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Diagnosis of Electricity Distribution Network Disturbances Using Fault Tree Analysis

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Article Info	ABSTRACT
Keywords: Electrical Distribution Disturbances, Fault Tree Analysis, PLN ULP Balige, System Reliability, and Root Causes	Disruptions in the electricity distribution network are one of the main problems that can reduce the reliability of electricity supply to customers. PT PLN ULP Balige as a customer service unit has the responsibility to ensure the continuity and quality of electricity distribution services in its operational area. This study aims to analyze the main causes of electricity distribution network disruptions using the Fault Tree Analysis (FTA) method. This method is used to identify the root causes of disruptions with a deductive approach arranged in the form of a fault tree. The data used in this study were obtained from disruption reports over the past year that occurred in the medium and low voltage distribution network at PT PLN ULP Balige. The results of the analysis indicate that several dominant factors causing disruptions include equipment component damage (such as transformers and cables), weather disturbances, and other external factors. With FTA modeling, logical relationships between causes can be systematically mapped, thereby facilitating the evaluation process and technical decision-making. This study is expected to be a basis for PT PLN ULP Balige in formulating prevention strategies and improving the reliability of the electricity distribution system through a more structured analytical approach.
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INTRODUCTION

The electricity distribution system is a vital component in the supply of electricity from generating plants to end consumers. The reliability of the distribution system significantly impacts the continuity of a stable and high-quality electricity supply. However, in practice, disruptions to the distribution network still frequently occur, both technical in nature, such as equipment failures and extreme weather events, and non-technical ones, such as operational errors. These disruptions not only disrupt public and industrial activities but also cause economic losses and undermine customer trust in electricity providers.

PT PLN ULP Balige, as the customer service unit responsible for electricity distribution in its area, faces challenges in quickly and accurately handling distribution network disruptions. One of the main obstacles is the lack of a comprehensive and systematic root cause identification system. Therefore, an analytical approach capable of structurally analyzing the causes of disruptions is needed.

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At the Balige UPL, disruptions frequently occur in the electrical distribution network. These disruptions are defined as energy losses, both technical and non-technical. This is evident in the significant difference between the electrical energy sent from the substation and that received by customers.

One method that can be used to analyze the causes of system failures is Fault Tree Analysis (FTA). FTA is a deductive method that constructs a logical tree from a major failure event to its root causes, both technical and non-technical. By using FTA, companies can gain a deeper understanding of the source of the disruption, the cause-and-effect relationships between system components, and potential vulnerable points in the distribution network.

This study aims to diagnose the root causes of disruptions in the electricity distribution network at PT PLN ULP Balige using the Fault Tree Analysis method. The results are expected to provide strategic recommendations for improving distribution system reliability and strengthening the system for preventing and handling disruptions in the future.

Several factors suspected of causing distribution network disruptions include tree strikes, and disturbances often caused by lightning. Electrical energy sent from substations cannot reach customers due to network damage during the distribution process, causing the electrical power to be converted into heat energy. In addition to the loss of electrical energy, damage to the distribution network can also result in power outages. When power outages occur, potential revenue from customer electricity consumption is reduced.

Literature Review

Electric Power Distribution System.

The electrical distribution system is the final component of the electrical power system, delivering electrical energy from substations to consumers. This system consists of medium- and low-voltage networks connected by various equipment such as distribution transformers, circuit breakers, cables, and household connections. The reliability of the distribution system is crucial because it directly impacts the continuity of service to consumers.

Electric power distribution is the final stage of the electric power system, delivering electrical energy from the substation to the end consumer. This distribution system consists of primary and secondary distribution networks that generally operate at medium voltage (20 kV) and low voltage (220/380 V) [Nasution, 2015].

Disruptions to the distribution network can cause outages, equipment damage, and reduced service quality to customers. Therefore, proper monitoring and analysis are necessary to identify the causes of disruptions and improve distribution system reliability.

Distribution system disruptions can be caused by various factors, both technical and non-technical. Technical disruptions include equipment failure, short circuits, lightning strikes, and overloading. Non-technical disruptions can include human error, vandalism, or other external disturbances such as fallen trees. Identifying and analyzing the root causes of disruptions is crucial to improving system reliability.

