Fault Analysis and Handling in Low-Voltage Networks at PT. PLN (Persero) UP3 Sidoarjo ULP Krian

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Abstract

Low-voltage electricity distribution networks have an important role in ensuring a reliable electricity supply for the community because they are directly connected to customers. However, this network is prone to disturbances due to natural factors such as extreme weather and external disturbances such as fallen trees, wild animals, and human activities. This study aims to identify the types of disorders that commonly occur and evaluate the effectiveness of the handling procedures implemented by PT PLN (Persero) UP3 Sidoarjo ULP Krian. The method used is qualitative descriptive through direct observation in the field with the PLN technical team. The results of the study showed that the most dominant disturbances were caused by strong winds, heavy rain, and cable connection disruptions. Handling procedures start from identifying the location of the fault through customer reports, technical checks using measuring instruments such as ampere pliers and tespen, to corrective actions and evaluations. In addition, the aspect of occupational safety is also a major concern in each stage. Evaluation of the system is carried out post-repair to ensure there is no potential for further disruption. In conclusion, the reliability of the distribution network can be improved through systematic handling procedures, periodic maintenance, and active participation of the community. This study provides a practical overview of the importance of network disruption management as part of efforts to improve the quality of national electricity services.

Keywords: *Power outage, Distribution network, System reliability, Technical handling*

I. INTRODUCTION

Electricity distribution networks, especially low-voltage networks, are part of crucial of an electrical system that is directly connected to consumers. The reliability and stability of this network greatly affects quality of electricity services to the community. However, low-voltage networks often experience disruptions caused by a variety of factors, both from nature such as extreme weather, and from human activities such as excavation and construction. These disturbances can result in power outages, voltage fluctuations, and even safety risks to the community. Therefore, an in-depth analysis of the types of faults and their handling procedures is indispensable to ensure a reliable electricity supply.

This article will discuss specifically the types of faults that are common in low-voltage networks in PT. PLN (Persero) UP3 Sidoarjo ULP Krian. The main focus will be on the cause of the disturbance, as well as the handling procedures implemented by the PLN engineering team. As such, this article will not discuss other aspects of electricity distribution systems that are not directly related to low-voltage grids.

“The purpose of this article is to identify and analyze frequent disturbances in low-voltage networks, as well as evaluate the effectiveness of handling procedures carried out by PLN's engineering team. With a better understanding of the disturbance and its handling, it is hoped that it can improve the reliability of the electricity distribution network, as well as make a positive contribution to better electricity services for the community. (Wawuru and Tharo,2023)”. This article also aims to provide insight for students and practitioners in the field of electrical engineering regarding the challenges and solutions in the management of low-voltage networks.

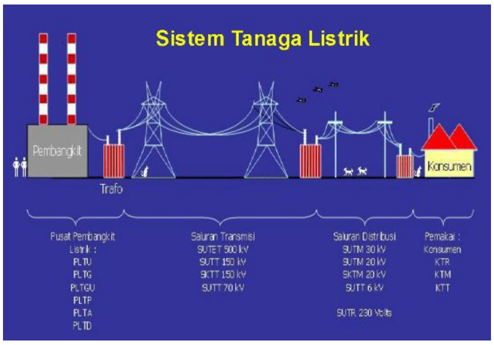
THEORY

Electric Power System

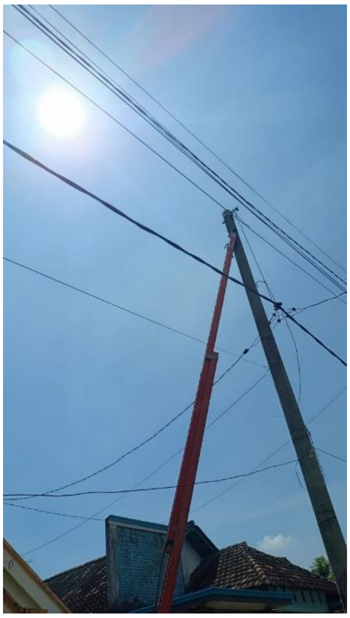
In the electric power system as a whole, the process of distributing energy from the source of generation to the final consumer involves three main stages, namely generation, transmission, and distribution. The distribution stage is the last part of this system that has a very vital role, as it functions directly to distribute electrical energy from the substation or distribution substation to the end customer. In other words, the distribution network is the spearhead of electrical energy services to the community, and the quality of service is largely determined by the reliability of this distribution system.

