analysis of the total economic losses [8][9].

Based on the Problem and related research, the researchers will analyze the reliability of the electrical distribution system on the GIBP-MESIR fedder using the Section Technique and the RNEA Method. The System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and the Customer's average interruption duration index (CAIDI). Calculate economic losses mathematically, the parameters used are the Energy Not Supplied (ENS) index, Average Energy Not Supplied (AENS), and Economic Loss. Then the results of the reliability analysis of the system with the method can be used as evaluation material for the system reliability value on the fedder GIBP-MESIR in PT.PLN (Persero) ULP Duri.

2 Method

The method used in this study is an analysis using the Section Technique and the RNEA Method with the following stages:

a. Study literature related to analyzing the reliability of electrical distribution systems.
b. Collect data and calculate system reliability using the Section Technique and the RNEA Method.
c. Comparing the results of the analysis of the two methods with SPLN No. 68 to 1986
d. Calculate the value of the economic loss in a year (2022) based on the data on energy not supplied and Average Energy not supplied.

The outcome of the study is shown in the following Fig. 1

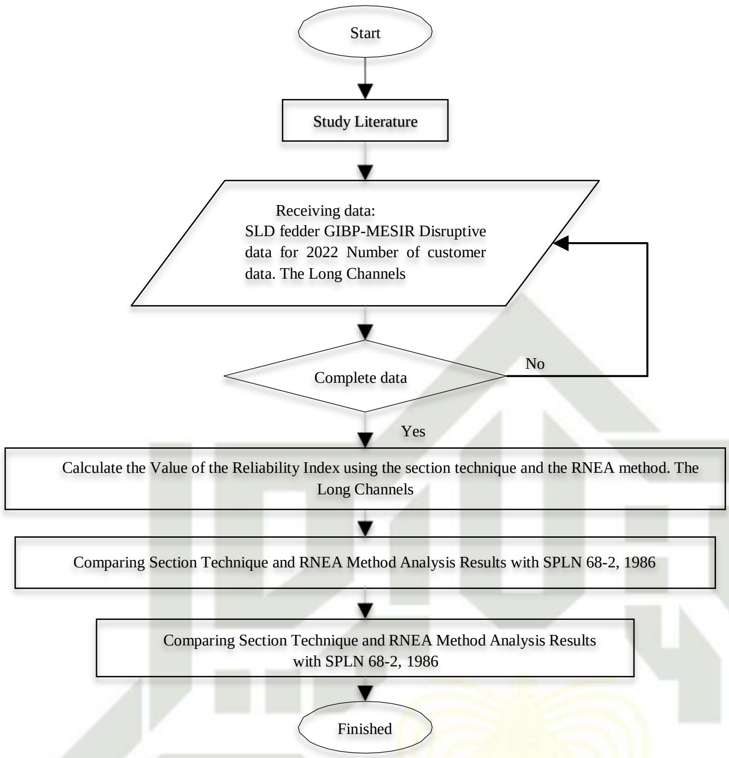

Fig. 1. Flowchart research

2.1 Data collection and processing parameters

This phase is done by collecting secondary data through a live interview in PT.PLN (Persero) ULP Duri. The data obtained are interference data, customer number, channel length, SAFI value, and SADI on fedder GIBP-MESIR.

Table 1. Disruption data, customer number, and repeat channel length for GIBP-MESIR

No	Year	Disturbance (Times/Year)	Number of customers	Channel Length (km)
1.	2022	51	17.141	160,9

Table 2. Data index SAIFI and SAIDI on repeat GIBP-MESIR

No	Year	SAIFI (times/customer/year)	SAIDI (hour/customer/year)
1.	2022	16,30313	22,88145

Table 3. Data ENS, AENS, and Economic Loss (RP) for one year in 2022

No	Year	ENS (kWh)	AENS (kWh/Customer)	Cost (Rp)
1.	2022	254.396.072,28	14.841,378	367.526.005.622

2.2 Division of Network Channels by Section Technique and RNEA

Data Single Line Diagram of the GIBP-MESIR dispatch obtained from PT.PLN (Persero) ULP Duri The number of Load Points on GIBP-MESIR is 118, totaling 17.141 customers per year. The total number of lines in the repeat is 163, with a full length of the channel of 160,9 km. While the equipment installed on this repeater, such as FCO, is 17 pieces, there are 2 LBS, one recloser, and 1 CB. Then there will be a channel division per section for the Section Technique Method, a branch channel division and a primary channel for the RNEA Method.

The network model uses the Section Technique Method, dividing the network into several Sections. On the GIBP-MESIR network, which is divided into four Sections, the division is determined based on the placement of the security attached to the channel[10]. can be seen in the following Table 4.