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Electricity Delivery Process

Due to various technical problems, electric power is only generated in certain places, while electricity users or electricity customers are spread across various places, so the delivery of electric power from the place of generation to the customer's location requires various technical handling. Electric power is generated in power centers such as hydroelectric power plants, then distributed through transmission lines after first increasing the voltage by a voltage-boosting transformer at the power center.

High-voltage transmission lines in Indonesia have a voltage of 150 kV, known as high-voltage overhead lines (SUTT), and a voltage of 500 kV, known as extra-high-voltage overhead lines (SUTET). Transmission lines can be either overhead lines or underground cables. Because overhead lines are much cheaper than underground cables, most transmission lines are overhead lines. The disadvantage of overhead transmission lines is the risk of natural disturbances such as heavy rain, lightning, and others.

After the electricity is distributed through the transmission lines, it arrives at the main substation (GI) where its voltage is reduced through a step-down transformer to medium voltage, also known as primary distribution voltage. The primary distribution voltage currently used is 20 kV. The network after leaving the GI is called the distribution network, while the network between the power plant and the GI is called the transmission network.

After the electric power is distributed through the primary distribution network, the voltage of the electric power is then reduced in the distribution substations to a low voltage of 380/220 Volts, then distributed through the low voltage network to be distributed to customer homes (consumers) through household connections. In practice, due to the vastness of the distribution network, many distribution transformers are required. Distribution substations are often simplified into pole transformers.

Distribution System Delivery

The voltage selection depends on the size of the supply area and the loading (voltage loss, conductor cross-section) as well as the voltage of the adjacent network, in low-voltage networks also on the permitted contact. The materials used for conductors are generally copper and aluminum, steel is only used for aluminum wire bones, so the type of conductor used is copper, aluminum or SCAC (steel cored aluminum conductor).

The selection of the conductor cross-section is influenced by considerations, including the permissible cable load depending on the insulation's ability to withstand temperature increases, so at the conductor temperature and the surrounding air temperature, the permissible air duct load is limited by the reduction in mechanical strength when the temperature increases, the permissible voltage variation is ± 5%.

Large conductor cross-sections reduce losses but increase the cost. The optimum ratio between losses and wire cost provides an economical conductor cross-section. Conductors commonly used for distribution conductors include:

The materials used in this type of conductor are copper, aluminum, steel, a combination of copper and steel, or a combination of aluminum and steel. Copper is the most widely used material for conductors because it is very good at conducting electric current, besides being quite cheap, it is also easy to connect. Aluminum is widely used

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especially in high voltage networks, compared to copper wire with the same physical carving, aluminum wire has 60% conductivity, 45% tensile strength and 33% weight. To obtain the same conductivity, the aluminum cross-section must be 1.66 times larger than the copper wire cross-section. Aluminum wire with this size has 75% tensile strength and 55% weight of copper wire. To increase its tensile strength, aluminum wire is usually reinforced at the core, this type of wire is called aluminum conductor steel reinforced wire or ACSR (aluminum conductor steel reinforced). The tensile strength of aluminum with the same current carrying capacity as copper wire is almost the same as the copper.

Cables can be used for overhead lines and underground lines, cable installation can be done directly or inserted into pipes. Cables used for underground line systems must be resistant to unshielded moisture with a working voltage of 600 V widely used for secondary distribution networks, cables can consist of conductors and so on depending on the number of conductors that are isolated from each other in the sheath. Cable insulation can be made and various materials, paper is widely used for cables with a voltage of 600V–35 KV, Polyethylene for 600 V–138 KV, varnished cloth for 600 V– 8 KV, Paper is used for higher voltages because of its low dielectric loss characteristics and low price.

Almost every country has its own conductor size standards that are different from each other, but among the many conductor size standards, the most widely used is AWG (American Wire Gage) and the size is based on the cross-section in mm2. The AWG standard used in the United States is based on the code number 0000 for a diameter of 0.46 mci and number 36 for a diameter of 0.005 inches, so the comparison between a diameter and an adjacent diameter with a difference of one code number is 1.1229322. For the conductor cross-section size in the United States, the "circular mil" (cm) size is used where 1 cm = 5.067 x 10-4 mm while the cross-section size with mm usually has a standard of 1.5; 2; 4; 6; 10; 16; 25; 35; 50 and so on.