The electricity distribution network in Indonesia is generally divided into two main parts, namely Medium Voltage Networks (JTMs) and Low Voltage Networks (JTR). Medium Voltage Networks typically operate at a voltage of 20 kV and are used to deliver electrical energy from the Substation (GI) to the Distribution Substation (distribution transformer). Meanwhile, the Low Voltage Network operates at a voltage of 220 Volts (single phase) or 380 Volts (three phases) and functions to distribute electricity from direct distribution transformers to residents' homes, public facilities, offices, and small industries. “Because the low-voltage network is directly connected to customers, the stability and continuity of this network greatly determines customer satisfaction and the image of electricity providers such as PT PLN (Persero). (Nurkamalia, et all,2021)”

"The use of standard materials and installation in accordance with technical requirements also determine the reliability of the system. In the context of PT PLN (Persero), all low-voltage distribution networks are required to follow operational and technical standards that have been set through documents such as SPLN (National PLN Standards) and technical manuals for distribution services" (Wahyudi Sarimun, 2011)”



Picture 1 *Electric Power Distribution System* (Ramadhan,2022)


Picture 2 *Power Pole*

“Technically, the distribution network consists of a number of important components that must work together in an integrated manner to ensure a smooth electricity supply. (Ramadhan,2022)”. The first component is the distribution pole, which is used to support the power cable in the overhead network, keeping the cable from touching the ground or being disturbed by the surrounding environment. These poles are also installation points for other components such as distribution transformers, insulators, and house connections. An insulator is a part of the distribution system that prevents electric current from leaking into poles or support structures, while protecting the system from short-circuit interference. Furthermore, there are conductors, which are wires that conduct electric current which can be copper or aluminum wires, depending on the capacity and terrain conditions. On the customer side, there is a Limiting and Measuring Device (APP) which functions as a safety overcurrent and as a measuring tool for customer electricity consumption. In addition, the connection from the network to the customer's installation is also a vital component because it is the first point of entry of current into the household system.

Picture 3 *Example of Conductor and Isolator*

Based on the installation method, the distribution network can be divided into two types, namely the aerial network and the underground network. Overhead Distribution Line is the most commonly used network in Indonesia because it is easier to install, maintain, and relatively inexpensive in terms of cost. However, this network is highly susceptible to external interference such as weather, trees, animals, and human activities. Meanwhile, underground networks (Underground Cable Distribution) have advantages in terms of aesthetics and protection against external interference, but require higher installation and maintenance costs and longer recovery times in the event of interference. In addition to being based on installation media, the network distribution also is classified by their array configuration, such as Radial System, loop systemand Network System. Radial systems are the simplest and most commonly used distribution systems, where the electricity supply flows from one source to multiple customer loads in one direction. However, the disadvantage of this system is the absence of a supply reserve in case of a disruption. The loop system provides a two-way electricity supply, so that if there is a disturbance in one of the lines, the electricity can still be supplied from the other lines. While integrated network systems are typically used in dense urban areas or business centers, which demand high reliability and have a supply of multiple sources at the same time.

"The reliability of the electricity distribution network is a key aspect in assessing the performance of electric power service providers. According to international standards such as IEEE and IEC, the level of network reliability is assessed based on several parameters, including SAIDI (System Average Interruption Duration Index) which measures the average duration of interruptions per customer, and SAIFI (System Average Interruption Frequency Index) which measures the average frequency of interruptions per customer. The lower the value of SAIDI and SAIFI, the higher the reliability of the network. (Sutrisno,2021)." "To achieve this reliability, electricity providers must implement various efforts such as preventive maintenance, quick repairs when disturbances occur (corrective maintenance), the use of automated monitoring systems such as SCADA, and periodic training for engineering personnel. (Putra and Hidayat,2022.)"

"However, challenges in operating the distribution network are still encountered in the field. Weather disturbances such as heavy rain, strong winds, and lightning strikes are still the main factors in damage to network infrastructure. In addition, external factors. Such as fallen trees, human activities (excavation, house construction), and disturbances from animals such as birds and rats also often cause system disruptions. (Anggraini and Saputra,2023)." Not only that, the condition of the old network, non-standard connections, and customer loads that exceed capacity also contribute to the decline in distribution reliability.

By understanding the basic theory and structure of the electricity distribution network system as a whole, it is possible to analyze and evaluate the types of disturbances that occur in the field, the factors that cause them, and the handling procedures applied by the technical team in service units such as PT PLN (Persero) UP3 Sidoarjo ULP Krian. A deep understanding of the distribution system is an important foundation in efforts to improve the reliability and quality of electrical energy services to the community.

