Power Loss Analysis to Overcome End Voltage Drop at AE005 Substation Golewa ULP Bajawa Feeder

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***Abstract*.**

Voltage drop at the feeder end is one of the problems that often occur in electrical power distribution systems, especially in networks with increasing loads. This study aims to analyze the power losses and the relationship between load conditions, network length, and the ability of the substation to maintain the voltage profile at the AE005 Substation of Golewa Feeder, ULP Bajawa. The analysis method used technical calculation of power losses, evaluation of load currents, and simulation of voltage profiles under several operating conditions to identify the dominant factors causing voltage drops. Based on the measurement results, the AE005 substation experienced a transformer load of 127.99% and a voltage drop of up to 22.9%, exceeding the standard limit of SPLN No.72:1987 which allows a maximum drop of 4%. To overcome this, a load breakage strategy was carried out to the AE023 substation with a capacity of 25 kVA. The results of the analysis showed that after the load break, the load of the AE005 transformer dropped to 67.62% and the AE023 increased to 81.88%, while the maximum voltage drop value dropped to below 5%. Thus, load breakage has proven to be effective in reducing power losses and improving voltage quality in the distribution network.

***Keywords**: Power Loss; Voltage Drop; Distribution Substation; Load Breaking and Golewa Feeder.*

I. INTRODUCTION

In the electric power distribution industry, distribution substations play a vital role in ensuring the efficient delivery of electrical energy to the end consumer [1]. However, in this distribution process, the phenomenon of power loss is one of the main challenges faced by electricity providers [2]. Power loss, which occurs due to resistance in cables, transformers, and other components, leads to energy waste and has a negative effect on the overall efficiency of the system [3]. In Indonesia, power loss is a significant problem in distribution substation operations. As a country with rapid industrial development, the demand for electrical energy continues to increase, putting additional pressure on existing distribution infrastructure [4]. In addition, with the adoption of increasingly sophisticated technologies such as automation systems and IoT (Internet of Things), more careful handling of power loss is needed to ensure the efficiency and reliability of the system. An in-depth understanding of the phenomenon of power loss at distribution substations is essential for electrical engineers to develop effective mitigation strategies. By minimizing power losses, electricity providers can improve their operational efficiency, reduce production costs, and even reduce the environmental impact of energy wastage [5].

Therefore, research on power loss in distribution substations has significant relevance in the context of sustainable and efficient electricity infrastructure development in Indonesia. Through a better understanding of the nature and causes of power loss, as well as the development of innovative solutions, we can create a more reliable, efficient, and environmentally friendly electricity distribution system [6] [7]. With reference to this, this study aims to investigate the phenomenon of power loss at distribution substations and identify appropriate mitigation strategies to overcome the problem. Through an analytical and experimental approach, it is hoped that this research will make a valuable contribution to the development of better electricity distribution technology in the future. One of the findings found in the Bajawa ULP is in the AE005 substation at the Golewa Feeder with a total of 63 customers. The AE005 substation, which is supplied from Golewa Feeders, is one of the distribution substations that has the largest TR side power loss because it is affected by the load of the distribution transformer and also the length of the low-voltage network.

Where the AE005 substation has two majors with a JTR (Low Voltage Network) length of 1.3 kms with a 3x50 mm NFA2X-T conductor type[2]. Substation AE005 has a transformer load of 127.99%. The reliability of the power grid line is an important point in the distribution of the electricity system, where PT PLN (Persero) sets the standard *Drop* voltage in SPLN No.72 : 1987 that the limit *Drop* The allowable voltage for a Low Voltage Network (JTR) is 4% of the working voltage [8] [9]. From these findings, the author plans to carry out load breakdown to the AE023 substation to reduce the power loss from AE005. Penullis specifies AE023 as the substation for load breaking of the AE005 substation because the AE023 substation is the nearest substation to AE005 and there is no need for the addition of a JTR conductor to carry out load breaking so as to maximize efficiency in the work.

