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An Analysis Of 20 KV Distribution Reliability System At PT. PLN ULP Tanjungbalai

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ABSTRACT

This paper analysed the reliability of the 20 kV distribution system at PT. PLN ULP Tanjung-balai. The reliability of the electricity distribution system is crucial to ensure a stable power supply with minimal interruptions to consumers. The study aims to identify and evaluate the factors affecting the reliability of the 20 kV distribution network and propose solutions to enhance the system's reliability. The methods used in this study include the collection of historical outage data, analysis of network performance, and calculation of reliability indices such as SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index), and CAIDI (Customer Average Interruption Duration Index). Additionally, the study utilizes network analysis software to simulate the operational conditions of the distribution network. The results of the study indicate that the reliability of the distribution system at PT. PLN ULP Tanjungbalai requires improvement, particularly in reducing the frequency and duration of power outages. Several identified causes of outages include extreme weather conditions, equipment failures, and external factors such as animals or vegetation. To improve system reliability, several actions are recommended, such as more intensive preventive maintenance, modernization of distribution equipment, and enhanced monitoring of the distribution network.

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INTRODUCTION

In the modern era, the need for a reliable and stable electricity supply is crucial for economic progress and the well-being of society. PT. PLN (Persero), as the main electricity provider in Indonesia, is responsible for ensuring that electricity distribution to customers is conducted with high reliability. One of the critical areas in the electricity distribution network is the 20 kV distribution system, which plays a key role in distributing electrical energy to various consumers, including households, industries, and businesses.

The 20 kV distribution system at PT. PLN ULP (Customer Service Unit) Tanjung-cbalai is one of the critical systems in ensuring the availability of electricity in the region. The reliability of this electricity distribution system significantly affects the quality of life for the community and industrial operations. However, like other electrical distribution systems, the

20 kV distribution system in Tanjung-balai also faces various challenges, such as technical disruptions, unexpected power outages, and equipment failures within the network.

A decline in the reliability of the distribution system can be caused by several factors, including aging equipment, weather disturbances, operational errors, and inadequate maintenance. Disruptions in the distribution system not only cause inconvenience to customers but can also result in significant economic losses.

Therefore, analysing the reliability of the 20 kV distribution system is essential to identify the factors causing disruptions and to find effective solutions to enhance the system's reliability. This analysis involves evaluating various reliability parameters, such as the frequency and duration of outages, reliability indices (SAIDI, SAIFI, and CAIDI), as well as the condition of equipment and the network.

This research is conducted by analysed the reliability level of the 20 kV distribution system at PT. PLN ULP Tanjung-balai and identifying steps that can be taken to improve system reliability. By understanding the weaknesses and potential improvements in the distribution system, PT. PLN can implement more effective strategies in the maintenance and management of the electrical network.

In the long term, improving the reliability of the electricity distribution system will have a positive impact on service quality to customers, reduce losses due to power outages, and support economic growth in the Tanjung-balai region. This research is expected to make a significant contribution to efforts to enhance the reliability and efficiency of the electricity distribution system in Indonesia, particularly at PT. PLN ULP Tanjung-balai.

Literature Review

Electrical Power System

The Electrical Power Distribution System Is The Process Of Transmitting And Distributing Electrical Energy From Power Plants To Loads. The Distribution Of Electrical Energy Begins At The Power Generation Source And Continues Through The Transmission Lines Until It Reaches The Electrical Distribution To Various Loads. The Electrical Power Distribution System Is Designed And Constructed To Supply Electrical Power To A Group Of Loads. The Design Of The Electrical Power Distribution System Is Quite Complex, Starting From The Installation Of Power Sources To The Installation At Load Centers.

Electrical Power Is Generated From Power Plants Such As Coal-Fired Power Plants (PLTU), Hydroelectric Power Plants (PLTA), And Gas-Fired Power Plants (PLTG). Once The Electrical Power Is Generated, It Is Transmitted Through Transmission Lines And Then Distributed To The Loads. This Process Can Be Illustrated In Figure 1.