Table 4. Division of Section Channels on Repeat GIBP-MESIR

Components			
Section 1	**Section 2**	**Section 3**	**Section 4**
Line 1-8, Line 38-69	Line 70-128, Line 162-163	Line 9-37	Line 129-161
Lp 1-6, Lp 27-52	Lp 53-94, Lp 118	Lp 7-26	Lp 95-117
CB	LBS SATE RINO	RC SIMP ANGGUR	RC PTP
RC BGKL	FCO	FCO	FCO
FCO	FCO	FCO	FCO
FCO	FCO	FCO	FCO
FCO		FCO	FCO
		FCO	FCO
		FCO	

The network model uses the RNEA Method, dividing the network into branches and main channels. In determining the channel branches, one can see the traffic layout separated by the security, and for the amount of load, there is more than one in the channel[11][12]. can be seen in the following table 5:

Table 5. The main channel on the repeat of GIBP-MESIR

Components	
Primary 1	**Primary 2**
Line 1-8, Line 38-40, Line 45-52, Line 59-69	Line 70-80, Line 104-128, Line 162-163
Lp 1-6, Lp 27-28, Lp 33-37, Lp 44-52	Lp 77-94
CB	Lp 118
RC BGKL	LBS SATE RINO
FCO	

Table 6. Channels in the GIBP-MESIR

Components				
Branch 1	**Branch 2**	**Branch 3**	**Branch 4**	**Branch 5**
Line 9-37	Line 41-44	Line 53-58	Line 81-103	Line 129-161
Lp 7-26	Lp 29-32	Lp 38-43	Lp 61-76	Lp 95-117
RC SIMP ANGGUR	FCO	FCO	FCO	RC PTP
FCO			FCO	FCO
FCO			FCO	FCO
FCO				FCO
FCO				FCO
FCO				FCO
FCO				

2.3 The GIBP-MESIR Feeder System Reliability Index

a. System Reliability Index for Load Points

The initial process of calculating this reliability index begins with calculating the reliability index based on the impact of the Load Point. There are two calculations to calculate the Load Point reliability index: calculating the frequency of shutdowns and counting the shutdown time[13][14]. can be seen in the following equation:

1) Frequency displacement

$$\lambda_{LP} = \sum_{i-k} \lambda_i \quad (1)$$

Explanation:
λ_{LP}: Frequency of Load Point Interference (failure/year)
λ_i: Failure rate for equipment K (failure/year)
K: Equipment for Load Point

2) Long removal

$$U_{LP} = \sum_{i-k} \lambda_i r_i \tag{2}$$

Explanation:
U_{LP}: Frequency of Load Point Interference (hour/year)
r_i: Failure rate for equipment K (failure/year)

The parameter used in this study is the System Average Interruption Frequency Index (SAIFI). System Average Interruption Duration Index (SAIDI) Customer's average interruption duration index (CAIDI)[15][16]. It can be seen in the following equation:

3) System Average Interruption Frequency Index (SAIFI)

$$\text{SAIFI} = \frac{\sum \lambda_i N_i}{\sum N} \tag{3}$$

4) System Average Interruption Duration Index (SAIDI)

$$\text{SAIDI} = \frac{\sum U_i N_i}{\sum N} \tag{4}$$

5) Customer's average interruption duration index (CAIDI)

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}} \tag{5}$$

Explanation:
λ_i: Average number of failures (failures/years)
U_i: Time of Customer Expiration (hour/year)
N_i: The number of customers served at the load point i
N: Number of customers served

b. System reliability of 20kV

When performing the calculation of the index in the electrical distribution system, it is necessary to pay attention to the standard of components and tools used, as can be seen in the following Table 7.

Table 7. Reliability of equipment SPLN 59 1985[17].

Komponen	λ (Failure Rate) (Rate of expense/year/km)	*Repair Time (Time / Hour)*	Rs (*Switching Time*) (Hour)
SUTM	0,2	3	0,15
Traffic Distribution	0,005	10	0,15
FCO	0,003	10	0,15
LBS	0,003	10	0,15
CB	0,004	10	0,15

As for measuring the reliability of the electricity distribution system, it requires a fixed benchmark or standard, which is helpful to assess a reliable electricity system. can be seen in the following Table 8.

Table 8. Standard Value of Confidence[18].