II. METHODS

The research was conducted in the distribution network of Penyulang Golewa – ULP Bajawa at two distribution substations, AE005 and AE023. The data used included the results of the measurement of peak current and voltage during the day and night, the specifications of transformers and conductors, as well as the length of the network and the load of each pole point. The analysis included the calculation of voltage drop before and after load break, the percentage of transformer loading, and the evaluation of system efficiency based on SPLN standards. The load breaking method is carried out by moving a portion of the customer from AE005 to AE023 without the addition of new conductors as the AE005 line passes through AE023. The overall stages of this research can be seen in detail in figure 1.

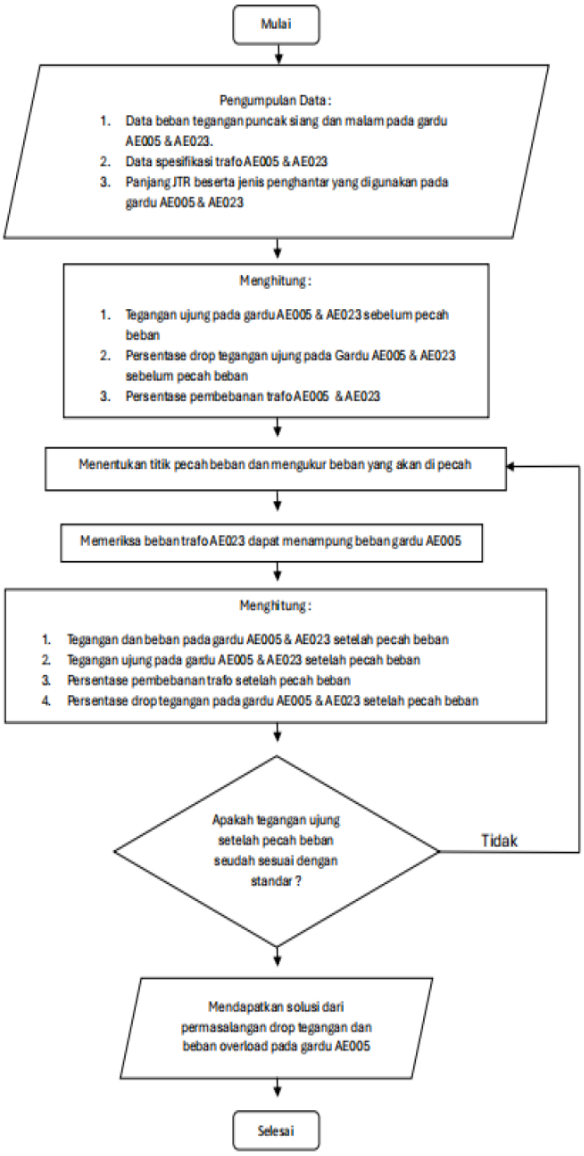

Fig 1. Research Flow Diagram

Data Analysis

Comparing End Voltage Drop Before Load Breaking

Before carrying out this study, it is necessary to compare the results of the end voltage measurement with the calculation *Drop* end voltage on the AE005 substation to ensure that the planned outcome is not much different from what we expected. To calculate the end voltage, it is necessary to collect data on the specifications of the conductor used, the length of the conductor and the load on the AE005 substation of major B.

Determining the Load Breaking Location Point

To maximize the results of the study, it is mandatory to determine the optimal location of the load breaking point so that the total load after load breaking does not exceed the capacity of the transformer at the AE023 substation. Based on the conditions in the field and the results of the transformer load measurement.

Calculating the Transformer Load Percentage

After determining the location of the load break, the load breaking point is obtained not far from the location of the AE023 substation because the load from the point of the planned load break to the end can still be accommodated by the AE023 substation.

Calculating *the* End Voltage Drop After Load Breakage

After obtaining the results of the calculation of the optimal transformer load percentage, the calculation is carried out again *Drop* the end tension on substation AE005 and substation AE023 based on the length of the conveyor and the latest load.

III. RESULT AND DISCUSSION

1.1 Current & Voltage Measurement Data

Table 1. Load and Voltage Measurement Data Before Load Breaking

Date	AE023 MEASUREMENT (Daytime)									
	Current (Ampere)				Voltage (Volts)					
	R	S	T	N	RS	RT	ST	RN	SN	TN
23 Jan 2025	13	11	14	6	401	401	399	229	230	230

1.2 Specification of Substation Conveyors AE005 and AE023

Substation AE005 has two departments, namely Department B and Department D. In Department B, LVTC 3×35 + 35 mm² conveyors are used with a total length of 2.1 kms, consisting of 41 JTR poles with an average distance of 50 meters between poles, as shown in Figure 2. Meanwhile, Substation AE023 has one department, namely Department D, which uses LVTC 3×35+35 mm² conductors with a total length of 0.05 kms and consists of one pole, as shown in Figure 3.