Network disruption

The distribution network is the part of the electric power system closest to the customer/consumer. In terms of physical volume, the distribution network is generally longer than the transmission network and the number of disturbances (a certain number of times per 100 km per year) is also higher compared to the number of disturbances on transmission lines. The distribution network, as is known, consists of a medium-voltage distribution network (JTM) and a low-voltage distribution network (JTR). The medium-voltage distribution network has a voltage between 3 kV and 20 kV. Currently, PLN is only developing a 20 kV medium-voltage distribution network. The medium-voltage distribution network mostly consists of medium-voltage overhead lines and underground cables. Currently, disturbances on medium-voltage overhead lines can reach 100 times per 100 km per year. Most disturbances on medium-voltage overhead lines are not caused by lightning but by contact with trees, especially since many medium-voltage overhead lines are located in cities with tall buildings and trees taller than medium-voltage overhead line poles. This causes medium-voltage overhead lines in cities to be largely protected from lightning strikes but often disrupted by contact with trees. In areas outside the city, lightning strikes are also

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common, in addition to tree contact. Both lightning and tree contact are temporary; therefore, using automatic reclosers will reduce supply interruption time.

Types of disturbances in the distribution system include:

1. Short circuit faults can occur between phases (3 phases or 2 phases) or 1 phase to ground and can be temporary or permanent in nature.
2. Permanent faults: Short circuits in cables, transformer windings, generators (insulation breaks).
3. Temporary disturbances: Flash Over due to lightning strikes, Flash Over with trees, blown by wind.

Overload faults occur when the distribution system is loaded beyond its installed capacity. These faults are not actually faults, but if allowed to persist, they can damage equipment.

Overvoltage disturbances are among the most common disturbances on distribution lines. Based on their cause, these overvoltage disturbances can be grouped into two categories:

1. Power Frequency Overvoltage.
   In distribution systems this is usually caused by an error in the AVR or tap regulator on the distribution transformer.
2. Surge Overvoltage

This disturbance is usually caused by a surge or lightning surge. Of these three types of faults, the short circuit fault is the most common and has the greatest impact on the distribution system. Therefore, the term "distribution system fault" generally refers to short circuit faults, and the protective equipment installed tends to mitigate these short circuit faults.

FTA (fault tree analysis) concept

One analysis used to identify the cause of a failure is Fault Tree Analysis (FTA). This analytical approach prioritizes a "top-down" approach, starting at the overall system level and then working down to the specific component level. Because FTA falls under the category of systems analysis, it is important to understand it within the framework of systems analysis itself. A system is defined as a collection of entities that interact and work together to achieve a specific function. Analytical methods are used to analyze system failures. System analysis can be simple or complex, but generally involves two categories of questions:

1. Questions Related to Cause.
   A cause is a condition that will lead to the occurrence of another event in the system. A cause is the initial event that must be analyzed thoroughly to prevent subsequent, undesirable events. An example of a question related to causes is what causes trains to collide.
2. Questions Related to Consequences.
   An effect is a condition that will arise within a system due to a cause. Analysis is then conducted to determine what consequences will arise if the initial condition (cause)

occurs. An example of a question related to causes is what would happen if a driver was drunk while driving.

FTA is a deductive analysis method for identifying system failures by depicting alternative scenarios in a structured block diagram. Deductive analysis can be performed on all complex systems.