Standard of reliability	SAIFI	SAIDI	CAIDI
SPLN No.68-2 1986	3.2 times/customer/year	21 hours/customer/year	6.6 hours/customer/year

2.4 Repeat economic losses of GIBP-MESIR

Analysis of economic calculation of electric power distribution systems, which is derived from energy not conducted during the disruption[19][20], can be seen in the following equation:

$$\text{P fedder} = \sqrt{3 \times \text{v} \times \text{I} \times \cos\theta} \tag{6}$$

$$\text{ENS} = \text{SAIDI} \times \text{P Fedder} \tag{7}$$

$$\text{AENS} = \frac{\text{ENS}}{\text{N}} \tag{8}$$

$$\text{Economic Loss} = \text{ENS} \times \text{TDL} \tag{9}$$

Explanation:

P Fedder : Power Of Recovery (VA)
V : Return To Return (v)
I : The Recovery Stream (A)
ENS : Energy Not Supplied (kWh)
AENS : Average Energy Not Supplied (kWh/Customer)

3 Results and Discussion

3.1 Calculation of the Reliability Index using the Section Technique Method

The initial step in performing system reliability analysis using the Section Technique method is to divide the network structure into four Sections. This division is seen based on the placement of the recloser and LBS on the network or channel in the GIBP-MESIR Fedder.

Table 9. Data Section 1: Components that Interact on the Load Point

Components	Load Points Affected
Line 1-8, Line 38-40	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52
L 41-44	LP 29-32
L 45-52	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52
L 53-58	LP 38-43
L 59-65	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52
L 66	LP50
L 67-69	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52
LP 1-6, LP 27-52	LP 1-6, LP 27-52
CB	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52
FCO	LP 29-32
FCO	LP 38-43
FCO	LP 50
RC BGKL	LP 1-6, LP 27-28, LP 33-37, LP 44-49, LP 51-52

In Table 9, if the circuit breaker fails, all the slowing and traffic affecting the circuit breaker will fail. If a failure occurs on Lines 1–8 and 38–40, the equipment and traffic that affect those channels will be the failure. If a failure occurs on the FCO equipment, the loss will be the equipment within its scope. If there is a failure in the trafo, then the failure occurs only in that trafo.

The next step is to calculate each component's shut-off frequency (λ) and count every element's shut-off time (U). To find the frequency of extinction (λ) and the length of extraction (U), use equations 1 and 2. For example, take the calculation at load point 1 (Section 1) as follows:

$$\lambda_{LP} = \sum_{i-k} \lambda_i = 0{,}2 \times 0{,}85 = 0{,}17 \text{ Failure/years}$$

$$U_{LP} = \sum_{i-k} \lambda_i r_i = 0{,}17 \times 3 = 0{,}51 \text{ Hour/years}$$

Table 10. Results of calculation of shutdown frequency (λ) and shut down time (U) section 1

Components	The failure rate of equipment (interruption/year/km)	The long channel (km)	λ (failure/year)	r	U (hour/year)
Lines 1-8, Line 38-69	0.02	32.531	0.65062	3	1.95186
LP 1-6, LP 27-52	0.005	-	0.16	10	1.6
CB	0.004	-	0.004	10	0.04
RC BGKL	0.003	-	0.003	10	0.03
FCO, FCO,FCO	0.003	-	0.009	10	0.09

In Table 10, for the total result of the calculation of the frequency of shutdown (λ) and the duration of shutdown (U) in Section 1, for the impact of measures in Section 2, Section 3, and Section 4, the same process is performed as in the calculations of Section 1.

Then calculate the reliability indices SAIFI, SAIDI, and CAIDI. To calculate this index, use equations 3, 4, and 5. Then take the example of Load Point 1 in Section 1, as follows:

$$\text{SAIFI} = \frac{\sum \lambda_i N_i}{\sum N} = \frac{0{,}5911 \times 115}{4438} = 0{,}015317 \text{ Time/Customer/Year}$$

$$\text{SAIDI} = \frac{\sum U_i N_i}{\sum N} = \frac{2{,}5573 \times 115}{4438} = 0{,}066266 \text{ Hours/Customer/Year}$$

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}} = \frac{0{,}066266}{0{,}015317} = 4{,}32630 \text{ Hours/Customer/Year}$$

Table 11. Results of calculation of SAIFI, SAIDI, and CAIDI indices versus Load Points in Section 1

Load Point	λ	U	NLP	N	SAIFI	SAIDI	CAIDI
LP 1-6, LP 27-28	0,5911	2,5573	761	4438	0,101358	0,43851	4,326341
LP 29-32	0,07396	0,3828	742	4438	0,012366	0,064015	5,176852
LP 33-37	0,5911	2,5573	664	4438	0,088439	0,382615	4,326341
LP 38-43	0,11656	0,5806	1278	4438	0,033565	0,167217	4,326341
LP 44-49	0,5911	2,5573	338	4438	0,045018	0,194765	4,326341
LP 50	0,045	0,191	323	4438	0,003275	0,013901	4,244444
LP 51-52	0,5911	2,5573	332	4438	0,044219	0,191308	4,326341

In Table 11 of the results of the SAIFI, SAIDI, and CAIDI index against Load Point, it can be seen that the highest resulting SAIFI, SAIDI, and CAIDI are found in LP 1-6 and LP 27–28, with a SAIFI value of 0,101358 times/customer/year, a SAIDI of 0,43851 hours/customer/year, and a CAIDI of 4.326341 hours/consumer/year.

