Repair of Donggo Feeder Voltage with the Power Evacuation Method to the Substation at PT. PLN (Persero) ULP Woha

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Abstract
In the distribution network, there is one problem, namely the rating capacity that exceeds the feeder load and the length of the feeder. This will cause the current distributed by a conductor to be greater and the distance of the load served is too far so that it can cause power losses and voltage drops to customers. One way to overcome the problem of overloading the feeder is to perform power evacuation. Based on the results of the study, it shows that at PT. PLN (Persero) the Donggo Feeder experienced a voltage drop at the end voltage. One of the causes of the end voltage drop is the length of the electrical system circuit from the source. One solution to this problem is to perform power evacuation. In this case, the working principle of power evacuation is to build a new feeder to increase the voltage. By carrying out this power evacuation, it has a good impact on improving the end voltage at the feeder load, where the end voltage drop must follow the standard, namely a minimum limit of +5% and -10% set by PT. PLN (Persero) in the standard voltage (SPLN No. 72,1987).

Keywords: ***Power Loss, Voltage Drop, Power Evacuation***

Introduction

The need for electrical energy in today's modern society is urgently needed in line with technological advances around the world. The need for electrical energy continues to increase not only influenced by the large number of people in an area but also by the economic activity of the population which continues to increase to meet their living needs. This is influenced by the increasing influence of the purchasing power of electronic goods so that the higher the economic activity, the greater the need for electrical energy.

Voltage Drop is the amount of power lost when current flows along a cable or wire during the process of distributing electricity from the source to the final load. One of the causes of voltage drop is the longer the electrical system circuit or the length of the cable, so the greater the voltage lost. Based on SPLN No. 72 of 1987, the reduction in the allowable voltage value in JTM for spindle/cluster systems is 2% of the working voltage and for Radial systems by 5% of the working voltage.

PT PLN (Persero) ULP Woha has a radial type distribution channel topology where the source is from the Woha Substation by supplying 19 feeders. Outgoing at GI Woha stops at the Bolo Connection Substation where the outgoing from the GH Bolo feeder there are several feeders, one of which is the Donggo Feeder. The Donggo feeder itself has a network length of 96,282 kMs with a load of 116 Ampere.

In this study, the problems faced at PT. PLN (Persero) ULP Woha due to a voltage drop that occurred at the Donggo Feeder. The simulation was carried out through the ETAP application version 19.0.1. Where when the simulation was carried out, the end voltage at the Donggo feeder was 18.4 kV. Meanwhile, according to SPLN No. 72 of 1987, the permissible voltage drop is +5% and -10%.

Literature Review

2.1 ELECTRICAL SYSTEM

Electrical energy is generated in power generation centers such as hydroelectric power plants (PLTA), steam power plants (PLTU), gas power plants (PLTG), nuclear power plants (NPP), and others. The voltage drop from the transmission voltage level is carried out at the Substation (GI). Where the voltage is lowered to a lower voltage, for example from 500 kV to 150 kV, or from 150 kV to 70 kV and so on. Then the next reduction is carried out at the distribution substation from 150 kV to 20 kV or from 70 kV to 20 kV. This 20 kV voltage is called the primary distribution voltage.

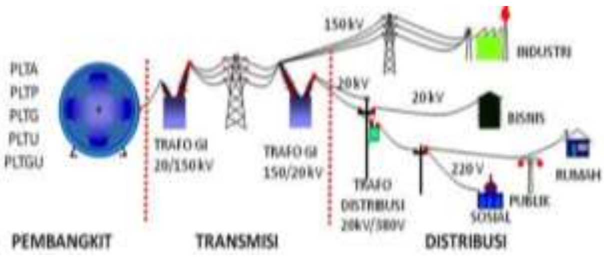


Figure 1. Electric Power System

2.2 VOLTAGE DROP

Voltage Drop is the amount of power lost when current flows along a cable or wire during the 582distribution process from the source to the final load. One of the causes of voltage drop is that the longer 582the system network 582is broken or 582the cable gap so that the greater the voltage lost. Based on SPLN No. 72 of 1987, the reduction in the allowable voltage value in JTM for *spindle/cluster* systems is 2% of the working voltage and for radial systems is 5% of the working voltage.