The starting point of FTA analysis is identifying the failure mode at the top level of a system. A fault tree illustrates the state of system components (basic events) and the relationship between basic events and top events. The elements representing these relationships are called logic gates. From this fault tree diagram, cut sets and minimal cut sets can be constructed. A cut set is a series of system components whose failure can result in system failure. Meanwhile, a minimal cut set is the minimal set that can cause system failure. FTA uses structured steps in analyzing a system. The FTA steps are:

1. Identifying the most important events/incidents in the system (top-level events) This first step in FTA is crucial because it will influence the results of the system analysis. This stage requires an understanding of the system and knowledge of the types of failures (undesired events) to identify the root cause of the system problem. Understanding the system is achieved by studying all information about the system and its scope.
2. Fault tree.
   Once the most important issues are identified, the next step is to construct a cause-and-effect fault tree. At this stage, a cause-and-effect diagram (Ishikawa diagram) can be used to analyze errors and explore the presence of hidden defects. The fault tree is constructed using Boolean symbols. Standardizing these symbols is necessary for communication and consistency within the fault tree.
3. Analyzing fault trees.
   Fault tree analysis is necessary to obtain clear information about a system and what improvements need to be made to the system. The stages of fault tree analysis can be divided into three, namely:
   a) Simplifying the fault tree.
      The first step in fault tree analysis is to simplify the fault tree by eliminating branches with similar characteristics. The purpose of this simplification is to facilitate further system analysis.
   b) Determining the probability of the occurrence of the most important event or incident in the system (top-level event). After the fault tree is simplified, the next step is to determine the probability of the most important event in the system. In this step, the probability of all inputs and logical relationships is used as a consideration in determining the probability.
   c) Reviewing the analysis results.

Review of the analysis results is carried out to determine possible improvements that can be made to the system.

The output obtained after conducting an FTA is the probability of the most important events occurring in the system and the root causes. These root causes are then used to prioritize appropriate system repairs. Fault Tree Analysis (FTA) is a systematic analysis method used to identify and describe the potential causes of a failure or disruption in a system. FTA works deductively, starting with the top event and working down to the underlying causes (basic events).

This process is structured in the form of a logic tree diagram using AND and OR gates. Some of the advantages of FTA are:

1. Can show logical relationships between causes of failure
2. Allows quantitative analysis of failure probability
3. Widely used in high-risk engineering systems such as energy, nuclear, and aviation.

FTA has been widely used in power system reliability analysis, particularly in detecting failure-prone points in distribution networks. By combining historical fault data and distribution system structure, FTA can be used to formulate more effective maintenance and fault prevention strategies.

An enumeration graph illustrates how damage can occur, using Boolean symbols. This enumeration graph is a fault tree that will be analyzed based on the probability of each cause of the error. An enumeration graph is called a fault tree because its structure resembles a tree, converging on a single event and branching down into other event branches. The symbols in an FTA can be divided into two categories:

METHODOLOGY

This research was conducted in the Customer Service Unit area to determine the condition and situation of the electricity distribution network system in the Balige Customer Service Unit. There are 2 types of data collected, namely primary data and secondary data. Primary data was conducted through interviews and direct observation from the Company, Secondary data was taken directly from PT. PLN Balige Customer Service Unit data. The secondary data include: Data on network disruptions in electricity distribution from January 2025 to June 2025.

The data collection methods used in this study are as follows:

1. Literature Methodis a data collection technique that involves examining various written sources relevant to the topic being researched. These sources can include books, scientific journals, academic articles, and even information from websites that support the discussion of the problem.
2. Observation Methodis a data collection technique carried out by directly observing the disturbance conditions in the electricity distribution network to obtain accurate information regarding the problem.
3. Discussion Methodis a data collection approach carried out through direct interviews with experts in the field of electricity, both final project supervisors in the field and sources at the research location.

The data processing process carried out in this study is by using FTA (Fault Tree Analysis). The FTA stage aims to identify the basic events or combinations of events that cause damage to the distribution network. In this phase, a more in-depth analysis will be conducted to find the most significant root causes of problems with disruptions in the

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electricity distribution network by utilizing FTA. The FTA method applies deductive analysis to explore the relationship between the causes and effects of an event in the system, and systematically considers all possible events (Events) and errors that can result in damage (Undesired Events). The stages of FTA are as follows:

1. Identification of Undesired Events (Errors) in the System
   This identification process aims to understand the problems that arise in the electrical distribution system, which can then be transformed into top-level events. The input for this stage is undesirable events in the electrical distribution system. From these events, one Undesired Event will be selected to become a Top-Level Event that can be clearly defined, observed, and measured.
2. Fault Tree Creation
   a. A fault tree diagram is constructed using Boolean symbols, including event symbols and symbols indicating the relationships between events that can cause a disruption. This diagram depicts the sequence of causes and effects of an event that results in a disruption. The steps in creating a fault tree diagram include:
   b. Identifying the location of disturbances in the electrical distribution network system.
   c. Drawing fault tree based on identification of electrical distribution network system.
3. Determining the Minimum Cut Set (Root Problem)
   The process of determining the minimum cut set is carried out after identifying the causes of damage at various levels of occurrence. From these levels, the most basic level can be determined, which will be the output of the minimum cut set, in the form of an event or combination of events that constitute the root cause. This is done by describing all the events that occurred and simplifying the repetition of the same basic event into a single basic event.

The initial step in this research was to conduct a literature review by gathering information from various relevant sources. Next, an analysis of the factors causing network disruptions in the electricity distribution system was conducted, referring to the problem formulation in Chapter I. The data used were derived from experimental results and analyzed using the Fault Tree Analysis (FTA) method.

The data obtained was then compiled and attached according to the findings in the following chapters. The data presentation is based on observations of network disruptions in electricity distribution. The findings of this study were then analyzed to draw conclusions, which are presented in the concluding chapter of the study.

RESULTS AND ANALYSIS

Data Processing Results.

This stage is the process of collecting and processing data. Data is obtained from PLN's monthly reports, while data processing is carried out using a Fault Tree Analysis (FTA) approach. Microsoft Excel software is used to assist with data processing and analysis.

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Table 1. Permanent Network Disturbance Data on Electricity Distribution

Date	Location / Feeder	Types of Disorders	The main cause	Duration of Interruption (Minutes)	Handling Status
2025-01-05	Feeder A - North Area	Short Circuit	Damaged cable	45	Finished
2025-01-18	Feeder B - West Area	Ground Disturbance	Broken insulator	60	Finished
2025-02-02	Feeder C - East Area	Phase to Phase Relationship	Lightning	30	Finished
2025-02-21	Feeder A - North Area	Neutral Disturbance	Loose connector	50	Finished
2025-03-07	Feeder D - South Area	Voltage Disturbance	Distribution transformer damaged	120	Finished
2025-04-16	Feeder B - West Area	Short Circuit	Cable cut by heavy equipment	75	Finished
2025-04-30	E Feeder - Central Area	Overload	Overload	90	Finished
2025-05-12	Feeder C - East Area	Phase Interference	Burnt connector	60	Finished
2025-05-27	Feeder A - North Area	Ground Disturbance	Damp soil/poor insulation	40	Finished
2025-06-15	Feeder D - South Area	Neutral Disturbance	Loose cable connection	55	Finished