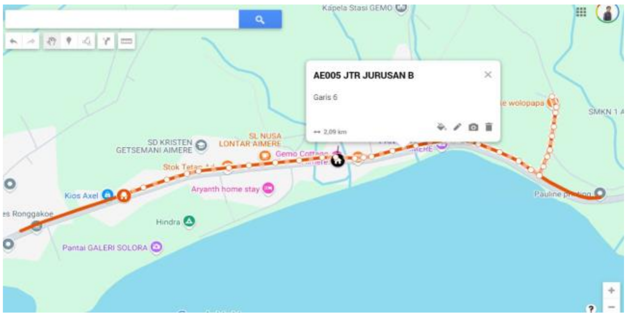

Fig 2. JTR Substation AE005 Conveyor Major B

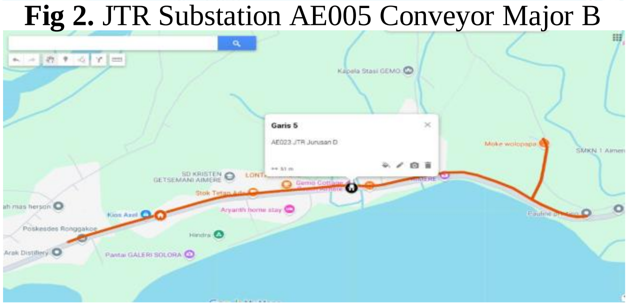

Fig 3. JTR Substation AE023 Dispatcher Major D

1.3 Analysis of End Voltage and Percentage Drop Voltage

The calculation of the end voltage and the percentage of voltage drop at this substation uses night peak load data, because the load value is higher than the peak load during the day. Based on the results of measurements on Substation AE005, the basis of calculation was obtained to determine the magnitude of the voltage drop and the percentage of voltage drop as follows:

At phasa R, the magnitude of the current at pole 2 is:

Is2=Is1−I1=82 A−0 A=82 Asquirrel

The magnitude of the voltage drop at each pole is [10]:

VDrop=I.L(Rcosφ+ Xwithoutφ)

VDrop=82 x 0.05(0.868 x 0.85 + 0.53 x 0.739) VDrop=4.630827 Volts

To calculate the amount of voltage on each pole as follows:

Vr = Vs − ΔV

Fri = 218.36 − 4.63

Fri = 213.73 volts

Meanwhile, to calculate the percentage of voltage drop of each pole can be calculated as follows [11][12][13][14][15]:

$$\%Vdrop = \frac{Vs - Vr}{Vs} \times 100$$

$$\%Vdrop = \frac{223 - 213,73}{223} \times 100$$

$$\%VDrop = 4.15\%$$

Based on the calculation above, it was obtained that the value of the end voltage in phase R was 171 Volts at the night peak load condition, in the S phase it was 197 Volts, and in the T phase it was back at 171 Volts at the night peak load.

1.4 Transformer Load Percentage Analysis

Based on the data from day and night load measurements at Substations AE005 and AE023, the percentage of transformer load can be calculated using the following equation [16]:

$$\%Transformer = \frac{I_R.V_{RN} + I_S.V_{SN} + I_T.V_{TN}}{Sn} \times 100\%$$

$$\%Transformer = \frac{27.228 + 21.224 + 25.226}{50.000} \times 100\%$$

$$\%Transformer = \frac{16.510}{50.000} \times 100\%$$

$$\%Transformer = 33,02\%$$

Based on the calculation example above, the value of the transformer load percentage at Substations AE005 and AE023 is shown in Table 2.

