Vol. 2, No. 1, April 2023, pp. 59-64
p-ISSN: 2963-8577
e-ISSN: 2964-3511
DOI: 10.57102/jescee.v2i1.58

JESCEE
Journal of Emerging Supply Chain, Clean Energy, and Process Engineering

ANALYSIS OF MAINTENANCE OPTIMIZATION ON MEDIUM VOLTAGE OVERHEAD LINES (SUTM) IN REDUCING ENERGY NOT SUPPLIED (ENS) AT PT. PLN (PERSERO) ULP TARAKAN

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Abstract
The background of this research is an analysis of equipment disturbances that occur in distributing electrical energy. The disturbance is a blackout. Power outages cause a decrease in the continuity of service to customers and result in a lot of loss of electrical energy that is not distributed to customers. The research objectives are to find out the optimization technique of distribution network maintenance, how to reduce the value of energy not supplied (ENS), find out the losses due to ENS, and find out the total electrical energy distributed after preventive maintenance is carried out. This research uses a preventive maintenance method, which is maintenance that can prevent unexpected damage to distribution system networks and equipment. This research optimized preventive maintenance actions by reducing disturbances after preventive maintenance from 7 disturbances in February to 2 disturbances in March. Before preventive maintenance, the loss due to ENS amounted to Rp. 36,192,017.626, and the total electrical energy not distributed was 25,025.76 kWh. After preventive maintenance, there was a significant decrease in the total loss due to ENS of Rp. 953,516,447, and the amount of electrical energy not distributed was 659.28 kWh. This research can increase maintenance efficiency due to electrical energy losses by 97.36% at the time interval when this research data is managed when data collection is carried out in the field.

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Keywords:
Electric energy; disruption; distribution system; preventive maintenance; PT. PLN (Persero) ULP Tarakan

Article History:
Received: March 19th, 2023
Revised: March 22th, 2023
Accepted: April 26th, 2023
Published: April 30th, 2023

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1. Introduction

Increasing population growth accompanied by rapid technological development has increased the demand for electricity for daily needs. Therefore, an electric power system is required to have good reliability in the distribution of electrical energy in the distribution network. In its realization in the field, the distribution system is inseparable from various disturbances that can disrupt the continuity of the distribution of electrical energy to customers/consumers [1]. So that the direct impact felt by customers feel is blackouts, frequent power outages certainly disrupt the activities of customers activities. In addition to losses on the customer side, blackouts also cause losses on the PLN side, namely decreasing customer continuity and resulting in a lot of energy not being distributed to customers. Maintenance activities on the repeater with potential interference are needed to minimize this disturbance. Effective maintenance can be realized by using preventive maintenance methods because preventive maintenance is maintenance that can prevent unexpected damage to the network and can maintain the life of equipment installed on the electricity network by optimizing maintenance activities can minimize the value of electrical energy that is not distributed to customers [1]. Thus, optimizing maintenance using preventive maintenance methods can reduce losses experienced by the company because it can distribute more energy (kWh) to customers and ensure satisfaction on the customer side.

2. Experimental Section

A. Place and Time of Research

This research was conducted at PT. PLN (Persero) ULP Tarakan on Feeder 4 within a period of data collection for four months.

B. Preventive Maintenance

This research uses a preventive maintenance method where preventive maintenance is maintenance to prevent interference with the network and to maintain network work so that it always operates with high conditions and efficiency [3]. The theory in this study follows the title of the discussion to be studied, and references are obtained from various journals, books, and others.