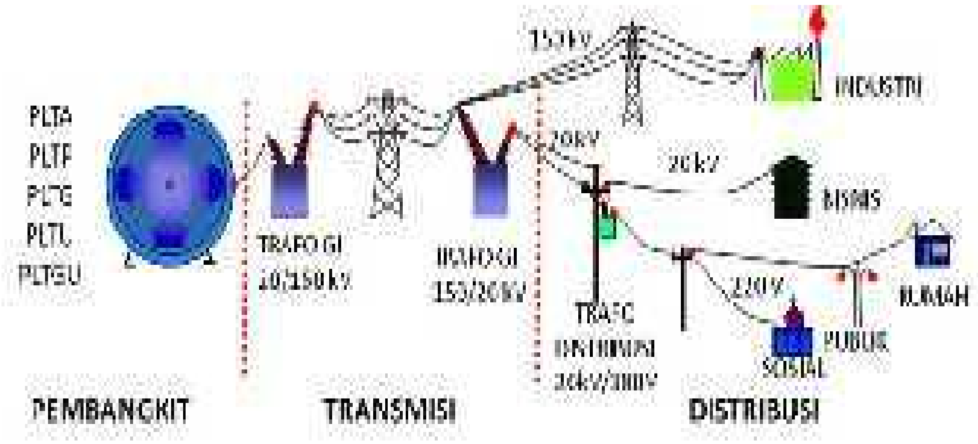

Figure 1. Wiring And Installation.

Electrical Power Generated By Large Power Plants, With Voltages Ranging From 11 Kv To 24 Kv, Is Stepped Up By A Substation Using A Step-Up Transformer To Voltages Of 70 Kv, 154 Kv, 220 Kv, Or 500 Kv, And Then Transmitted Through Transmission Lines. The Purpose Of Stepping Up The Voltage Is To Reduce Power Losses On The Transmission Lines, As Power Loss Is Proportional To The Square Of The Current Flowing ($I^2.R$). For The Same Amount Of Power, Increasing The Voltage Reduces The Current, Which In Turn Reduces Power Losses.

From The Transmission Lines, The Voltage Is Stepped Down To 20 Kv Using A Step-Down Transformer At The Distribution Substation. This Voltage Level Is Then Used In The Primary Distribution System To Deliver Electrical Power. The Primary Distribution Lines Supply Voltage To Distribution Substations, Where It Is Further Stepped Down Using Distribution Transformers To Low Voltage Systems, Typically 220/380 Volts. According To The Function Of The Substation, The Substation Can Be Classified As Follows:

1. Voltage Boosting Substation Functions As A Voltage Booster. The Substation Will Increase The Voltage Of The Power Plant To The System Voltage. This Substation Is Located At The Power Plant Location. Because The Output Voltage Produced By The Power Plant Is Relatively Small And Must Be Distributed Over Long Distances, The Voltage Is Increased To Extra High Voltage Or High Voltage In Order To Reduce Losses.
2. Voltage Reducing Substation A Voltage Reducing Substation Functions To Reduce The Voltage, From High Voltage To Lower And Medium Voltage Or Distribution Voltage. The Substation Is Located In The Center Of The Load Center
3. Distribution Substation A Distribution Substation Is A Substation That Distributes Electric Power From System Voltage To Distribution Voltage. Distribution Substations Are Located Near The Load Centers, Because It Is At This Substation That Customers (Loads) Are Served.

Components in SUTM (medium voltage overhead line).

In Indonesia, the operating voltage of SUTM is generally 6 KV and 20 KV. However, gradually the operating voltage of 6 KV was eliminated and currently almost all of them use an operating voltage of 20 KV. SUTM transmission is used in a three-level network, namely a distribution network that connects from the Main Substation, Feeder, SUTM, Distribution Substation, to the Utilization Installation (Customer/Consumer).

In the SUTM network, switching equipment is also used to optimize distribution operations. The switching equipment used includes: Load Break Switch (LBS), in addition to LBS, there can also be a Disconnecting Switch (DS). Load Break Switch (LBS) is a three-phase switch or circuit breaker placed outside the section on the pile, which is controlled electronically. The switch with the placement above the pile is optimized through remote control and automation schemes. LBS is installed on the interconnection srdial channel, which consists of more than one single radial channel.