In a voltage drop power line , in general, the length of the channel will be directly proportional and will be inversely proportional to the area of the cross-sectional conductor.

$$R=\rho \frac{L}{A} \quad (1)$$

Where:
R = the magnitude of the wire resistance (Ω)
ρ = Wire type resistance value (m/mm2)
L = length of conveyor wire (m)
A = wire cross-section area (mm2)

2.3 SHRINKING ELECTRICITY DISTRIBUTION

Distribution Shrinkage or loss of Electricity power is the difference between electrical energy that enters the system and energy that leaves the system because it is lost for free so that the power received by customers is reduced. The shrinkage in question is the difference between the distributed Electrical energy (Px) and the Electricity energy used (Pp).

$$Losses = \frac{Px - Pp}{Px} x\ 100\% \quad (2)$$

Information:
Losses = Rugi-rugi
Px = Electrical energy channeled
Pp = Used electrical energy

2.4 CORRELATION OF VOLTAGE DROP AND *LOSSES* TO DISTRIBUTION NETWORK STANDARDS

When planning a medium-voltage network layout, it is important to take into account the potential voltage drop and the technical losses that may occur. In order to get the desired value, it is important to enter the following parameters:

a. Size (cross-sectional area) of the conveyor
b. Nominal load of the conveyor
c. Network length

Based on SPLN 72:1987, the voltage drop criteria for the design of the Medium Voltage Network (JTM) are as follows:

a. Spindle tension drop is a maximum of 2%.
b. Open *Loop* and Radial voltage drop is a maximum of 5%.

Consideration of network shrinkage in designing a network is as follows:

a. Maximum spindle shrinkage of 1%
b. Maximum open loop *and radial depreciation of 2.3%.*

Example: The maximum length of a 3z240mm2 A3C feeder with nominal/maximum load is 7 kMs (Kilometers circuit) load evenly.

2.5 ETAP (ELECTRICAL TRANSIENT ANALYSIS PROGRAM)

ETAP is software used in electrical network systems. This application allows the simulation of the electric power system to be carried out offline, and can be operated online for real-time data processing. The software is equipped with a variety of features that serve to analyze the power generation system. The types of electrical power analysis that can be done through ETAP include:

a. Short-circuit analysis
b. Power flow analysis
c. Protection coordination
d. Transient stability analysis
e. *Starting* motor
f. *Arc Flash Analysis*

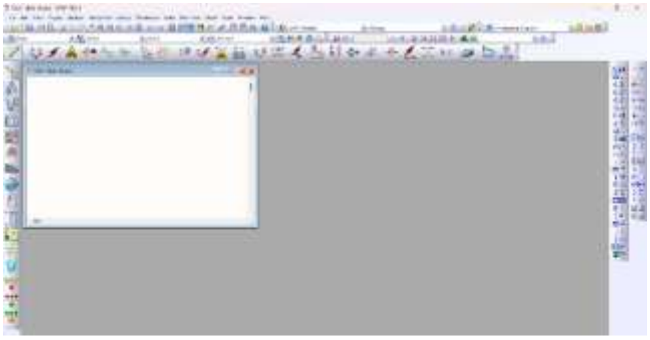


Figure 2. ETAP 19.0.1 *Power Station*

Research Methodology

3.1 RESEARCH STAGES

In this study, there are several stages as follows:

1. Data and Information Collection
   The stage of collecting information and data about the Donggo ULP Woha Penyulang to build a theoretical basis and obtain technical information for research needs.
2. Data Processing
   This data processing stage is a data processing activity for the assets of the donggo, including the creation of a single line diagram, the length of the feeder, to the mapping of the feeder load.
3. Data collection of transformer loading at the Woha Substation
   Compile transformer load data as a reference for modeling the total load of the network.
4. Input Asset Data into ETAP 19.0.1
   All asset and load data is fed into ETAP software version 19.0.1 for network modeling.
5. Simulation and Test of Run Load Flow at ETAP
   Perform load flow simulations to ensure that the network model runs according to existing parameters and data.
6. Evaluation of Simulation Results
   After a simulation of the evacuation of the Donggo feeder's power, it can be seen the difference between the results before and after, whether this simulation can improve voltage drops, losses.
7. Conclusion
   Draw conclusions based on the results of simulation analysis and evaluation of the performance of the electricity distribution system.