C. Electric Energy (kWh)

Energy is defined as the rate at which electrical power is used multiplied by the time it is used. There are several kinds of energy, such as mechanical energy, electrical energy, heat energy, and so on. From one, energy can be converted into another. The amount of electrical energy can be determined by voltage, current, and time [2]. The formula for electrical energy is as follows:

$$W = P \,.\, t \tag{1}$$

By:
W = Energy (kWh)
P = 1 phase power (Watt)
t = time (hour)
The SI unit for electrical energy is the joule (J) or watthour (Wh).
In a 3-phase system, the energy calculation formula in kilowatt hour (kWh) is:

$$W\ (kWh) = \frac{\sqrt{3} \text{ x } V_L \text{ x } I_L \text{ x } \cos\theta \text{ x t}}{1000} \tag{2}$$

Where:
W = Energy (kWh)
V_L = Line voltage (volts)
I_L = Line current (amperes)
Cos θ = Power factor
t = time (hour)

$$Ct = W\ (kWh) \text{ x } C \tag{3}$$

With:
Ct = Losses due to ENS
C = Selling price of electricity

D. Research Procedure

Data is co by direct observation and conducting interviews with the parties concerned. After obtaining the data, the next step is calculating the total initial ENS before maintenance and describing and analyzing the maintenance process. Then recalculate the total ENS after maintenance, the data obtained is analyzed as a result of the research, and conclude a confirmation of the results of the research that has been done.

3. Results and Discussion

A. Disturbance Data Before Preventive Maintenance

Table 1 shows disturbances at several key-point in February 2021 in Feeder 4 of PT. PLN (Persero) ULP Tarakan.

Table 1. Disturbance Data Before Preventive Maintenance

No	Keypoint	Current (A)	Load (kW)	Outage time (hours)	ENS (kWh)	Total loss (Rp)
1.	Simpang Intraca	71,83	1.988,29	0,57	1.133,33	1.639.214,408
2.	REC 613	93,31	2.582,86	3,59	9.272,5	13.411.597,957
3.	Trk 4	140,72	3.895,38	1,5	5.843,08	8.450.946,014
4.	Trk 4	13,15	364.26	8,37	3.048,86	4.406.652,834
5.	Trk 4	11,01	304.85	7,19	2.191,94	3.169.368,413
6.	Trk 4	14,82	410.24	7,28	2.986,61	4.319.537,424
7.	Simpang Intraca	29,05	554.98	0,99	549,44	794.700,576
Total undelivered kWh					25.025,76	
Total loss due to ENS						Rp.36.192.017,626

Based on the data in Table 1, in this case, it is taken from the first key point of the Intraca Junction with a measured current of 71,83 A, a load of 1.988,29 kW with a blackout time of 0,57 hours and the amount of energy that is not distributed is 1.133,33 kWh so that the total rupiah at the keypoint is 1.639.214,408 rupiah.
Then the data obtained from PT. PLN (Persero) ULP Tarakan voltage of 20 kV cos θ of 0.8, the amount of energy that is not distributed can be calculated as follows:

$$W(\text{kWh}) = \frac{\sqrt{3} \times V_L \times I_L \times COS\theta \times t}{1000}$$

$$W(\text{kWh}) = \frac{\sqrt{3} \times 20000 \times 71{,}83 \times 0{,}8 \times 0{,}57}{1000}$$

$$W(\text{kWh}) = \frac{1.134.648{,}47}{1000}$$

$$W(\text{kWh}) = 1.134{,}64 \text{ kWh}$$

According to TUL III-09 (electricity sales report), the selling price of rupiah/kWh is Rp. 1.444,70/kWh. By multiplying the amount of kWh against the selling price of electricity, the rupiah estimate is obtained as follows:
Rupiah = 1.134,64 x Rp.1.444,70
Rupiah = Rp. 1.639.214,408

For calculations at other key-point carried out in the same way as above, the results of calculating undistributed energy at other key points can be seen in Table 1 above.

B. Maintenance Data

Maintenance data in March on Feeder 4 can be seen in Table 2 below.

Table 2. Maintenance Data on Feeder 4

No	Feeder	Location	Jobs
1	Feeder 4	Jl. Aki balak juata krikil	Transformer grounding replacement
2	Feeder 4	Jl. Aki balak juata krikil	Transformer grounding replacement
3	Feeder 4	Juata Kopri	Transformer grounding replacement
4	Feeder 4	Jl. Aki Balak	Substation handle replacement