After knowing the value of the reliability index in each Section, it is possible to obtain the repeated GIBP-MESIR reliability Index value by summarizing the entire results of the reliability index in every Section. It can be found in the following table:

Table 12. Index results in SAIFI, SAIDI, and CAIDI for each section on repeat GIBP-MESIR

Section	SAIFI (times /customer/year)	SAIDI (hours/customer/year)	CAIDI (hours/customer/your)
1	0,32824	1,45233	4,42459
2	0,62368	2,5743	4,12759
3	0,1659	0,69756	4,20467
4	0,14023	0,60003	4,27882
TOTAL	1,25805	5,32422	4,23212

It can be analyzed that the results obtained from the sum of the sections are a SAIFI index of 1,25805 times/customer/year, a SAIDI of 5,32422 hours/customer/year, and a CAIDI of 4,23212 hours/customer/year on the repeat GIBP-MESIR.

3.2 Calculation of Reliability Index using the RNEA Method

The reliability analysis using the RNEA Method on GIBP-MESIR fedders must determine SAIFI, SAIDI, and CAIDI index values. To obtain the value of the index, the frequency of shutdowns (λ) and shutdown time (U) on the branch and main channels will be calculated. Can be seen in the following table:

Table 13. Results of calculation of shutdown frequency (λe1) and shutdown time (Ue1)

Components	The failure rate of equipment (interruption/year/km)	The long channel (km)	Failure rate (λe1) (failure/year)	r	Ue1 (hour/year)
Line 9-37	0,02	26,37	0,5274	3	1,5822
LP 7-26	0,1	-	0,1	10	1
RC SIMP ANGGUR	0,003	-	0,003	10	0,03
FCO	0,018	-	0,018	10	0,18
Totally			0,6484		2,7922

For example, the calculation is taken from the first line on the first branch as follows:

$\lambda_{e1} = \sum_{i-k} \lambda_i = 0,2 \times 1,05 = 0,021$ Failure/years

$U_{e1} = \sum_{i-k} \lambda_i r_i = 0,021 \times 3 = 0,063$ Hours/year

Table 14. Calculation of Load Point 1

LoadPoint	λ	U $r = \lambda$	U
LP 1-6	1,4328	4,260469012	6,1044
LP 7-26	2,0812	4,274745339	8,8966
LP 27-28	1,4328	4,260469012	6,1044
LP 29-32	1,50676	4,305450105	6,48728
LP 33-37	1,4328	4,260469012	6,1044
LP 38-43	1,54936	4,314736407	6,68508
LP 44-60	1,4328	4,260469012	6,1044
LP 61-76	2,25396	4,077658876	9,19088
LP 77-94	1,4328	4,260469012	6,1044
LP 95-117	2,21492	4,235710545	9,38176
LP118	1,4328	4,260469012	6,1044

For example, the calculation is taken from the first LP on the first branch as follows:

$LP_1 = \lambda_{e1} + \lambda_{branch} = 0,6484 + 1,4328 = 2,0812$

$LP_1 = U_{e1} + U_{branch} = 2,7922 + 6,1044 = 8,8966$

Selajut calculated the SAIFI, SAIDI, and CAIDI reliability indexes on GIBP-MESIR as follows:

Table 15. Results of the calculation of SAIFI, SAIDI, and CAIDI indices

Load Point	λ	U $r = \lambda$	U	NLP	SAIFI	SAIDI
LP 1-6	1,4328	4,2604690	6,1044	645	924,156	3937.338
LP 7-26	2,0812	4,2747453	8,8966	3893	8102,1116	34634,4638
LP 27-28	1,4328	4,2604690	6,1044	116	166,2048	708,1104
LP 29-32	1,50676	4,3054501	6,48728	742	1118,01592	4813,56176
LP 33-37	1,4328	4,2604690	6,1044	664	951,3792	4053,3216
LP 38-43	1,54936	4,3147364	6,68508	1278	1980,08208	8543,53224
LP 44-60	1,4328	4,2604690	6,1044	2159	3093,4152	13179,3996