Reliability of Electric Power Distribution System

Reliability is one of the most crucial aspects of an electric power distribution system. System reliability refers to the ability of a power system to provide a continuous supply of electricity, without significant interruption, to the end customer. In the context of low-voltage distribution networks, reliability is critical because even a small disruption can have a direct impact on the comfort, safety, and productivity of the electricity user community.

In general, the reliability of the electric power system is measured using several quantitative indicators, including:

SAIDI (System Average Interruption)

Measures the average duration of power outages experienced by each customer over a given period (hours/customer/year).

SAIFI (System Average Interruption Frequency Index)

Measures how often disruptions occur to customers in a year (frequency/subscriber/year).

CAIDI (Customer Average Interruption)

Measures the average duration of outages per customer that experienced an outage.

In its implementation in the field, the reliability of the distribution system is greatly influenced by many factors, including the physical condition of the network infrastructure, the protection system, the speed of response of technical officers in repairing disturbances, as well as environmental factors such as weather and regional topography. The better the protection and maintenance system is, the higher the level of reliability.

One of the strategies to increase reliability is to carry out preventive maintenance, which is periodic maintenance of equipment such as transformers, conductors, insulators, connections, and other protective equipment. In addition, the application of distribution automation systems such as SCADA (Supervisory Control and Data Acquisition) is also a form of modernization that can detect and handle disturbances faster without having to wait for manual reports from customers.

"The use of standard materials and installation in accordance with technical requirements also determine the reliability of the system. In the context of PT PLN (Persero), all low-voltage distribution networks are required to follow operational and technical standards that have been set through documents such as SPLN (National PLN Standards) and technical manuals for distribution services.(Wahyudi Sarimun,2011)."

"Handling of disturbances is carried out through systematic procedures, ranging from identification of fault locations based on customer reports, field inspections using technical equipment such as ampere pliers and tespen, to system repair and evaluation by the technical team. This procedure has proven to be effective in restoring power supply quickly and safe, as long as it is done appropriately and coordinated" (Sari and Prasetyo, 2020)"

By understanding the basic concept of the reliability of this electric power system, it can be thoroughly evaluated how effectively the handling of disturbances is applied by the PLN engineering team in the field, as well as what are the factors that are still obstacles in maintaining the continuity of electricity supply to customers.

III. METHOD

This study uses a descriptive qualitative method because it aims to directly and in-depth describe the process of handling low-voltage network disturbances based on field observations. "This study aims to identify the types of disorders that commonly occur and evaluate the effectiveness of the handling procedures implemented by PT PLN (Persero) UP3 Sidoarjo ULP Krian" (Wulandari and Hermawan, 2020)"

This approach is considered most appropriate given that the main focus of the study is to analyze how customer reporting procedures are handled by technical officers, particularly in the context of checking and repairing KWh meters that are reported to be experiencing problems. All activities were carried out directly in the field with the engineering team from PT PLN (Persero) UP3 Sidoarjo ULP Krian during the independent internship period. The observation process involves the author's active involvement in following every stage of the officer's work, starting from receiving customer reports, work preparation, to inspection and repair activities of the KWh meter unit.

Picture 4 *Flowchart of Disturbance Handling by PLN Engineering Team*

Technical inspection of the KWh meter is carried out using various work equipment that is commonly used by field technicians. One of the main tools used is the Ampere Pliers, which function to measure the amount of electric current flowing into the KWh meter. This tool is very important to find out if the electricity flow is up to standard or if there is an anomaly that indicates a disturbance. In addition, a test is also used to detect the presence of electrical voltage in the cable and connection terminals, as well as a screwdriver as an aid to open or close the KWh meter cover when an internal inspection of the device is needed. During the observation process, the author recorded in detail every technical step taken by the officer, including the results of the measurement, the cause of the disturbance found, and the way in which it was handled. All of these data are then analyzed to gain a comprehensive understanding of the types of common disorders and the effectiveness of treatment procedures implemented in the field.

Picture 5 *Example of APD*

In addition to work tools, the aspect of work safety is also an important part of this method. All technical activities are carried out using complete Personal Protective Equipment (PPE) in accordance with the operational procedures that apply in the PLN work environment. The PPE used includes safety helmets, reflective vests, protective glasses, isolation gloves, and K3 standard safety shoes. The use of PPE aims to prevent work accidents when handling electrical components that are voltage. Not only that, in certain conditions such as checking cable connections on distribution poles or working positions at heights, officers also use body harnesses as a complement to the safety system. All work equipment and PPE are always checked and re-corrected during the morning apple before the team is dispatched to the field.