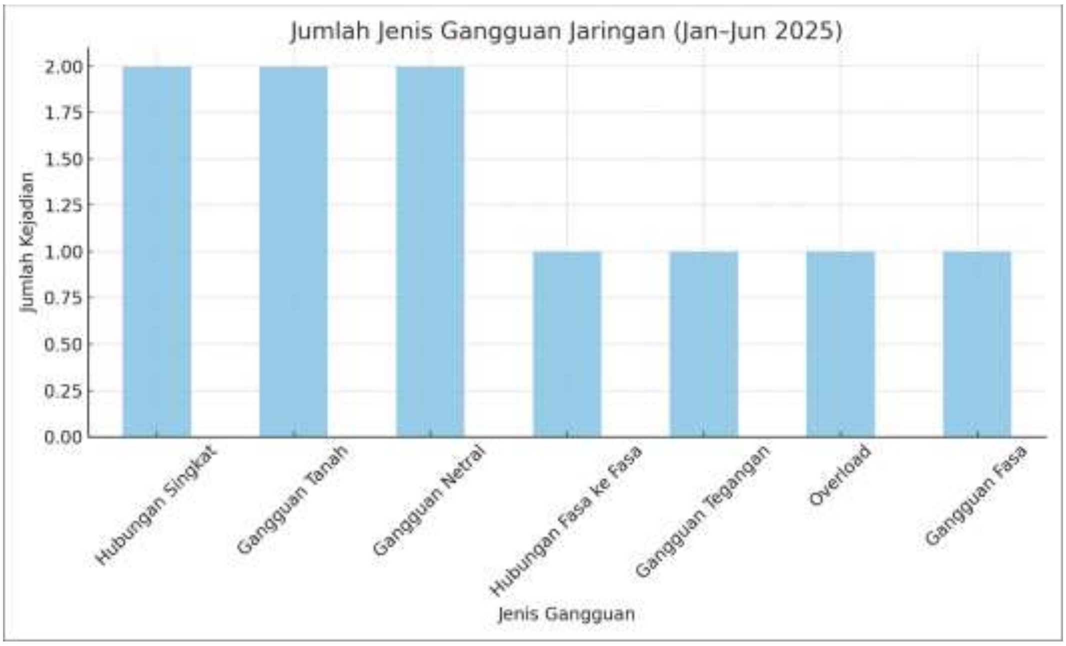

Figure 1. Temporary disturbance data (internal and external)

Table 2. Temporary network disruption data on electricity distribution

Date	Location / Feeder	Types of Disorders	Temporary Causes	Duration (Minutes)	Frequency of Interference	Handling Status
2025-01-04	Feeder A - North Area	Voltage Drop	Sudden increase in load	15	1x	Back to Normal
2025-01-17	Feeder C - East Area	Flicker Lights	Lightning around the network	10	2x	Stable
2025-02-03	Feeder B - West Area	Temporary Disruption	Animals (birds)	5	1x	Auto Recover
2025-02-19	Feeder D - South Area	Inrush Current	Large customer connection	20	1x	Monitoring
2025-03-11	Feeder A - North Area	Lightning Disturbance	Lightning without physical damage	8	3x	Safe
2025-03-25	E Feeder - Central Area	Transient	Switching recloser	6	1x	Stable
2025-04-08	Feeder C - East Area	Voltage Disturbance	Unstable grounding	12	2x	Checked
2025-04-21	Feeder B - West Area	Mild Short Circuit	Tree branch touches the cable	10	1x	Cleaned

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2025-05-09	Feeder D - South Area	Voltage Rise	Sudden power outage	7	1x	Normal
2025-06-18	E Feeder - Central Area	Temporary Disruption	Small animals touch the insulator	5	1x	Auto Recover

Distribution Network Disturbance Data

Based on distribution network disruption data collected from internal reports of PT PLN ULP Balige during the periodMay 2023 to April 2024,it is known that there is a total of536 incidents of disruption, which is divided into two main categories, namelypermanent impairmentAndtemporary disruption.Internal permanent disturbancedominated by damage toMedium Voltage Network (MVNet) componentssuch as distribution transformers and isolators, with a total92 disturbances.External permanent disturbancemostly caused bynatural disasterssuch as fallen trees and lightning strikes, as many as108 disturbances.Internal temporary disturbancereach137 incidents,generally caused by load surges and contact between conductors.External temporary disturbancebe the most dominant with a total199 disturbances,caused bykites, pennants, wild animals, and human interference.

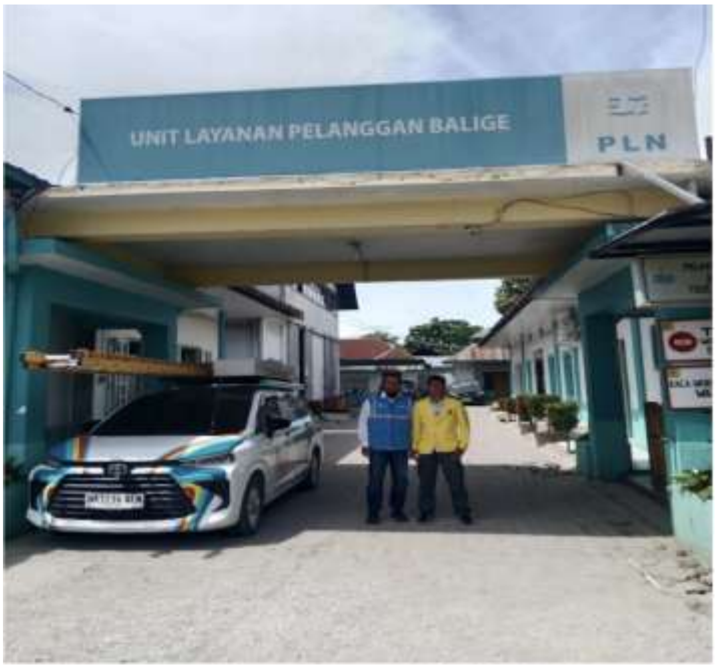

Figure 2. Location of the Research

Fault Tree Analysis (FTA)