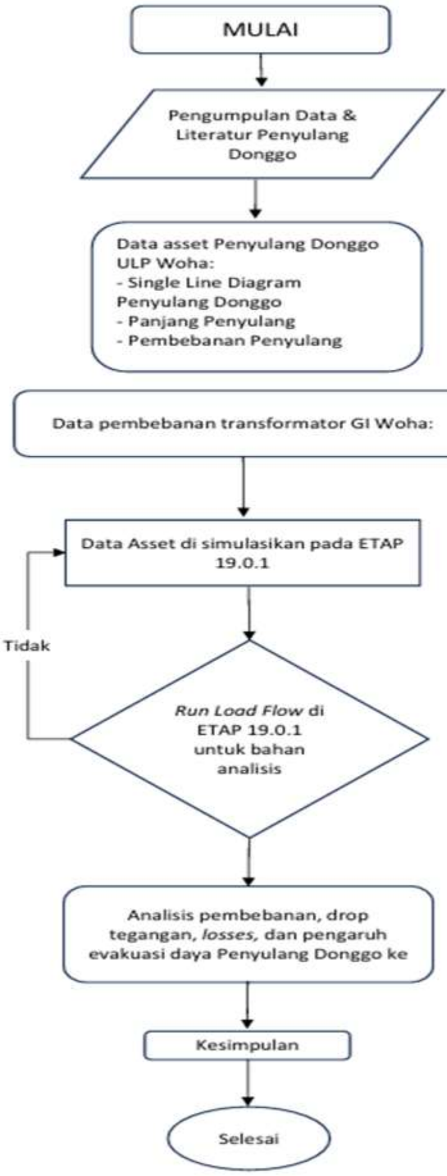


Figure 3. Research flow chart

3.2 DATA SOURCES

3.2.1 Primary Data

Technical data from direct measurements in the field at Donggo ULP Wohe feeders, such as measurements of feeder length, actual loading, and transformer operational conditions. Interviews and direct observations with PLN officers related to the operation and load of the distribution network. Real-time data monitoring from the measurement systems available at the Woha Substation and Donggo Feeder.

3.2.2 Secondary Data

The secondary data in this study is in the form of technical documentation and archive of historical data on load flow from PT PLN (Persero) ULP Woha. Single Line Diagram (SLD) and data parameters of the distribution network that have been documented. Transformer loading data as well as technical information on transformers and air ducts obtained from official reports and related literature. Previous Simulation and analysis data that has been published or stored as a reference.

3.3 DATA COLLECTION TECHNIQUES

Data collection is carried out through several main methods to ensure the accuracy and completeness of the information. First, field surveys and direct measurements were carried out to obtain primary data related to operational conditions and loading of donggo feeders. Second, an in-depth interview with PLN as a source of qualitative information related to procedures and operational constraints. Third, the study of technical archive documentation, historical reports, and monitoring of electricity distribution system data that is based on secondary research data. Data was collected systematically and triangulated for the validity of the results.

3.4 DATA ANALYSIS TECHNIQUES

The data analysis in this study was carried out using a quantitative approach by utilizing ETAP simulation software version 19.0.1 to conduct load flow analysis. The data has been put into the test and tested in simulations to identify loads, voltage drops, and power losses. The results of the simulation are statistically explained to produce the effect of the power of the Donggo Feeder on the system as a whole. Data interpretation is carried out by comparing conditions before and after treatment to provide valid and relevant results for network optimization.

3.5 RESEARCH LOCATION

This research was conducted at PT. PLN (Persero) ULP Woha which includes Donggo Feeder at the Bolo Connection Substation. The research was conducted using data from the simulation results of Donggo Feeders on *Software* ETAP 19.0.1 with input of asset management and measurement in September 2024. In this study, it does not discuss non-technical shrinkage. The time and implementation start from the preparation of the report to the collection of data, namely from April to June 2025.

RESULTS AND DISCUSSION

4.1 ELECTRICAL SYSTEM PT PLN (PERSERO) ULP WOHA

In this study, it was simulated based on a single line diagram on the Donggo feeder. The simulation was conducted using ETAP software version 19.0.1. The simulation process refers to the data or variables obtained from GH Bolo. The following is an image of the single line diagram that has been outlined in ETAP 19.0.1.