Disturbances in the Electric Power Distribution System

In the operation of the electric power system, disturbances often occur which can disrupt the distribution of electric power to consumers. Disturbances are a condition of the electric power distribution system that deviates from normal conditions. Based on ANSI/IEEE Std 100-1992, disturbances are defined as a physical condition caused by the failure of a device, component or element to work according to its function. A short circuit is an abnormal connection (including arcing) at a relatively low impedance that occurs accidentally or intentionally between two points that have different potentials.

The causes of disturbances that often occur in the 20 kV line distribution system are disturbances originating from within the system itself and disturbances originating from outside the system. Disturbances originating from within the system can be in the form of failure of the function of network equipment, damage to network equipment and damage to load-breaker equipment. Disturbances originating from outside the system can be caused by the touch of trees or branches on the conductor, lightning strikes, humans, animals, weather and others.

Types of Disturbances

The duration of the disturbances that occur in the 20 kv distribution system can be divided into 2, namely:

1. Permanent disturbances (can be caused by equipment damage, the disturbance will only disappear after the damage is repaired). Permanent disturbances (persistent), namely disturbances that are permanent. In order for the network to function again, repairs need to be carried out by eliminating the disturbance. This disturbance will cause a permanent blackout on the electricity network and at the point of disturbance there will be permanent damage. Example: decreased solid insulation capacity or transformer oil. Here it will cause permanent damage to the transformer, so that in order to operate again, repairs must be made.
2. Temporary disturbances (disruptions that will not last long and can be normal or disappear by themselves followed by the re-closing of the connecting equipment). Temporary disturbances, the occurrence of disturbances is temporary, so no action is

required. The disturbance will disappear by itself and the electricity network will work normally again. This type of disturbance is: the occurrence of flashover between conductors and the ground (poles, traverses or ground wires) due to lightning strikes, flashovers with trees, and so on. While the types of short circuit disturbances that can occur are divided into:

a. Single phase to ground disturbance
b. Two phase to ground disturbance
c. Phase to phase disturbance
d. Three phase to ground disturbance

Definition in Distribution Reliability

The meaning of reliability has various meanings, one of which is that reliability states the possibility of a piece of equipment or system working according to its function at a certain time interval and under certain conditions. Reliability can also be used as a comparison of one piece of equipment or system with another. The reliability of a distribution system is determined by the reliability of the components that form a distribution system. From the meaning of reliability which states the possibility of a piece of equipment or system working according to its function at a certain time interval and under certain conditions, it can be explained as follows:

a. The reliability of a component needs to be seen whether a component can perform its function properly over a certain period of time.
b. The reliability of each piece of equipment is highly dependent on the operational conditions of the environment, including operation and storage, etc.
c. Reliability will decrease over time or with the increasing age of the equipment.

METHOD

The type of research conducted is a case study, and in accordance with the form of research to be conducted, it aims to try to conduct a study of the technical data that occurs in the 20 kV SUTM. The data obtained will then be processed by performing mathematical calculations to obtain reliability index figures and compare them with the figures targeted by PT.PLN (Persero). and where is the Place and Time of Research To meet the data needed in the calculation, the location of this research will be carried out on the distribution of medium voltage overhead lines (SUTM) 20 KV at PT. PLN (Persero) ULP Tanjung Balai. where the data collection techniques used in this study are as follows:

Field Research was conducted, where the author made direct observations at PT. PLN (Persero) ULP Tanjung-Balai 20 kV distribution system to obtain data and information related to the research problem, where the author obtains information for problem solving by using references that are in accordance with the problems raised or literature studies. then Discussion / interview is conducted, to obtain data through interviews with staff of PT. PLN (Persero) ULP tanjung-balai.