Table 2. Data of Calculation of Transformer Load Percentage Before Load Break

AE005 Calculation (Daytime)								
Total Load								
Date	SN				TN			Percentage (%)
	R	S	T	N	RN	SN	TN	
23/01/2025	27	21	25	16	228	224	226	33,02
Major: B								
23/01/2025	20	16	32,2	14	228	227	226	31,03

AE005 Calculation (Night)								
Total Load								
Date	SN				TN			Percentage (%)
	R	S	T	N	RN	SN	TN	
23/01/2025	86	58	91	44	224	221	223	104,75
Major: B								
23/01/2025	82	34	82	43	223	222	224	88,36

AE023 Calculation (Noon)								
Total Load								
Date	SN				TN			Percentage (%)
	R	S	T	N	RN	SN	TN	
23/01/2025	5,5	4,3	4,5	1,4	237	238	238	13,59

AE023 Calculation (Night)								
Total Load								
Date	SN				TN			Percentage (%)
	R	S	T	N	RN	SN	TN	
23/01/2025	13	11	14	6	229	230	230	104,75

1.5 Determining the Load Breaking Location Point

To ensure that the load breaking location produces optimal performance, it is necessary to ensure in advance that the load to be transferred to Substation AE023 does not exceed the capacity of the transformer. Considering that the JTR of Substation B AE005 passes through Substation AE023, it is necessary to measure the JTR load at the meeting point between JTR Substation AE005 and Substation AE023. This step aims to minimize implementation costs, as no new JTR network is required in the process of breaking the load of Substation AE005. The location of the meeting point of the JTR Substation AE005 with Substation AE023 is at the JTR T18 Pole, with the results of the load flow measurement of each phase, namely phase R of 20 A, phase S of 8 A, and phase T of 23 A.Based on the location of the load break and the amount of load that has been obtained, the total load transferred to Substation AE023 can be calculated as follows.

$$Beban\ AE023 = IT_{18} + Imalam$$
$$Beban\ Fasa\ R\ AE023 = 20A + 13A = 33A$$
$$Beban\ Fasa\ S\ AE023 = 8A + 11A = 19A$$
$$Beban\ Fasa\ T\ AE023 = 23A + 14A = 37A$$

$$Beban\ AE005 = Imalam - IT_{18}$$
$$Beban\ Fasa\ R\ AE005 = 82A - 20A = 62A$$
$$Beban\ Fasa\ S\ AE005 = 34A - 8A = 26A$$
$$Beban\ Fasa\ T\ AE005 = 82A - 23A = 59A$$

If implemented, the load will break at the location assuming the voltage used is 230 Volts. Therefore, from this data, the percentage of transformer load can be calculated as follows [16]:

$$Pembebanan\ transformator\% = \frac{I_R.V_{RN} + I_S.V_{SN} + I_T.V_{TN}}{Sn} \times 100\%$$

$$AE023 = \frac{33.230 + 19.230 + 37.230}{25.000} \times 100\%$$

$$\%Trafo\ AE023 = 81,88\%$$

$$AE005 = \frac{62.230 + 26.230 + 59.230}{50.000} \times 100\%$$

$$\%TrafoAE005 = 67,62\%$$

From the results of the calculation, it can be seen that the value of the transformer load percentage at that point gets results that are in accordance with the expected results, namely at Substation AE005 at 67.62% and at Substation AE023 at 81.88%.

Fig 4. Picture of Location of Load Breaking Point of Substation AE005 to Substation AE023

IV. CONCLUSION

Based on the results of the discussion and analysis that have been described previously, it can be concluded as follows.

1. At substation AE005 Department B, the amount of voltage at the end pole (T41) before the load break was carried out, namely the R phase 171 V with a voltage drop percentage of (23%), the S phase 197 V (12.56%) and in the T phase 171 V (22.9%) at the night peak load with a JTR conveyor length of 2.1 kms.
2. The voltage drop is affected by the length and magnitude of the load on a conductor. The longer the conductor used, the greater the voltage drop that will occur to the customer due to the loss of conductive power.
3. The AE023 substation is able to accommodate the load break of the AE005. The percentage of loading after implementation was 81.88% in AE023 and 67.62% in AE005.
4. After the load break was carried out to reduce the load and also the length of the conductor, a large calculation of the voltage at the end pole (T41) was obtained, namely in the R phase 216 V with a voltage drop percentage of (5.6%), the S phase 224 V (2.25%) and in the T phase 219 V (4.49%) with a JTR conductor length of 1.2 kms.

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