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An analysis of protection system reliability in the distribution network at PT PLN Rayon West Binjai

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ABSTRACT
Continuity in the distribution of electrical energy is the main aspect in supporting all economic, social and development activities. The reliability of the distribution system has an important role in distributing electricity to customers. Disturbances that occur in the distribution system result in outages for customers. This paper describes system reliability which is influenced by system configuration, installed safety devices and the protection system. The reliability index is a benchmark indicator for viewing or describing the reliability of a distribution system expressed in terms of probability. In writing this final assignment, an analysis was carried out on the reliability of the protection system on the distribution network at PT PLN Rayon Binjai Barat by looking for the value or number of distribution system failure rates, the SAIDI Index (System Average Interruption Frequency Index) and the SAIFI index (System Average Interruption Frequency Index) as an indicator of the distribution system reliability index in obtaining the index value, the calculation is carried out with a customer orientation. In determining whether the distribution system is reliable or unreliable, PT PLN Rayon Binjai Barat has set a cumulative target index of 1031.778 for SAIDI and 10.0023 for SAIFI. The distribution system can be said to be reliable if the realized SAIDI and SAIFI values are below the predetermined targets

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INTRODUCTION

Reliability of electrical energy is defined as the opportunity for a device to operate according to its function within a certain period of time and in a certain operation, so that it can meet customers' electricity needs. The reliability of power availability in an energy generator can be determined based on reliability indices, namely: LOLP (Loss of Load Probability) and UE (unserved Energy). The research was carried out by designing 2 generator system configuration models based on peak load values, then taking failure rate and repair rate data from each generator system component which was then used to calculate the FOR (Forced Outage Rate) value that had been obtained to be used as a formula for calculate the reliability value.

The reliability of a distribution network can be determined by a reliability index, which is a quantity for comparing the appearance of a distribution substation system. The

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reliability index is basically a number or parameter that shows the level of service and the level of reliability from the electricity supply to consumers. Reliability indices that are often used in a distribution system are SAIFI (System Average Interruption Frequency Index), SAIDI (System Average Interruption Duration Index) and CAIDI (Customer Average Interruption Duration Index).

SAIFI (System Average Interruption Frequency Index) is defined as the average number of system interruptions that occur per customer served by the system per unit time. SAIDI (System Average Interruption Duration Index) is defined as the average value of the length of system interruption that occurs per customer served by the system per unit time. Meanwhile CAIDI (Customer Average Interruption Duration Index) is a comparison between SAIDI and SAIFI. So if the SAIFI index shows the number or frequency of disturbances, then the SAIDI index shows the duration of disturbances.

Literature Review

Electric Power System

Electrical power produced at power plants must undergo several stages of distribution before the power is used by consumers. Where the generation and distribution of power from a central generator allows power to be generated at one location for use at any time at another distant location. Due to various technical problems, power is only generated in certain places, while electricity consumers are spread across various places. Transmission of electric power from the place where it is generated to the customer requires various technical measures. Transmission of electrical power in very large quantities over very long distances is most efficient using high voltage. High voltage is used in transmission lines to reduce power losses in transmission lines.

Figure 1. Electric Power Systems

Basically, the electric power system is known as two parts, namely:

a. Primary Network System

The Primary Network System can be called a medium voltage network (JTM). In the distribution of electric power to electric power users in an area, the use of a medium power system as the main network is the main effort to avoid distribution losses

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(looses) with quality voltage requirements that must be met by PT PLN Persero as the main business authority holder as regulated in the Electricity Law No. 30 of 2009.

b. Secondary Network System
The secondary network system can be called the low voltage network (JTR). The low voltage distribution network is the downstream part of an electric power system. Through this distribution network, electric power is distributed to consumers or electricity customers. The low voltage network functions to distribute electrical voltage from distribution substations to low voltage consumers. The low voltage used by PT. PLN (Persero) is 127/220 V and 220/380 V.

Electric Power Protection System

Definition of Electric Power Transmission Protection: This is protection installed on electrical equipment during the transmission of electric power from the power plant to the Substation Distribution channel so that it can be distributed safely to consumers who use electricity. Electric power transmission protection is applied to electric power transmission so that if equipment related to electric power transmission is disturbed, damage does not occur. This also includes when maintenance occurs while it is on. If the protection works well, workers can carry out maintenance on electric power transmission under voltage conditions. If a disturbance occurs during maintenance, the installed safety precautions must work to protect the system and the people carrying out the maintenance. These abnormal conditions can include, among others

a. Short circuit
b. Overvoltage
c. Overload
d. Low system frequency
e. Asynchronous
f. And others

Protection functions as follows:

1. To avoid or reduce damage to equipment due to interference (abnormal conditions of system operation). The faster the reaction of the protection device used, the less impact the interference will have on the possibility of equipment damage.
2. To quickly localize the size of the disturbed area to be as small as possible.
3. To be able to provide electricity services with high reliability for consumption and also good quality electricity.
4. To protect humans from the dangers posed by electricity.