The Fault Tree Analysis method is used to identify the main root causes of electrical distribution system disruptions. The process begins by determiningTop Event,namely "Disruption in the Electricity Distribution Network." This Top Event was then broken down into severalIntermediate EventsAndBasic Eventsthrough logic gatesANDAndOR,as follows:

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Fault Tree Structure:

a. Top Event: Disturbance in the Distribution Network
b. Intermediate Event 1: Interference from Internal Factors
    1. Basic Event: JTM Damage
    2. Basic Event: Isolator Failure
    3. Basic Event: Overload
c. Intermediate Event 2: Disturbance from External Factors
    1. Basic Event: Fallen tree
    2. Basic Event: Lightning strike
    3. Basic Event: Kite / foreign object
    4. Basic Event: Vandalism

dentify Root Causes

From the results of the FTA mapping, it was obtained thatthree main root causes of disordersbased on the highest frequency are:

1. Disturbance from kites and pennants(234 incidents, 43.7%)
2. Internal JTM component damage(92 incidents, 17.2%)
3. Disruption due to extreme weather (lightning & fallen trees)(108 incidents, 20.1%)

The analysis shows thatexternal disturbances are temporaryis the most dominant, and is mostly of acan be preventedwith a preventive approach, such as:

1. Routine cleaning of the tissue area from foreign objects
2. Public education about the dangers of kites near power lines
3. Improved lightning protection and grounding systems

While disturbances from internal factors indicate the need for:

1. Periodic maintenance of JTM components
2. Strengthening the distribution protection system
3. Evaluation of the service life of electrical equipment

Load Data

The network used in this power loss calculation is the medium voltage network of January – June 2025 BLG 01 feeder of PT. PLN (Persero) ULP BALIGE as an example of calculating power losses with data.obtained in the field, namely:

Table 3..Medium Voltage and Low Voltage Current Side Load Data BLG 01 PT. PLN (PERSERO) ULP BALIGE

Name Branch	WHEN LOCATION	TM FLOW (A)			TR current (V)			TR VOLTAGE (V)		
		IR	IS	HE	IR	IS	HE	virtual reality - N	VS-N	virtual reality - N
English: BL01	200	1.6	1.2	1.2	165	124	120	222	220	214
BL02	160	1.5	1.1	0.9	144	103	92	220	218	216

BL09	200	1.2	0.5	1	120	58	104	221	228	227
BL15	100	0.9	0.8	0.8	95	79	85	219	217	218
BL17	50	1.3	1.3	0.9	129	134	92	224	223	222
BL18	50	1	0.7	0.9	100	75	96	222	219	218
BL26	100	0.9	0.8	0.5	90	89	55	216	222	220
BL27	100	1.3	1.2	0.9	129	116	94	214	220	218
BL28	50	1.2	0.9	1.1	119	94	113	220	218	216
BL38	100	1.2	1.1	1.1	123	113	113	218	216	215
BL39	250	1.5	1.3	0.9	146	133	95	221	216	223
BL42	50	0.9	0.7	0.8	90	75	80	220	218	216
BL43	250	1.7	1.2	1.2	175	124	120	230	234	234
BL48	250	1.6	1.5	1.3	160	155	132	228	227	227
BL55	100	1.1	1	1.1	111	97	112	231	229	234
BL67	250	1.3	1.2	1.1	132	124	111	228	226	227
BL71	50	1.1	1	0.9	111	98	90	224	218	220
BL75	50	1.1	0.7	1.1	113	75	111	222	228	216
BL76	250	1.4	1	1	145	103	95	222	219	223
BL80	250	1.3	1	1.2	135	104	121	220	218	218
BL83	160	1.3	1.3	0.9	129	134	92	219	216	218
BL86	100	1	1.2	1	94	103	92	222	218	220
BL87	100	1.4	1.1	1	141	109	97	220	222	222
BL90	160	1.4	1.1	1	134	113	95	218	220	220
BL93	50	1.2	1	1.1	121	103	112	218	215	216
BL94	100	1.1	2	1.2	113	103	110	215	213	212