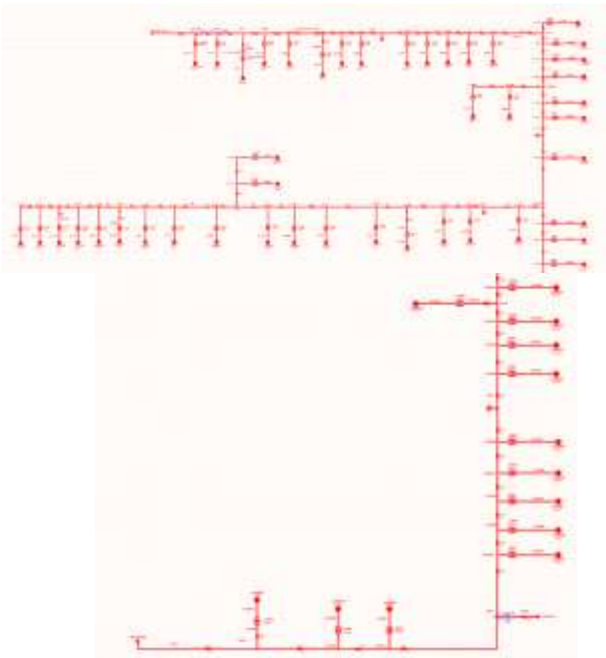


Figure 4. Single Line Diagram of Donggo Feeder in ETAP 19.0.1 application

4.2 ELECTRICAL SYSTEM PT PLN (PERSERO) ULP WOHA

In this study, it was simulated based on a single line diagram on the Donggo feeder. The simulation was conducted using ETAP software version 19.0.1. The simulation process refers to the data or variables obtained from GH Bolo. Here is a picture from *Single Line Diagram* which has been outlined in ETAP 19.0.1.

With the area served by PT. PLN (Persero) ULP Woha, ULP Woha has medium voltage network assets, distribution substations, and low voltage networks with the following details:

Table 1. JTM, Substation and JTR Woha Assets Recap

Description	Network Length (kMs)	Number of Substations	Number of Feeders
ULP Woha	511,403	352	19

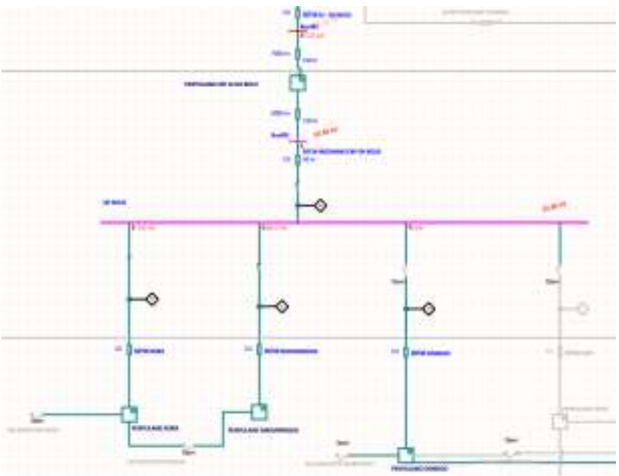
The simulation was carried out in two circumstances, namely before and after the breakdown of the Donggo Feeder's load, marked by the existence of Express GH Bolo. The first experiment is before the breakdown of the load, the flow of power (*Load Flow*) calculated with the load condition of the transformer fixed and the load presentation of all feeders is 100%. Second, the power flow simulation (*Load Flow*) after the breakdown of the load from Express GH Bolo and the load of the Donggo Feeder of 150 A with a feeder length of 96,282 kMs was transferred to the Woha Substation by building a new feeder, namely the Bajo Feeder which was simulated with a Medium Voltage Overhead Line length of 19,448 kMs.

4.3 ANALYSIS OF POWER FLOW BEFORE THE BREAKAGE OF THE DONGGO FEEDER LOAD

Power flow simulation is performed using *Software* ETAP 19.0.1. The reference data used is the load data in June 2025 obtained from PT. PLN (Persero) UP3 Bima.

The simulation was carried out in two circumstances, namely before and after the evacuation of the power of the Donggo Feeder, In the first experiment, the condition of loading the transformer was fixed and the presentation of all feeders was 100%. For the second experiment, the power flow after the power evacuation from the Bolo Express Substation (GH) was diverted to the Bajo Feeder from the Woha Substation.

Based on the flow diagram in Figure 2, it is known that the series of simulations of the Donggo feeder power flow before the load breakage is shown in Figure 3 below:



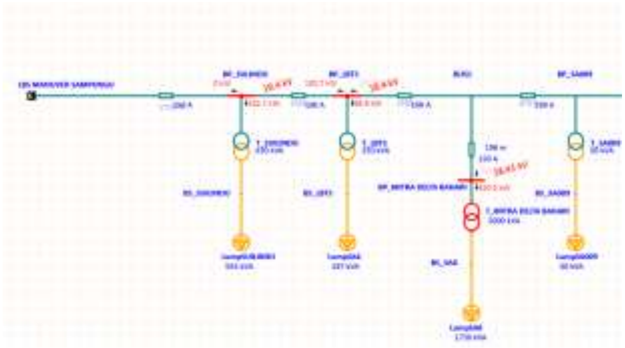


Figure 5. Simulation *of Single Line Diagram* of Donggo Feeder on ETAP 19.0.1 Before Power Evacuation

The simulation above shows that the Donggo Feeder is still supplied by Express Substation (GH) Bolo. The Donggo feeder has a JTM length of 96,282 kMs and is shown from *Running Load Flow* that the voltage at the end of the Donggo feeder is 18.4 kV, namely at the TM voltage to the Suilindo customer substation.