Protection Quality Requirements

There are several requirements that really need to be considered in planning an effective protection system, namely:

1. Selectivity and discrimination
The effectiveness of a protection system can be seen from the system's ability to isolate only parts that experience interference.

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2. Stability
   Properties that remain inoperative if disturbances occur outside the protective zone (external disturbances).
3. Speed of operation
   This property is more obvious, the longer the fault current continues to flow, the greater the damage to the equipment. The most important thing is the need to open the disturbed parts before the generators connected synchronously lose synchronization with the rest of the system. Typical fault clearance time in high voltage systems is 140 ms. Where in the future this time will be shortened to 80 ms so that it requires a relay with a very high speed (very high speed relaying).
4. Sensitivity (sensitivity)
   Namely the amount of interference current for the device to work. This price can be expressed as the amount of current in the actual network (primary current) or as a percentage of the secondary current (current transformer).
5. Economic considerations
   In the system, the economic aspect almost overcomes the technical aspect, because there are so many feeders, transformers and so on, as long as the basic safety requirements are met. In transmission systems, it is precisely the technical aspects that are important. Protection is relatively expensive, but so is the system or equipment being protected and guaranteeing the continuity of system equipment is vital. Usually two separate protection systems are used, namely primary protection or main protection and main protection (back up).
6. Reliability (reliability)
   This characteristic is clear, the main cause of circuit "outage" is protection not working properly (mal operation).
7. Supporting protection
   Supporting protection (back up) is a completely separate structure and works to remove the disturbed part.

Figure 2. Protection system diagram

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Electric Power distribution system

The distribution system is part of the electric power system. This distribution system is useful for distributing electric power from bulk power sources to consumers. So the main function of the distribution system is to distribute and distribute electric power from distribution substations to electricity customers with adequate service quality. One element of service quality is service continuity which depends on the topology and construction of the network and medium voltage equipment. The main problem in carrying out the distribution network function is overcoming disturbances quickly considering that most disturbances in the electric power system are in the distribution network. Especially medium voltage networks.

In an electric power distribution system, the level of reliability is very important in determining the performance of the system. This reliability can be seen from the extent to which the supply of electric power is continuous to consumers. The most basic problem in the electric power distribution system lies in the quality, continuity and availability of electric power services to customers.

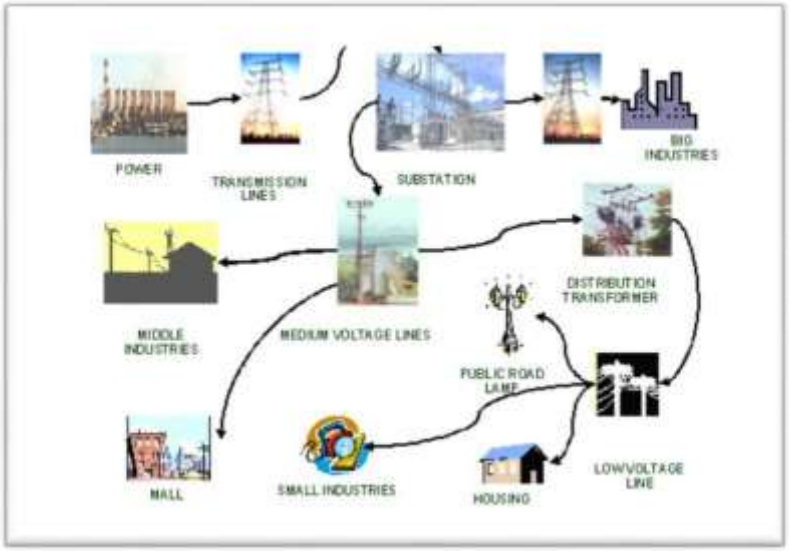

Figure 3 Electric Power Distribution System

SAIDI (System Average Interruption Duration Index)

SAIDI (System Average Interruption Duration Index) is the average value of the duration of failure for each customer for one year. This index is determined by dividing the number and duration of continuous failures for all customers during a specified time period by the number of customers served during that year.

SAIFI (System Average Interruption Frequency Index)

SAIFI (System Average Interruption Frequency Index) is the average number of failures that occur per customer served per unit of time (generally a year). This index is determined by dividing the number of all failures in a year by the number of customers served by the system.