Low voltage side load data is obtained from the measurement results at each distribution substation and is measured for each phase, namely load current (ITR), load voltage (VTR), and sometimes load power (STR) or calculated. explained in Table 4.1 Calculation of Load Current (ITM'), Load Voltage (VTM'), Load Power (STM'), is carried out at each distribution substation. The conductor used in this power loss calculation is a conductor with a cross-sectional area of 240 mm² for overhead lines and there are no line cables. Conductor data is listed in the table

CONCLUSION

Based on the results of data analysis and the application of the Fault Tree Analysis (FTA) method to the electricity distribution network disruption at PT PLN ULP Balige, several things can be concluded as follows: Disruption of the electricity distribution networkat PT PLN ULP Balige during the observation period was dominated bytemporary disruption from external factors,with the highest number of incidents reaching234 disturbances,caused bykites, pennants, wild animals,and other foreign objects. From the internal side,damage to the Medium Voltage Network (JTM) components,such as distribution transformers, insulators, and conductor cables, are the main causes of permanent faults, with a total92 disturbances. MethodFault Tree Analysis (FTA)successfully identified the cause-effect

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relationships of the disturbances that occurred, and systematically described the root causes, both from internal and external factors. The fault tree mapping results show that most of the disruptions can be prevented through: Routine maintenance and replacement of worn components, Increasing public awareness not to fly kites near power lines, As well asinstallation of protective equipment such as lightning rods and automatic circuit breakerson the distribution network. The use of the FTA analysis approach has proven effective in supportingtechnical decision making and prevention strategiesfuture disruptions, so that it can improvereliability and continuity of electricity supplyto customers.

REFERENCES

Basuki, E. (2017). Reliability Analysis of Electrical Distribution Systems Using the FTA (Fault Tree Analysis) Method. Journal of Electrical and Computer Engineering, 6(2), 85–92

Darmawan, I., & Nurcahyo, A. (2020). Analysis of the Causes of Electricity Distribution Network Disruptions Using Statistical Methods and FTA. Indonesian Journal of Energy and Electricity, 9(1), 15–22.

Dani, A., & Erivianto, D. (2022). STUDY OF SOLAR POWER GENERATION SYSTEM OFF GRID HOUSEHOLD SCALE IN BAGAN DELI AREA USING Pvsyst.*Indonesian Journal of Social Technology*,*3*(9).

Dani A, et al (2024)The potential of rooftop solar electric energy on campus buildings is high School of Technology Sinar Husni using helioscope software. Jurnal Info Sains: Informatics and Science, 14(01), 219-231.

Dalimunthe, ME, Lubis, Z., Sutejo, E., & Sari, DP (2023). Analysis of Solar Cell Potential in Building I of Pembangunan Panca Budi University.*Fidelity: Journal of Electrical Engineering*,*5*(2), 102-109.

Erivianto D et al (2024)Training on the Use of Programmable Logic Controllers (PLC) to Improve Technician Competence at PT. Prima Multi Peralatan. Pedamas (Community Service), 2(03), 762-769.

IEC. (2006). IEC 61025: Fault Tree Analysis (FTA). International Electrotechnical Commission.

Naidu, M. S., & Kamaraju, V. (2015). High Voltage Engineering (5th ed.). New Delhi: McGraw-Hill Education.

PLN (2023). Distribution Network Disruption Report of PT PLN ULP Balige 2023. Balige: PT PLN (Persero) Customer Service Unit.

Suparman, H. (2019). Electric Power Distribution System Maintenance Management. Yogyakarta: Deepublish.

Villemeur, A. (1992). Reliability, Availability, Maintainability and Safety Assessment: Methods and Techniques. New York: Wiley.

Widodo, A., & Santosa, P. (2018). Electrical Protection System Planning for 20 kV Distribution Networks. Surabaya: ITS Press.