Load Point	λ	U $r = \lambda$	U	NLP	SAIFI	SAIDI
LP 61-76	2,25396	4,0776588	9,19088	1825	4113,477	16773,356
LP 77-94	1,4328	4,2604690	6,1044	1885	2700,828	11506,794
LP 95-117	2,21492	4,2357105	9,38176	3620	8018,0104	33961,9712
LP118	1,4328	4,2604690	6,1044	314	449,8992	1916,7816
Totally					31617,579	134028,630

Calculate the results of the SAIFI, SAIDI, and CAIDI indices as follows:

$$\text{SAIFI} = \frac{31617{,}579}{17141} = 1{,}84455 \text{ times/customer/year}$$

$$\text{SAIDI} = \frac{134028{,}6302}{17141} = 7{,}81918 \text{ hours/customer/year}$$

$$\text{CAIDI} = \frac{7{,}81918}{1{,}84455} = 4{,}239054119 \text{ hours/customer/year}$$

It can be analyzed that using the RNEA Method has a SAIFI index result of 1,84455 times/customer/year, a SAIDI of 7,81918 hours/customer/year, and a CAIDI of 4,239054119 hours/customer/year on the GIBP-MESIR feeder.

3.3 Reliability Index Between Section Technique and RNEA Compared to SPLN No. 68-2, 1986

From the results of analysis and reliability calculations that have been performed using both the Section Technique and the RNEA methods, we will compare the outcomes of the SAIFI, SAIDI, and CAIDI indexes with SPLN No. 68 to 1986. It can be seen in the following table and picture:

Table 16. Comparison of System Reliability Index Values Between Section Technique Method and RNEA with SPLN No. 68-2, 1986

Reliability Index	PLN	*Section Technique*	RNEA	SPLN
SAIFI (times/customer/year)	16,30313682	1,25806	1,84455	3,2
SAIDI (hours/customer/year)	22,88145557	5,32422	7,81918	21
CAIDI (hours/customer/year)	-	4,23210	4,23905	6,56

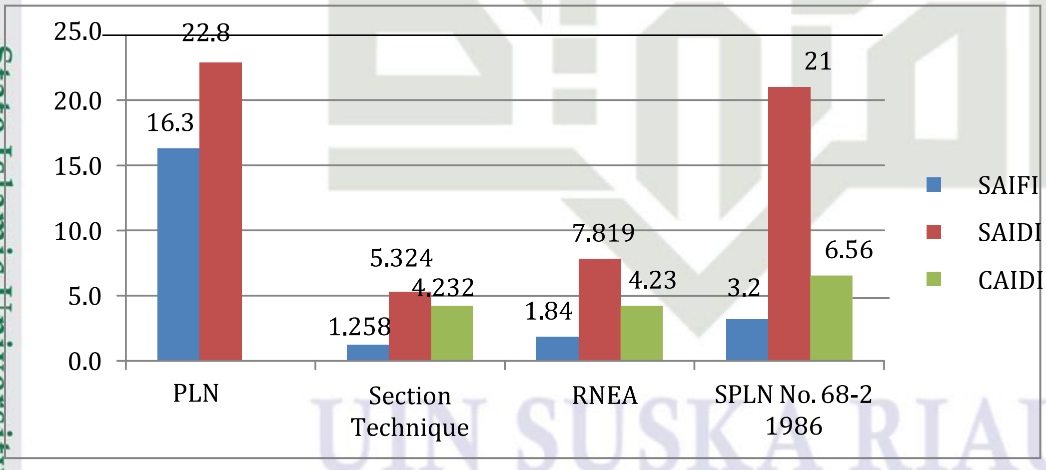

Fig. 2. Comparison of the System Reliability Index

Based on the results in Table 16, before using the Section Technique and RNEA methods, PT.PLN (Persero) ULP Duri has a SAIFI reliability index of 16,30313682 times/customer/year and a SAIDI index of 22,88145557 hours/customer/year, from the results of the reliability index, PT.PLN (Persero) ULP Duri is above the PLN standard No. 68-2 1986, so the repeat of GIBP-MESIR is said to be unreliable. The system reliability index on the GIBP-MESIR feeder when using the Section Technique method was 1,25806 times/customer/year, the SAIDI index was 5,32422 hours/customer/year, and the CAIDI index was 4,23210 hours/customer/year. The value of the GIBP-MESIR reliability index when using the Section Technique method is still below the standard, so it is said to be reliable. When using the RNEA method, the SAIFI reliability index was 1,8445 times/customer/year, the SAIDI index was 7,81918 hours/customer/year, and the CAIDI index was 4,23905 hours/customer/year. Then the reliability of the GIBP-MESIR recovery system when using the RNEA method is below the standard and reliable. The differences resulting from the two methods are that the Section Technique method has a lower reliability index value than the RNEA method.