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CAIDI (Customer Average Interruption Duration Index)

CAIDI (Customer Average Interruption Duration Index) is an index of the average duration of consumer interruptions each year, informing about the average time for disruptions to return to normal for each customer in years. Mathematically, CAIDI can be calculated with the following equation

METHODS

The type of research carried out is a case study, and according to the form of research that will be carried out the aim is to try to assess the technical data that occurs in the Protection System on the Distribution network. The data obtained will then be processed by carrying out mathematical calculations to obtain reliability index numbers and compare them with the numbers targeted by PT PLN (Persero). To fulfill the data required for calculations, the location of this research will be carried out at PT PLN RAYON BINJAI BARAT. In October I carried out field observations. And in November I filled in the data according to the research instrument. The data collection techniques used in this research are as follows:

a. Field research, where the author made direct observations at PT. PLN RAYON BINJAI BARAT to obtain data and information related to research problems
b. Library research, where the author obtains information to solve the problem by using references appropriate to the problem raised or literature study.
c. Discussions / interviews, carried out to obtain data through interviews with PT staff. PLN RAYON WEST BINJAI

Where the data needed in this case study analysis is in the form of customer-oriented technical data obtained from data consisting of:

a. Protection System Intrusion Data
b. Protection Data used

RESULT AND DISCUSSION

Analysis of Disturbances in Incoming and Feeding

In this research, reliability analysis uses the minimum cut set method, namely by looking for the possibility of failure of the equipment or combination of equipment in the primary distribution network being analyzed which is explained in chapter two. There are three things that can be obtained from calculating reliability using Edsa Micro corporation software, namely: There are 4 types of disturbances that commonly occur in incoming and 20 kV feeders, namely:

1. OCR (Over Current Relay) / Overcurrent interference is a disturbance that occurs due to a load that is excessive than its normal nominal value.
2. Moment OC (Moment Over Current) disturbances / Large overcurrents are disturbances that occur due to short circuits between phases or 3 phases in the feeder.
3. GFR (Ground Fault Relay) Faults / Ground faults are disturbances that occur due to the connection of the phase wire to the ground through other objects (e.g. trees, animals).

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4. Moment GFR (Moment Ground Fault Relay) disturbance / Large ground fault is a disturbance that occurs due to a short circuit in one phase to the ground.

Table 1. Results of Trip Incoming feeder disturbance index analysis results

TRANSFORMER	TYPE OF DISORDER					TRIP INCOMING
	OC R	MOC	GF R	MGF	TOTAL	
BN 4	3	6	2	9	20	21
BN 5	1	1	1	0	3	11
BG 3	1	1	7	2	11	13

Analysis of the Saidi and Saifi Index

From the results of the calculations that have been carried out, the system reliability index values (SAIDI and SAIFI) of PT can be summarized. PLN (Persero) Lubuk Alung Rayon from January to December 2015 in the following table:

Table 2. Saidi and Saifi Reliability Results

Month	SAIDI		SAIFI	
	Data from PLN	The calculation results	Data from PLN	The calculation results
Jan	1,2000	1.1900	0.0300	0.03015
Feb	32,460	32,400	0.3760	0.3780
Mar	32,520	32,550	0.3784	0.3790
Apr	58.7040	58.7050	0.9024	0.9022
May	70.4160	70.4200	1.2747	1.2746
Jun	147.6600	147.6650	2.4832	2.4830
Jul	156.7680	156.7681	2.6720	2,6700
Aug	166.8890	166.8893	3.2048	3.2047
Sept	181.7220	181.7200	3.8140	3.8149
Oct	183.4380	183.4385	3.8668	3.8668

Table 3. Calculation results of feeder load data on September 24 2023

TIME	FEEDER LOAD					
	BG 1	BG 2	BG3	BG 4		
	164	133	167	84		
	INC TD1 : 548 / 20.7					
	BN 1	BN2	BN 3	BN 4	BN 5	BN 6
	43	81	110	75	180	96

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14.00 WIB	INC TD2 : 570 / 20.7						
	MG 2	MG 3	MG 4	MG 5	MG 6	MG 7	MG 8
	100	104	101	92	158	73	59
	INC TD3 : 506 / 20.8						
	BJ 1	BJ 2	BJ 3	BJ 4	BJ 5	BJ 6	
	69	46	60	103	92	52	
	INC TD4 : 427 / 20.7						