The data needed in this case study analysis is in the form of customer-oriented technical data obtained from disturbance monitoring data consisting of: a) Customer-

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oriented technical data obtained from disturbance monitoring data, the data is in the form of: number of customers, duration of outages (hours), frequency or number of outages (times), number of outage customers, and number of disturbances. b) Realization data and performance targets of SAIDI and SAIFI set by PT. PLN. c) Single line diagram of the 20 kV distribution system of PT. PLN (Persero) ULP Tanjung balai then the Data Analysis technique is carried out. The methods or steps taken in this calculation are as follows and Calculating the system reliability index by determining the failure rate (λ). and Calculating the additional reliability index by determining the SAIDI and SAIFI values and comparing them with the target values set by PLN.

RESULT

System Model

PT. PLN (Persero) ULP Tanjung Balai is distributed through 2 150/20 kV voltage reduction transformers from the Tanjung Balai Main Substation.

Table 1. Substation Tanjung Balai and Customers

LP	Power (kva)	Calculated Value	Load kVA
1	50	44	37.56
2	25	22	20.13
3	50	47	42.54
4	50	43	39.43
5	50	103	90.54
6	100	221	195.13
7	25	51	46.34
8	50	47	42,43
9	25	53	46.76
10	199	397	323.23
11	50	43	98.42
12	50	53	40.09
13	50	100	40.58
14	25	49	88
15	100	91	80.18

From the calculations, it was found that the reliability index value of the Tanjung Balai ULP feeder is as follows :

Table 2. Reliability Index Value of Tanjung Balai ULP

Index Value	System reliability results	Result LN (March 2017)
SAIFI	8,264 *fail/yr. customer*	3,27 *fail/yr. customer*
SAIDI	10,60 *hr/yr.customer*	2,53 *hr/yr.customer*
CAIDI	1,28 *h/customer failure*	1,29 *h/customer failure*
ASAI	0,985	
ASUI	0,015	

There is a difference between the results of the system reliability calculations in this final project and the results of the PLN calculations. This is due to the difference in the methods used. In this final project, the FMEA method is used, which assumes equipment failure and sees the effects that occur in the system. While the method used by PLN is the result of real failures that occur in the field. So the data obtained only describes the condition of the system reliability that occurs when there is a failure in some equipment. While the comparison of the reliability index of all feeders can be seen in the following graph:

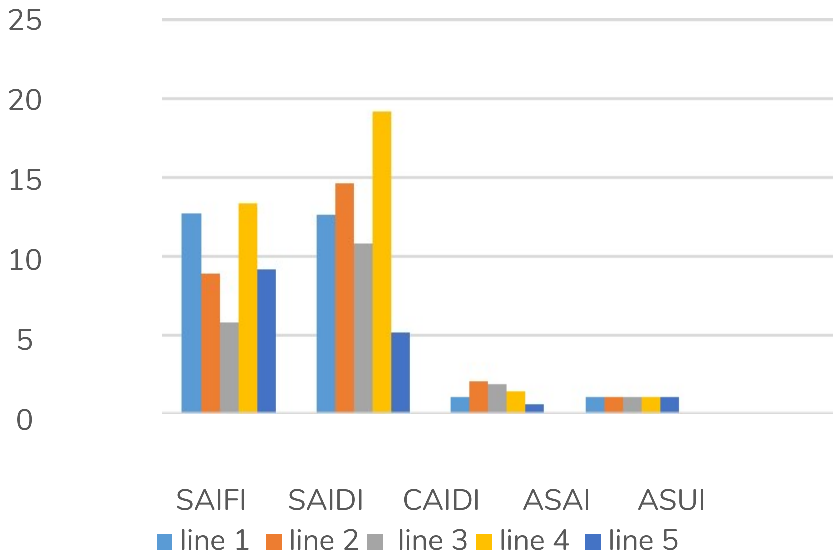

Figure 2. Comparison of Reliability Indexes Between Feeders

Judging from the graphic image above, when compared to the standard of SPLN, namely SAIFI: 1.2 times/customer/year and SAIDI: 0.83 hours/customer/year, the SAIFI reliability index for all feeders exceeds the standard. Compared to all feeders whose reliability index has been calculated, in terms of SAIFI and SAIDI, feeder 5 is the worst of the others. Therefore, efforts will be made to improve the system reliability of feeder 5.