3.4 Calculation of the Index Based on the Economic Loss on the Feeder GIBP MESIR

In the analysis Energy Not Supplied (ENS), use equation 7. The first thing to know before searching for the ENS index value is the mathematical calculation of the active power during the disruption. It can be seen in equation 6.

$$\text{P fedder} = \sqrt{3 \times \text{v} \times \text{I} \times \cos\theta}$$

$$\cos\theta = 0{,}85$$

$$\text{P fedder} = \sqrt{3 \times 20.000\ \text{V} \times 218\ \text{A} \times 0{,}85} = 11.118.000\ \text{kW}$$

Next, calculate ENS on the section technique method and RNEA method, performed using equation 7. can be seen as follows:

$$ENS = SAIDI \times \text{Power feeder}$$

$$ENS\ section\ technique = 5{,}32422 \times 11.118.000 = 59.194.677{,}96\ \text{kWh}$$

$$ENS\ \text{RNEA} = 7{,}81918384 \times 11.118.000 = 86.933.685{,}93\ \text{kWh}$$

Calculate the average Energy Not supplied (AENS). To calculate AENS, you can use equation 8 as follows:

$$AENS = \frac{\text{ENS}}{\text{N}}$$

$$AENS\ section\ technique = \frac{59.194.677{,}96}{17141} = 3.453{,}396\ \text{kWh/customer}$$

$$AENS\ \text{RNEA} = \frac{86.933.685{,}93}{17141} = 5.071{,}681\ \text{kWh/customer}$$

If the results of the ENS and AENS values calculation have been obtained, then calculate the economic loss of unchanneled energy due to power outages. This process is carried out by increasing the ENS value with the Electric Power Tariff that the ESDM Minister established in 2022. in recognition using equation 9. This can be seen as follows:

$$\text{Economic Loss} = \text{ENS} \times \text{TDL}$$

$$\text{Economic Loss Section Technique} = 59.194.677{,}96 \times 1444{,}70 = \text{Rp. } 85.518.551.248$$

$$\text{Economic Loss RNEA} = 85.933.685{,}93 \times 1444{,}70 = \text{Rp. } 125.593.096.063$$

Table 17. Economic Losses Before Using The Method

Before using the method	ENS (kWh)	AENS (kWh/customer)	Economic Loss(Rp)
Loss PLN ULP Duri	254.396.072,28	14.841,378	367.526.005.622

Table 18. Economic Losses After Using The Method

Use of methods	ENS (kWh)	AENS (kWh/Customer)	Economic Loss (Rp)
Section Technique	59.194.677,96	3.453,396	85.518.551.248
RNEA	86.933.685,93	5.071,681	125.593.096.063

The results of economic losses can be seen in Tables 17 and 18. Before using system reliability analysis methods, use the Section Technique and RNEA methods. The economic losses experienced by the PT.PLN (Persero) ULP Duri amounted to Rp. 367.526.005.622, with uncontained energy of 254.396.072,28 Kwh. The average unchanneled energy consumption was 14,841,378 kWh/customer. Section Technique and RNEA methods found meager results in its economic losses, ENS and AENS. The technical section of Rp. 85.518.551.248, with uncharted energy of 59.194.677,96 Kwh. The average unchanneled energy was 3,453,396 kWh/customer. Then use the RNEA method: 125.593.096.063, with an uncharted energy of 86.933.685,93 Kwh. The average unchanneled energy was 5.071,681 kWh/customer.

4 Conclusion

Analysis of the reliability of the electricity distribution system using Section Technique and RNEA Method: the result of Section Technology has a SAIFI value of 1,25806 times/customer/year, a SAIDI value of 5,32422 hours/customer/year, and a CAIDI value of 4,232102648 hours/customer/year. When analyzing the reliability of the system using the RNEA Method, the SAIFI value was 1.84455 times/customer/year, the SAIDI value was 7.81918 hours/customer/year, and the CAIDI value was 4.239054119 hours/customer/year. Then, the two methods will be compared with SPLN No. 68-2, 1986. When performing system reliability analysis both ways, the system reliance index on the GIBP-MESIR fedder is below the standard used. The differences obtained from the two methods are that the system reliability analysis results from the Section Technique Method are lower than those from the RNEA Method. When the system reliability analysis process is done, the Section Technique method is simpler to analyze. Both ways are said to be reliable.