4.4 ANALYSIS OF POWER FLOW AFTER THE BREAKDOWN OF THE DONGGO FEEDER LOAD

Based on the image of the previous simulation series, it is known that the simulation series of Donggo feeder power flow after the load rupture is shown in Figure 4 below.

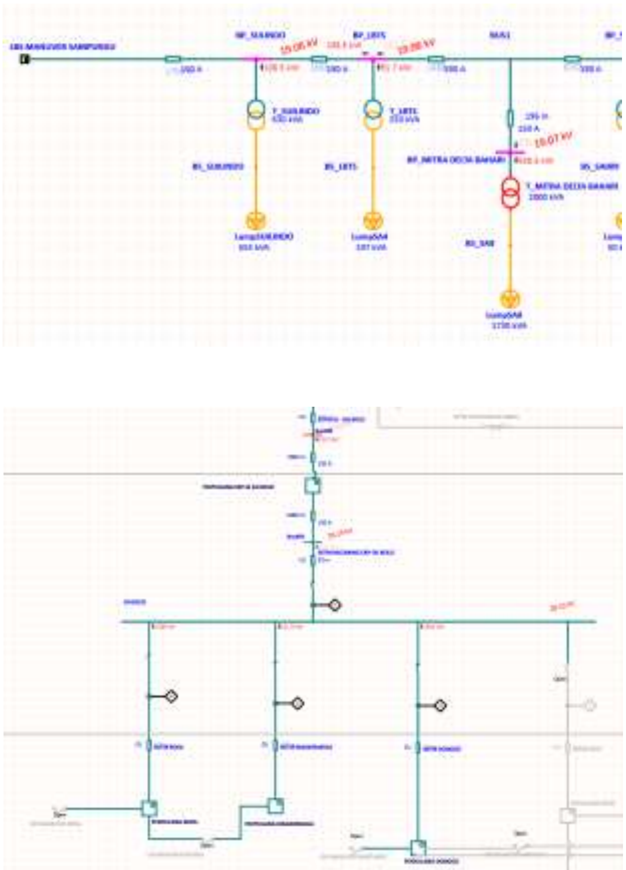


Figure 6. Simulation *of Single Line Diagram* of Donggo Feeder on ETAP 19.0.1 After Power Evacuation

The simulation above shows that the Power Evacuation was carried out from the Donggo Feeder to the new Feeder sourced from the Woha GI, namely the Bajo Feeder. With the construction of a new network of Medium Voltage Overhead Lines (SUTM) which was built along 19,448 kMs to connect the Donggo feeder which was originally supplied from Express GH Bolo to GI Woha. With the power evacuation, it is shown in *Running Load Flow* that the end voltage at the Bajo feeder is 19.06 kV.

Table 2. Rated End Voltage & Length of Donggo Feeder Network Before & After Power Evacuation

Donggo Feeder	Network Length (kMs)	Rated End Voltage (kV)
Before Power Evacuation	96,282	18,4
After Power Evacuation	115,73	19,06

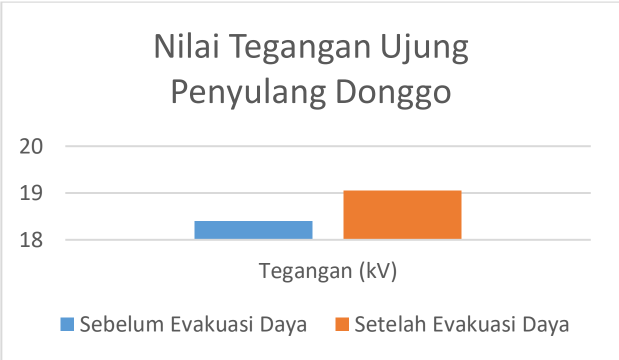


Figure 7. Diagram of the Voltage Value of the Donggo Feeder End Before and After Power Evacuation