5	Feeder 4	Jl. Jembatan Kuning Juata	7-point tree-guard installation
6	Feeder 4	Jl. Jembatan Kuning Juata	FCO cover installation of two sets
7	Feeder 4	Jl. Jagung Persemaian	3-point tree-guard installation
8	Feeder 4	Jl. Jagung Persemaian	Installation of FCO cover 1 set
9	Feeder 4	Juata Laut	FCO cover installation of five sets
10	Feeder 4	Juata Laut	5-point tree-guard installation
11	Feeder 4	Jl. P. Aji Iskandar	FCO cover installation of two sets
12	Feeder 4	Jl. P. Aji Iskandar	Replacement of FCO jumper cables in two sets
13	Feeder 4	Jl. P. Aji Iskandar	2-point tree-guard installation

B. Maintenance Performed

The maintenance process is carried out in several locations in Feeder 4. The maintenance carried out is the replacement of transformer grounding at the location of Jl. Aki Balak Juata Krikil and Juata Krikil, the time required to perform maintenance is about 1 hour. The process of replacing the old grounding cable transformer grounding is replaced with a new grounding cable. Then the new grounding pipe is planted until it gets a predetermined grounding resistance value. Transformer grounding is installed to anticipate damage to transformer equipment due to lightning strikes. Then the replacement of the substation handle is carried out at the location of Jl. Aki Balak, the time required to perform maintenance is about 1 hour. A substation handle is a tool that functions as a switch on the substation. Replacement of substation handles is done because the old ones are no longer suitable for use, so they are replaced with new ones. For maintenance, a tree guard is installed at Juata yellow bridge, Jl. Jagung Persemaian, Juata Laut, and Jl. P. Aji Iskandar; the time needed to carry out maintenance at each location is about 1 hour. A tree guard is installed to prevent outages due to animals. Tree-guard is an electrical cable wrapper on the power grid; tree-guard protection can prevent phase-to-phase or phase-to-ground contact. Then the FCO cover is installed at the Juata yellow bridge, nursery corn, Juata Laut, and Jl. P. Aji Iskandar; the time needed to carry out maintenance at each location is about 1 hour. FCO cover is a material used to protect FCO cover protection can prevent interference caused by animals.

Furthermore, the replacement of jumpered cables is carried out at the location of Jl. P. Aji Iskandar; the time required for maintenance is around 30 minutes. The jumper cable is an A3C type cable because the cable does not yet have a protector, unlike the A3CS cable, which already has a protector. The following are the jumper cable of the FCO replacement work steps.

C. Disturbance Data After Preventive Maintenance

Table 3 shows the disturbance data after preventive maintenance is carried out in Feeder 4.

Table 3. Disturbance Data After Preventive Maintenance

No	Keypoint	Current (A)	Load (kW)	Outage time (hours)	ENS (kWh)	Total loss (Rp)
1	Rec 613	109,95	3.043,5	0,06	182,61	Rp. 264.120,054
2	Rec 613	101,29	2.803,9	0,17	476,67	Rp. 689.396,393
Total undelivered kWh					659,28	
Total loss due to ENS						Rp.953.516,447

Based on the data after preventive maintenance, in Table 3, the first keypoint rec 613, the measured current is 109,95 A, the system voltage is 20 kV cos θ is 0,8, and the outage time is 0,06 hours. And the amount of energy that is not distributed is 182,61 kWh, so the total rupiah at the keypoint is 264.120,054 rupiah.

$$W(\text{kWh}) = \frac{\sqrt{3} \times V_L \times I_L \times COS\theta \times t}{1000}$$

 p-ISSN: 2963-8577
e-ISSN: 2964-3511

$$W(\text{kWh}) = \frac{\sqrt{3} \times 20000 \times 109{,}95 \times 0{,}8 \times 0{,}06}{1000}$$

$$W(\text{kWh}) = \frac{182.821{,}42}{1000}$$

$$W(\text{kWh}) = 182{,}82 \text{ kWh}$$

According to TUL III-09 (electricity sales report), the selling price of rupiah/kWh is Rp. 1.444,70/kWh. By multiplying the amount of kWh against the selling price of electricity, the rupiah estimate is obtained as follows:

Rupiah = 182,82 x Rp.1.444,70
Rupiah = Rp. 264.120,054

For calculations at other key-point carried out in the same way as above, the results of calculating undistributed energy at other key points can be seen in Table 3 above.