For the value of economic losses obtained before using the Section Technique and RNEA Methods. Fedder GIBP-MESIR resulted in economic losses in the form of an Energy Not Supplied (ENS) value of 254396072,28 kWh, an Average Energy Not Supplied (AENS) value of 14841,378 kWh/customer, and Rp. 367.526.005.622 for his loss. When using the Section Technique and RNEA methods, the Section Technique method has an ENS value of 59194677,96 kWh, an AENS value of 3453,396 kWh/customer, and Rp. 85.518.551.248 for his loss. In the RNEA method, the ENS value was 86933685,93 kWh, the AENS value was 5071,681 kWh/customer, and Rp. 125.593.096.063 for his loss.

5 References

[1] F. Funan dan W. Sutama, "Evaluasi Keandalan Sistem Distribusi Tenaga Listrik Berdasarkan Indeks Keandalan SAIDI dan SAIFI pada PT PLN (PERSERO) Rayon Kefamenanu," *J. Ilm. Telsinas Elektro*, vol. 3, no. 1, hal. 32–36, 2020, [Daring]. Tersedia pada: https://journal.undiknas.ac.id/index.php/teknik/article/view/2888

[2] B. Kevin dan y. A. Dewi, "ANALISIS INDEKS KINERJA LAYANAN DISTRIBUSI 20 KV PENYULANG PAINAN MENGGUNAKAN METODE SECTION TECHNIQUE DI PT.PLN (PERSERO) ULP PAINAN," *Semin. Nas. Sains dan Teknol.*, vol. 12, no. 1, hal. 589–596, 2022, doi 10.36499/post.v12i1.7247.

[3] A. Makruf, R. Ilham, B. Sakti, E. Syam, M. Akbar, dan Y. Yudistira, "Analisis Keandalan Sistem Distribusi 20 Kv Gi Tengkawang Pada Penyulang T4," *Emit. J. Tek. Elektro*, vol. 22, no. 2, hal. 155–160, 2022, doi: 10.23917/emitor.v22i2.16770.

[4] R. Harahap, S. A. Siregar, S. Hardi, dan S. HS, "Analisis Sistem Jaringan Distribusi 20 KV Penyulang SB.02 Pada PT. PLN (Persero) ULP Sibolga Kota Menggunakan Metode Section Technique dan Failure Mode Effect Analysis (FMEA)," *J. Electr. Technol.*, vol. 7, no. 2, hal. 87–95, 2022.

[5] R. Harahap, H. Farizi, S. T. Kasim, dan S. HS, "ANALISIS INDEKS KEANDALAN PADA JARINGAN DISTRIBUSI 20 KV PENYULANG KA.1 , KU.1 DAN TW.1 DI PT. PLN (Persero) UP3 LUBUK PAKAM," *Semnastek*, hal. 140–150, 2022, [Daring]. Tersedia pada: https://jurnal.uisu.ac.id/index.php/semnastek/article/view/5645

[6] U. Usman, M. Thahir, Indra, Sofyan, dan S. T. Idris, Ahmad RosyidThaha, "Penentuan Keandalan Sistem Distribusi 20 KV Penyulang Malili dengan Metode Section Technique dan FMEA," *PROtek J. Ilm. Tek. Elektro*, vol. 9, no. 2, hal. 126–133, 2022, doi http://dx.doi.org/10.33387/protk.v9i2.4985.

[7] G. Sihombing, "Analisis Indeks Keandalan Secara Teknis dan Ekonomis Jaringan Distribusi 20 KV Menggunakan Metode Section Technique pada PT. PLN (Persero) Rayon Belawan," *JEE J. Edukasi Elektro*, vol. 06, no. 02, Hal. 105–115, 2022, doi http://dx.doi.org/10.21831/jee.v6i2.53946.

[8] M. N. Ramadhan, T. Suheta, N. P. U. Putra, R. Sulistyowati, N. H. Rohiem, dan I. Masfufiah, "Keandalan Sistem Distribusi 20KV Pada Penyulang Sistem Distribusi PT . PLN UP3 Surabaya Utara Dengan Metode Reliability Network Equivalent Approach (RNEA)," *ITATS Inst. Teknol. Adhi Tama Surabaya*, hal. 1–8, 2022, [Daring]. Tersedia pada: http://ejurnal.itats.ac.id/sntekpan/article/view/3656

[9] R. N. Annisa, Hamma, dan N. R. Najib, "Analisis Keandalan Sistem Jaringan Distribusi 20 kv Di PT. PLN (Persero) ULP Kalebajeng Dengan Metode Reliability Network Equivalent Approach (RNEA)," *Posiding Semin. Nas. Tekik Elektro dan Inform.*, vol. 8, no. 1, hal. 338–343, 2022, doi: 10.57152/ijeere.v2i2.468.