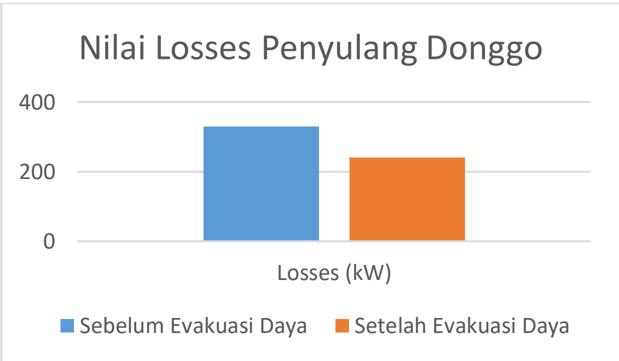


Figure 8. Diagram of the Voltage Value of the Donggo Feeder End Before and After Power Evacuation

4.5 DISCUSSION OF THE RESULTS ANALYSIS

From the simulation results *Load Flow* before the evacuation of the power of the Donggo feeder shown in Figure 4. by using *Software* ETAP 19.0.1, following the shrinkage from *Single Line Diagram* PT. PLN (Persero) ULP Woha on *Branch Losses Summary Report* below:

Table 3. *Branch Losses Summary Report* Before Evacuation of Donggo Feeder Power

Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag
	MW	Mvar	MW	Mvar	kW	kvar	From	To	
3366	0.771	0.435	-0.766	-0.436	5.0	-1.6	95.7	95.0	0.66
Line136-1-1	-0.047	-0.030	0.047	0.029	0.0	-0.7	100.2	100.2	0.00
Line153-1-1	-0.047	-0.030	0.047	0.027	0.0	-2.3	100.1	100.1	0.02
Line156-1-1	0.055	0.028	-0.055	-0.032	0.0	-3.9	100.2	100.1	0.06
Line157-1-1	-0.062	-0.033	0.062	0.032	0.0	-0.5	100.2	100.2	0.00
Dst									
T_SA009	0.013	0.008	-0.013	-0.008	0.1	0.2	92.5	91.3	1.21
T_SUILINDO	0.103	0.064	-0.102	-0.063	0.6	0.9	92.0	91.2	0.76
T1_GI WOHA	4.357	2.892	-4.353	-2.721	3.8	170.9	100.0	102.1	2.10
T2_GI WOHA	0.000	0.000	0.000	0.000	0.0	0.0	100.0	102.5	2.50
					330.4	122.4			

* This Transmission Line includes Series Capacitor.

In Table 3 above, you can see the system shrinkage from the simulation results *Load Flow* before the break, the load of the Donggo feeder was 330.4 kW. Meanwhile, from the simulation results *Load Flow* after the evacuation of the Donggo feeder power to the Bajo feeder shown in Table 4 using *Software* ETAP 19.0.1, shrinkage of the Donggo feeder system in *Branch Losses Summary Report* (Table 3) is 240.6 kW.

Table 4. Calculation *of kWh Saving* After Evacuation of Donggo Feeder Power

Technical depreciation at BP	(kW)
Before Breaking the Load	330,4
After Load Break	240,6
Difference	**89,8**

Technical Depreciation Per Year	(kWh/year)
Before Breaking the Load	2.894.304,0
After Load Break	2.107.656,0
Difference	**786,648**

From the above results, it was obtained *that the kWh saving* from the Evacuation of Donggo Feeder Power to Bajo Feeder at PT. PLN (Persero) ULP Woha at the time of the peak load at night is:

330.4 kW – 240.6 kW = 89.8 kW

Known *Load Factor* (LF) PLN ULP Woha obtained from data from PT. PLN (Persero) UP3 Bima in 2022, which is 0.54, so it is obtained *Saving* kWh in 1 year:

89.8 kW x 24 hours x 365 days = 786.648 kWh/year

Conclusion

Based on the results of the analysis of the improvement of the end voltage at the Donggo feeder through the power evacuation method at PT. PLN (Persero) ULP Woha, can be concluded the following.

a. Based on the results of the simulation that has been carried out, the amount of end voltage at the Donggo Feeder before power evacuation is 18.4 kV.
b. The amount of end voltage at the Bajo feeder after power evacuation is 19.06 kV.
c. The construction of a new feeder, namely the Bajo Feeder from the Woha Substation along 19.448 kMs, is planned as a measure to evacuate power at the Donggo Feeder and change the limit voltage value from the original 18.4 kV to 19.06 kV.
d. The value of the end voltage after evacuation on the medium voltage network of 19.06 kV has met the SPLN standard No. 72 of 1987.
e. As a result of this power evacuation simulation, a *kWh saving* of 786,648 kWh/year was obtained.

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