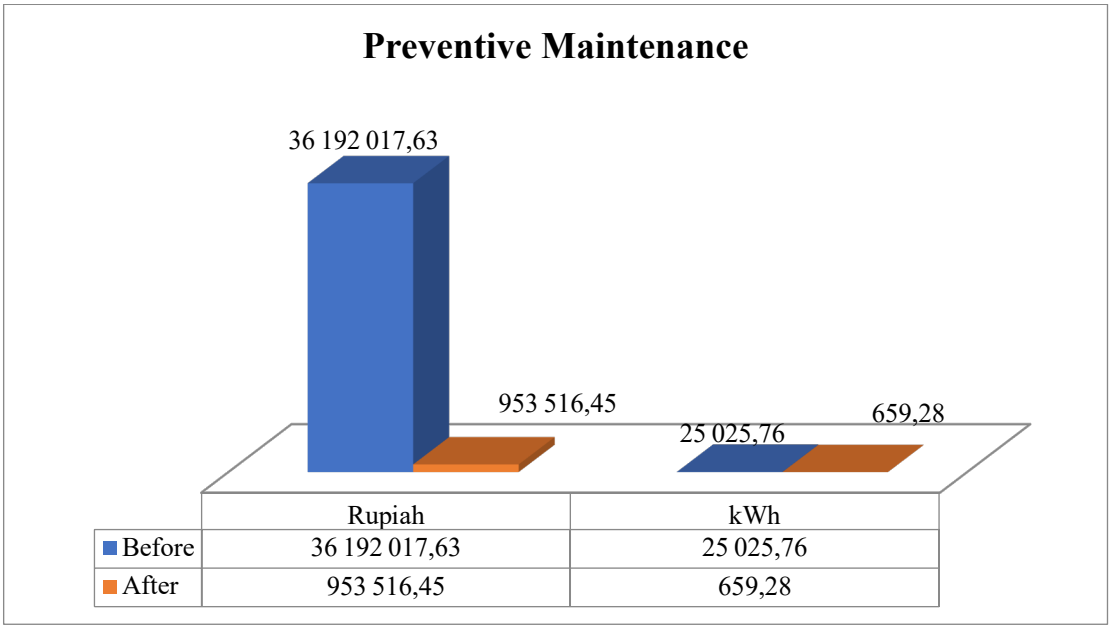

Figure 1. Comparison Chart of Results Before and After Preventive Maintenance

Fig. 1 above shows the difference data from calculating total undistributed kWh (kWh) and total losses due to ENS (Rp) before and after preventive maintenance. Before preventive maintenance, the total undistributed kWh was 25.025,76 kWh, and the total loss due to ENS was Rp. 36.192.017,626, while after preventive maintenance, there was a significant decrease in the amount of energy that was not distributed; namely 659,28 kWh and the total loss due to ENS was Rp. 953.516,447. So that it can be seen the results of the comparison of the difference in the amount of energy (kWh) that can be distributed after the preventive maintenance is carried out by 24.366,48 kWh, and the difference in total losses due to ENS (Rp) after preventive maintenance is Rp.35.238.501,179. So from the above analysis, maintenance carried out on the feeder four medium voltage network using the preventive maintenance method is very effective as a form of effort in reducing energy not supplied (ENS).

4. Conclusion

Based on the results of research on maintenance optimization analysis on medium voltage overhead lines (SUTM) in reducing energy not supplied (ENS) at PT PLN (Persero) ULP Tarakan, conclusions were obtained, among others: The total energy in feeder four that was not supplied (ENS) before preventive maintenance was 25.025,76 kWh while after preventive maintenance the total energy not supplied was only 659,28 kWh so that the percentage reduction in energy not supplied (ENS) before and after preventive maintenance was 97,36%. The total loss due to ENS in feeder four before preventive maintenance is Rp.36.192.017,626, while after preventive maintenance, the total loss due to ENS is Rp. 953.516,447, so the difference in losses due to ENS before and after preventive maintenance is Rp. 35.238.501,179.

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