[10] R. Maulana, Suriadi, dan R. H. Siregar, "Analisa Sistem Keandalan Jaringan Distribusi Menggunakan Metode Section Technique," *KITEKTRO J. Komputer, Iformasi Teknol. dan Elektro*, vol. 6, no. 3, hal. 39–44, 2021, [Daring]. Tersedia pada: https://jurnal.untan.ac.id/index.php/jteuntan/article/download/35507/75676582857

[11] ROMIANDI, M. Iqbal Arsyad, dan B. Sirait, "Analisa Keandalan Sistem Jaringan Distribusi 20 Kv Di Pt. Pln (Persero) Area Singkawang Dengan Metode Reliability Network Equivalent Approach (Rnea)," *J. Tek. ELEKTRO Univ. TANJUNGPURA*, vol. 2, no. 1, hal. 1–12, 2020, [Daring]. Tersedia pada: https://jurnal.untan.ac.id/index.php/jteuntan/article/view/42008

[12] M. F. Adiguna, "Analisis Keandalan Sistem Distribusi 20 kv Pada Penyulang Kayutangi Menggunakan Metode Reliability Network Equivalent Apporoach (RNEA)," *Semin. Has. Elektro S1 ITN Malang*, vol. 1, no. 1, hal. 2–9, [Daring]. Tersedia pada: http://eprints.itn.ac.id/4212/10/8_JURNAL.pdf

[13] M. A. Teguh dan T. Rijanto, "Penentuan Kerugian Ekonomis Berdasarkan Nilai Saidi, Saifi Dan Caidi Menggunakan Metode Section Technique Di Pt. Pln Distribusi Area Gresik.," *J. Tek. ELEKTRO*, vol. 8, no. 2, hal. 445–452, 2019, [Daring]. Tersedia pada: https://ejournal.unesa.ac.id/index.php/JTE/article/view/27647

[14] P. Sinaga, Hardiansyah, dan Purwoharjono, "Analisa Keandalan Sistem Distribusi Berdasarkan Metode Section Technique Pada PT. PLN (Persero) Area Pontianak," *J. Tek. Elektro Univ. Tanjungpura*, vol. 2, no. 1, hal. 1–15, 2019, [Daring]. Tersedia pada: https://jurnal.untan.ac.id/index.php/jteuntan/article/view/35507

[15] Muliadi dan Aswijar Jamal, "Analisa Keandalan Sistem Distribusi Berdasarkan Indeks SAIFI, SAIDI, dan CAIDI Pada Penyulang Suak Ribee ULP. Meulaboh Kota," *Ajeetech*, vol. 2, no. 1, hal. 14–18, 2022, [Daring]. Tersedia pada: https://core.ac.uk/download/pdf/525632036.pdf

[16] M. Marwan, Alimin, dan A. E. T. Putri, "Penggunaan Metode Reliability Network Equivalent Approach untuk mengevaluasi Keandalan Sistem Jaringan Distribusi 20 kV," *J. Teknol. Elekterika*, vol. 17, no. 2, hal. 81–88, 2020, doi: 10.31963/elekterika.v4i2.2256.

[17] P. P. (Persero).1985., "Standar PLN 59 : 1985 Keandalan Pada Sistem Distribusi 20kv dan 6 kv." Departemen Pertambangan dan Energi Perusahaan Umum Listrik, Jakarta, 1985. [Daring]. Tersedia pada: https://www.academia.edu/27038366/SPLN_59_1985_Keandalan_Sistem_Distribusi_20kV_dan_6_kV

[18] P. P. (Persero)., “Spln 68-2:1986 - Tingkat Jaminan Sistem Tenaga Listrik - Bagian Dua : Sistem Distribusi.” Departemen Pertambangan dan Energi Perusahaan Umum Listrik, Jakarta, 1986. [Daring]. Tersedia pada: https://www.scribd.com/doc/215461581/spln-68-2-1986

[19] A. Nafiarman, U. Situmeang, Zulfahri, dan Arlenny, “Pengaturan Grouping Proteksi Titik Kontingensi Peralatan Switching Untuk Menurunkan ENS,” *J. Sain, Energi, Teknol. Ind.*, vol. 5, no. 2, hal. 68–78, 2021, [Daring]. Tersedia pada: https://journal.unilak.ac.id/index.php/SainETIn/article/view/6427

[20] S. S. Akhmad, Bakhtiar, dan Nirmayani, “Analisis Pengaruh Rekonfigurasi Jaringan terhadap Keandalan Sistem Distribusi 20 kV PT. PLN (Persero) Unit Layanan Pelanggan (ULP) Tomoni,” *Semin. Nas. Tek. Elektro dan Inform.*, hal. 17–23, 2021, [Daring]. Tersedia pada: http://jurnal.poliupg.ac.id/index.php/sntei/article/view/2835

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