Efforts to Improve Reliability Index

In an effort to improve the reliability of an electric power system, there are various ways, the first way is to reduce the frequency of disturbances, and the second way is to reduce the duration of the disturbance. If we want to reduce the frequency of disturbances, we can use a fuse to localize the disturbance, if we look back at the FMEA method, the function of the fuse itself can localize the disturbance without any switching time at the surrounding load point, so that in the calculation of each load point a smaller lambda will be obtained. If the lambda (failure rate) is smaller, the frequency of blackouts will also decrease. If referring to the duration, it can reduce the duration of the blackout due to repairs to components that have been damaged by adding a sectionalizer. the addition of a sectionalizer if we refer to the FMEA method, it can be seen that when a failure occurs in a certain section and because of the sectionalizer in that section, the blackout can be localized only in a certain section, because the sectionalizer works when there is no load, then other sections will only experience switching time because the CB can close again.

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Efforts to Improve the Blora 5 Reliability Index

In an effort to improve the reliability of the Blora 5 feeder, it is necessary to reduce the frequency of disturbances and reduce the duration of disturbances. This can be done by adding sectionalizer and fuse equipment at certain points that are considered to have a role in contributing to failures.

Addition of sectionalizers at channel points 234, channel 239, channel 165 and channel 170. Placement at these points is to reduce the localization area if a disturbance occurs. Initially, if a failure occurs on the channel between points 224 - 243, section 7 localizes the disturbance which results in a blackout at load points 165 - 244. By adding sectionalizers at points 234, 239, the area can be reduced. Meanwhile, if a disturbance occurs between channel points 157 - 175, it will affect load points 109 - 163. By adding sectionalizers at channel points 165 and 170, the localization of the disturbance can be reduced.

The addition of fuses is placed on single-phase channels. There are several points that require fuse installation, namely at channel points 84, 131, 209, 268, 274. So if there is a disturbance in channel 84-89 or a disturbance in transformer 52-57, the blackout is 52-57, while before the fuse was installed, the blackout was from load point 45-57. Likewise with the installation of fuses on channel 131, before installation if there is a disturbance in transformer 87-92 or channel 122- 133, load point 87-97 will be blacked out. After the fuse is installed, the blackout only occurs at points 88-91.

Recloser is installed at channel point 228 so that it can reduce the number of load points that experience switching time due to opening the CB to operate the sectionalizer. After making efforts to improve reliability by installing several equipment, the following results can be obtained for the reliability index of the Tanjung balai 5 feeder:

Table 3. Before and after repair

Indeks Value	Before	After
SAIFI	13,35	12,12
SAIDI	19,13	18,19

After making improvements to the reliability value of the Tanjung balai SAIFI feeder which previously had a value of 13.35 improved to 12.12. While the previous SAIDI value of 19.13 improved to 18.19. The increase in reliability value is quite small because there are still many equipment in the feeder line 5, so it also affects the number of contributors to failure.

Field Condition Reliability Index

Failure rate is the average number of failures that occur in a component within a certain period of time. In finding the failure rate in this final project, we use the failure history within one year. So that the results obtained show the reliability of the system within a period of one year. Likewise with the average length of power outages within a period of one year. The failure rate is obtained as in the following table.

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Table 4. Annual Failure Rate

Failure	Air Duct	Fuse	Trafo
Total	24	18	4
Duration	21:57:00	10:22:00	1:33:00
λ	0,0027	0,0021	0,0005
U	0,9147	0,5758	0,3875

From the graph in the image above, it can be seen that the cumulative target of SAIDI and SAIFI is directly proportional to the time period. From the graph, it can also be seen that the cumulative realization rate also moves directly proportional to the time period. To see whether the distribution system of PT. PLN (Persero) ULP Tanjung Balai is reliable, which can be seen in the comparison of the cumulative realization index value to the cumulative target,