On the other hand, customer reporting procedures are the starting point in a series of nuisance handling activities. Customers usually submit complaints through the PLN 123 Call Center or the PLN Mobile application, by including information in the form of customer ID, KWh meter number, and the location and chronology of the disturbance incident. Once the report is in, the system will distribute reports to the relevant technical work units, in this case ULP Krian. The team of technicians then conducted initial verification and prepared all the necessary equipment before conducting a field visit. When arriving at the customer's location, the officer conducted an initial check on the physical KWh meter. If the unit is in a dead condition, the voltage and inlet current are checked using ampere pliers and tespen. If it is found that the current does not reach the customer's unit, the officer will continue to check the connection network on the distribution pole to ensure that there is no disruption to the main line.

All observational data, from visual inspections, current and voltage measurements, to repair documentation, is recorded in the field technical report form. The results of these findings are not only analyzed for research purposes, but also serve as official documentation that will be used by PLN for performance evaluation, fault mapping, and long-term maintenance planning. With this descriptive qualitative approach, it is hoped that the results of the research will be able to provide a real picture of the technical conditions in the field as well as provide input to improve the reliability of the distribution system, especially in the aspect of handling customer KWh meters which are often a critical point in the electric power distribution chain.

IV. RESULTS AND DISCUSSION

Definition of Low Voltage Networks During the internship activities, the author gains an in-depth understanding of electricity distribution systems, especially in low-voltage networks. The low-voltage network is the final part of the distribution system that functions to distribute electrical energy from the distribution substation directly to customers' homes.

In this learning process, the author studies the different types of cables used in distribution networks, including air cables and ground cables. Air cables are typically mounted on electrical poles and are designed to withstand a wide range of weather conditions, while ground cables are installed underground to protect against physical damage and environmental disturbances.

The authors also study the structure of a distribution network that includes several important components, such as:

- Power Pole: This pole serves as the main support for the distribution cable, keeping the cable fixed on the safe altitude from environmental disturbances and human activities.
- Insulator: This component serves to prevent electric current from flowing to poles or other structures, thus maintaining the safety and reliability of the system.
- Conductor: A part of the cable that conducts electrical current. The authors study the different types of conductors used, including copper and aluminum conductors, as well as the characteristics of each.
- Home to Network Connection: This is the point at which the wires from the distribution network are connected to the electrical installation in the customer's home. The authors understand the importance of good connections to ensure a stable and safe supply of electricity.

The understanding gained of these components is a very important basis in understanding the different types of faults that can occur in low-voltage networks. The authors learned that the disturbance can be caused by internal factors, such as damage to insulators or loose cable connections, as well as external factors, such as extreme weather or human activity. With this knowledge, the author can better understand

How the handling of the outage is done technically, including identification, repair, and evaluation measures to ensure the electricity distribution system functions properly and safely.

Types of Interference in Low Voltage Networks

"The low-voltage network is the final part of the electricity distribution system that is directly connected to the customer. Because it is located in an open and densely populated environment, this network is highly susceptible to various disturbances, both caused by nature and human activities. The disturbances that occur can result in power outages, unstable voltages, and potential safety hazards for local residents. (Nurkamilia,Qomariah, and Syahrani,2021)"

Disturbances due to extreme weather (strong winds, heavy rain)

Extreme weather is the main cause of disruption in low-voltage networks. Strong winds can cause the cable to sway violently, wind, or even break, especially if it doesn't has a strong hold. Cables hanging in the air can wobble in strong winds, increasing the risk of breaking or falling. In addition, strong winds can also cause cables to get wrapped or rolled, thus disrupting the flow of electricity.

Heavy rain can also cause a short circuit due to moisture entering the connection that is not waterproof or inundation in the low part of the installation. A short circuit can occur when water enters the wiring connection, disrupting the flow of electricity and causing a blackout. In some cases, cables that fall due to extreme weather can endanger residents around the site, especially if they are still conducting electrical current.

Disturbances due to external factors (trees, animals, human activities)

The environment around the network is one of the factors that has the potential to cause disruption. Trees that are too close to the cable often cause interference, either because they get stuck, rub against the cable when blown in the wind, or fall directly into the network. Trees that grow too close to the wires can cause interference, especially if the tree falls or its branches touch the wires.

In addition, animals such as birds or mice that touch the conductor can also cause short circuits. Animals touching the conductor can cause an electric current to flow to the ground, disrupting the flow of electricity and causing blackouts.