Table 4. Binjai GI Feeder Load Index Value at 19.00 WIB

TIME	FEEDER LOAD						
19.00 WIB	BG 1	BG 2	BG3	BG 4			
	171	178	224	118			
	INC TD1 : 691 / 20.7						
	BN 1	BN2	BN 3	BN 4	BN 5	BN 6	
	63	127	150	85	199	123	
	INC TD2 : 738 / 20.7						
	MG 2	MG 3	MG 4	MG 5	MG 6	MG 7	MG 8
	139	131	52	102	139	114	36
	INC TD3 : 573 / 20.7						
	BJ 1	BJ 2	BJ 3	BJ 4	BJ 5	BJ 6	
	102	88	72	76	122	75	
	INC TD4 : 546 / 20.7						

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CONCLUSION

As for the research results, it can be concluded as follows: The reliability of a distribution network can be determined by a reliability index, which is a quantity for comparing the appearance of a distribution substation system. The reliability index is basically a number or parameter that shows the level of service and the level of reliability from the electricity supply to consumers. Reliability indices that are often used in a distribution system are SAIFI (System Average Interruption Frequency Index), SAIDI (System Average Interruption Duration Index) and CAIDI (Customer Average Interruption Duration Index). Electrical power produced at power plants must undergo several stages of distribution before the power is used by consumers. The generation and distribution of power from a central generator allows power to be generated at one location for use at any time at another distant location. Due to various technical problems, power is only generated in certain places, while electricity consumers are spread across various places. Transmission of electric power from the place where it is generated to the customer requires various technical measures. Transmission of very large amounts of electrical power over very long distances is most efficient using high voltage. High voltage is used in transmission lines to reduce power losses in transmission lines. Electric Power Transmission Protection Is protection installed on electrical equipment in the transmission of electric power from the power plant (Power Plant) to the electricity distribution channel (Substation Distribution) so that it can be distributed safely to consumers who use electricity. Electric power transmission protection is applied to electric power transmission so that if equipment related to electric power transmission is disturbed, damage does not occur. This also includes when maintenance occurs while it is on. If the protection works well, workers can carry out maintenance on electric power transmission under voltage conditions. The distribution system is part of the electric power system. This distribution system is useful for distributing electric power from bulk power sources to consumers. So the main function of the distribution system is to distribute and distribute electric power from distribution substations to electricity customers with adequate service quality. One element of service quality is service continuity which depends on the topology and construction of the network and medium voltage equipment. The main problem in carrying out the distribution network function is overcome disturbances quickly considering that the most disturbances in the electric power system are in the distribution network. Especially medium voltage networks. Distribution system reliability is the ability of the distribution system to distribute electric power properly and stably to customers, especially large power customers who require absolute continuity of electric power distribution. If the electricity is cut off or not distributed, it will disrupt the production process of these large customers. The structure of the medium voltage network plays an important role in determining the reliability of electric power distribution because a good network makes it possible to maneuver voltages by allocating places for disturbances and loads can be moved through other networks.

REFERENCES

1. Dr. Susilawati, M., SI. 2019. Basics of Hydroponic Growing. Unsri Palembang Campus: UPT. Sriwijaya University Publishing and Printing.
2. Karsono, Sudibiyo et al. 2002. Household Scale Hydroponics. Parung: PT Agro Media Pustaka.
3. Linga Pine, Self-Help Spreader. 2005. Hydroponics, Farming Without Soil. Wisma Hijau Jl. Raya Bogor km.30 bloomsari, cimanggis, depok 16952.
4. Rm. Francis D. Yury et al. 1992. Hydroponic or Soilless Plant Growing Techniques and Bonsai. Masin, PO. BOX 21 Pekalongan.
5. S. Aryza, , Lubis, Z., Indrawan, MI, Efendi, S., & Sihombing, P. (2021). Analyzing Data-Based Modeling of New Design Piezoelectric Power Generation Systems.*Budapest International Critic and Research Institute-Journal (BIRCI-Journal)*,*4*(3), 5537-5547.
6. S. Aryza, , Lubis, Z., & Indrawan, MI (2021). NEW ANALYSIS IN DETECTING ONE PHASE NETWORK SHORT CONNECT DISTURBANCE.*Servant Science Journal*,*13*(2), 175-186.
7. S. Anisah, ., Fitri, R., Taro, Z., & Wijaya, RF (2022). Comparison of Lighting Efficiency (Led-CFL) Based on Environmentally Friendly Technology.*Journal of Applied Engineering and Technology Science (JAETS)*,*4*(1), 568-577.
8. Nugraha, Tutun and Didik Sunardi. 2012. Solar energy. Jakarta: PT. Rainbow archipelago knowledge.
9. Kadir, Abdul. 2017. From Zero to E Pro Arduino. Yogyakarta: Andi Publishers.
10. Dede Erge. 2020. Getting to know PVC Power Pipes.PT. Cross Synergy Mandiri.