CONCLUSION

Based on the results of the calculations and analysis that have been carried out, the following conclusions are drawn: The results of the calculation of the reliability of the 20 kV electric power distribution system at ULP Tanjung-Balai using the FMEA method are as follows:

• Line 2 feeder:
SAIFI: 12.66 failure/year customer
SAIDI: 12.59 hour/year customer
• Line 3 feeder:
SAIFI: 8.26 failure/year customer
SAIDI: 10.60 hour/year customer
• Line 4 feeder:
SAIFI: 5.78 failure/year customer
SAIDI: 6.05 hour/year customer
• Line 5 feeder:
SAIFI: 13.35 failure/year customer
SAIDI: 19.13 hour/year customer
• Line 6 feeder:
SAIFI: 5.43 failure/year customer
SAIDI: 4.53 hour/year customer

The results of efforts to improve the reliability index of the SAIFI line5 feeder which previously had a value of 13.35 improved to 12.12. While the previous SAIDI value of 19.13 improved to 18.19. The frequency of failures on the line contributes to the frequency of failures in the system which is quite high compared to the frequency of failures of equipment in the distribution system such as transformers, switches and CBs so that it affects the SAIFI index value. While the SAIDI index value will also increase following the line due to the duration of the failure that occurs. To compensate for the large SAIFI and

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SAIDI values, fuse and sectionalizer components are needed so that the system remains in reliable performance.

REFERENCES

[1] Akbar, M. A., Tarigan, A. D., & Lesmana, D. (2024). ANALISIS PERENCANAAN SISTEM PEMBANGKIT LISTRIK HYBRIDE (PLTS DAN DIESEL) PADA KAPAL TANKER. *Power Elektronik: Jurnal Orang Elektro*, *13*(1), 58-63.

[2] Anisah, S., Fitri, R., Taro, Z., & Wijaya, R. F. (2022). Comparison of Lighting Efficiency (Led-CFL) based on Environmentally Friendly Technology. Journal of Applied Engineering and Technological Science (JAETS), 4(1), 568-577

[3] Hutabarat, M. A., Aryza, S., & Lesmana, D. (2023). ENHANCES PERFORMANCE OF REAL-TIME KWH METER BASED ON IOT AND ESP-32 MICROCONTROLLE. *Jurnal Scientia*, *12*(04), 347-355.

[4] PLN ISSN : 0852 –8179 No. 02401.120722. Statistik PLN 2011. Jakarta : Sekretariat Perusahaan PT. PLN (Persero)

[5] Prabowo, Aditya Teguh. 2014. Analisis Keandalan Sistem Distribusi 20 KV pada Penyulangan Pekalongan 8 dan 11. Tugas Akhir. Teknik Elektro, Universitas Diponegoro. Semarang

[6] Putra, Dorry Aznur. 2014. Evaluasi Keandalan Sistem Distribusi 20 KV BerdasarkanSAIDI dan SAIFI pada PT PLN Ranting Balai Salasa. Tugas Akhir. Teknik Elektro Institut Teknologi Padang. Padang[

[7] Rahmaniar, R., Syahputra, M. R., Lesmana, D., & Junaidi, A. (2022). Sosialisasi Pemahaman Bahaya Tegangan Sentuh Dan Hubung Singkat Sistem Kelistrikan Bagi Masyarakat Desa Kota Pari. *RESWARA: Jurnal Pengabdian Kepada Masyarakat*, *3*(2), 357-362.

[8] Standar PLN (SPLN) No. 59. 1985. Keandalan Pada Sistem Distribusi 20kV. Jakarta : Departemen Pertambangan dan Energi.

[9] Stevenson, William D. Jr. 1984. Analisis Sistem Tenaga Listrik. Jakarta : Eralangga.

[10] Vendra, Yan Ronal. 2011. Indeks Keandalan Sistem Jaringan Distribusi 20 KV di PT. PLN (persero) Wilayah Sumbar Cabang Padang Ranting Sungai Penuh. Tugas Akhir. Teknik Elektro InstitutTeknologi Padang. Padang