Human activities such as excavation, house construction, or antenna installation without paying attention to the existence of power cables are also triggers for disturbances that occur quite often in the field. Human activities that do not pay attention to the presence of power cables can cause interference, especially if they are interrupted or disconnected.

Interrupted Cable Interruption

The cable connection between the customer's home and the main grid is vital in electricity distribution. Interference with these joints can be caused by installation that is not in accordance with procedures, non-standard materials, or due to the age factor of the installation that is no longer feasible. Loose or broken connections may result in customers losing power even if the main network continues to function normally.

This glitch is often found when the team conducts inspections after reports of outages from individual customers. An inspection performed by the team can help identify the cause of the disturbance and make appropriate remedies.

Fault Handling Procedures Handling Faults in the Voltage Network is a process that requires precision and coordination between field officers and control centers. Any disruption that occurs must be immediately identified, corrected, and evaluated so that the power supply can return to normal quickly and safely. Here are the procedures applied to deal with power grid outages.

Identify Fault Locations and Customer Reports

The first step in dealing with the disturbance is to identify the affected locations. This process begins with receiving a report from the customer. Customer reports typically include information about the area where the power was disconnected, the time of the incident, and the possible cause of the outage. After the report is received, the technician team will check the location, either through direct monitoring in the field to obtain more accurate data regarding the position of the disturbance.

Quick and precise identification is essential to speed up the repair process. A team of technicians will use adequate equipment, such as GPS and measurement equipment, to accurately determine the location of the fault. In addition, the team of technicians will also communicate with the customer to ensure that the interference has been correctly identified.

Corrective Action by the Engineering Team After the Fault Location Is Successful

identified, the engineering team will carry out corrective steps according to the type of disturbance that occurs. If the interference is caused by extreme weather factors such as broken cables or being dragged by the wind, technicians will replace or reconnect the damaged cables. In the event of disturbances due to external factors such as fallen trees or animals, technicians will cut down trees or secure the surrounding area to avoid further risks.

The repair process also involves checking the quality of the joints, replacing damaged materials, and strengthening the construction if necessary. The speed and precision of the action greatly affect the restoration of the power supply which is fast and safe for customers. The team of technicians will work closely with the rest of the team, such as the maintenance team and the security team, to ensure that repairs are carried out safely and effectively.

Evaluation After Treatment

Once the outage has been successfully addressed, the next step is to conduct an evaluation to ensure that the entire system is back to normal functioning and there is no potential for further disruption. Evaluation is carried out by testing connections, monitoring voltage stability, and ensuring that no current leaks or other hazards may occur after repairs.

The team of technicians will also document the entire repair process that has been carried out, as well as record any findings that can be used as a reference in future network maintenance. In addition, the team will also provide reports to customers about the cause of the disruption and the recovery time, as a form of transparency and service to the community.

An evaluation will also be carried out to ensure that the repairs made are effective and safe. The technician team will re-check to ensure that the system has returned to normal function and there is no potential for further disruption.

V. CONCLUSION

A low-voltage distribution network is a vital part of an electric power system that is directly connected to customers. The reliability of this network greatly determines the quality of electricity services and community comfort. Based on the results of observation and analysis during internship activities at PT PLN (Persero) UP3 Sidoarjo ULP Krian, it can be concluded that disturbances in low-voltage networks are most often caused by extreme weather factors, external disturbances such as trees and animals, and human activities that do not pay attention to electrical safety. In addition, damage to cable connections and installation components is also a significant causative factor.

Handling of disturbances is carried out through systematic procedures, ranging from identification of fault locations based on customer reports, field inspections using technical equipment such as ampere pliers and tespen, to system repair and evaluation by the technical team. This procedure has proven to be effective in restoring power supply quickly and safe, as long as it is done appropriately and coordinated.

“The reliability of the electricity distribution system depends not only on the physical infrastructure, but also on the aspects of periodic maintenance, the readiness of technical personnel, and the use of monitoring systems such as SCADA. (Ryandityo,Setiadji, and Hosea,20224)”. Therefore, preventive efforts such as tree trimming, public education, the use of standard materials, and routine maintenance need to be continuously improved to prevent disturbances that can harm customers and companies. Overall, a deep understanding of the structure of the network, the types of faults, and the techniques for handling them is essential not only for field officers, but also for students and practitioners of electrical engineering. This knowledge is an important provision to improve the reliability of the distribution system and strengthen national electricity services.

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