# Study of Measurement and Consideration of Energy Sustainment on The Electric Power Distribution System of PT PLN (Persero) ULP Pasir Pangaraian

M. Ridwan Hidayatulloh
e-mail: rwanwan23@gmail.com
Pristisal Wibowo
e-mail: pristisalwibowo@dosen.pancabudi.ac.id
Siti Anisah
e-mail: sitianisah@dosen.pancabudi.ac.id

Universitas Pembangunan Panca Budi

**Abstract**

Depreciation is an important discussion at this time because it is related to the quality of power that will be delivered to consumers and opens up potential income for the State Electricity Company (PLN) because the losses that occur in the network will reduce the potential for power sales by PLN. In general, power depreciation can be divided into two types, namely technical depreciation, which occurs as a result of impedance in generation equipment and distribution equipment in transmission and distribution so that there is power lost in the form of heat. power depreciation is impossible to avoid because the equipment cannot have a 100% efficiency level, but what needs attention is whether the depreciation that occurs within reasonable limits. Most of the existing depreciation is suspected to be in the distribution network. From the results of the research that has been done, the results obtained The average load current measured for approximately one month from April to May 2025 shows the highest average load at 14.00, namely Phase R = 405 A, Phase S = 351 A and Phase T = 448 A. The percentage of WBP loading based on connected power from PLN reaches up to 80%. Percentage of Peak Load Time (WBP) loading on the transformer reaches up to 70%.

**Keywords**: ***Measurement and Calculation of Energy Losses in Power Distribution Systems***

## Introduction

In an electric power system there is a factor called the loss factor or depreciation of power. This depreciation can be found in various places on the electric power network, ranging from generation, transmission, to distribution to consumers. Depreciation is an important discussion at this time because it is related to the quality of power that will be delivered to consumers and opens up potential revenue for the State Electricity Company (PLN) because the losses that occur in the network will reduce the potential for power sales by PLN. In general, power depreciation can be divided into two types, namely technical depreciation, which occurs as a result of impedance in generation equipment and distribution equipment in transmission and distribution so that there is power lost in the form of heat. Non-technical shrinkage is caused by errors in the reading of measuring instruments, calibration errors in measuring instruments, and errors due to unauthorized use (theft) or other administrative errors.

However, it should be noted that power depreciation is impossible to avoid because the equipment cannot have a 100% efficiency level, but what needs attention is whether the depreciation that occurs is within reasonable limits. Most of the existing shrinkage is suspected to be in the distribution network. So it is done in this study to determine the amount of energy shrinkage that occurs in the electric power distribution network and analyze the value of the energy shrinkage, through measurement and calculation methods

## Literature Review

### 2.1 Electric Power System

The Electric Power System is said to be a collection / combination consisting of equipment or electrical devices such as generators, transformers, transmission lines, distribution lines and loads that are interconnected and are a single unit so as to form a system. The block diagram of the electric power system can be described as in the following figure:

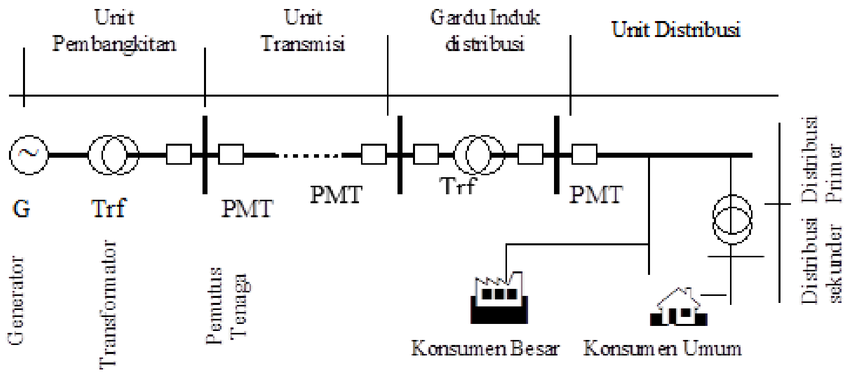


**Figure 1. Power System Installation**

Electric power generated by large power plants with voltages from 11 kV to 24 kV is raised by the substation with a voltage boosting transformer to 70 kV, 154kV, 220kV or 500kV and then channeled through the transmission line. The purpose of raising the voltage is to minimize electric power losses on the transmission line.

### 2.2 Electric Power Distribution

There are two ways of distributing electricity to residential areas, including through distribution substations or through local distribution.

### 2.3 Distribution substation

Power distribution using distribution substations uses a three-phase system for medium voltage networks (JTM) and low voltage networks (JTR) with three-phase transformers with a large enough capacity. The low voltage network is drawn from the secondary side of the transformer and then distributed to consumers. Transformer substations for general and special consumers.

1. Wall Substation for SKTM
2. Wall Substation for SUTM
3. kiosk substation
4. Pole Substations: Portal, Cantol

### 2.4 Distribution Voltage

Voltage for distribution networks can be divided into several types, including:

1. Primary Distribution System
2. Secondary Distribution System
3. Service voltage, service voltage is a provision of electric power providers for customers. In Indonesia the amount of service voltage in general, among others: 380/220 V three phase four wire. 220 V one phase two wires. 20 kV three-wire phase. 12 kV three-wire phase. 6 kV three phase three wire

### 2.5 Power Quality

#### 2.5.1 *Peak Demand Load*

Peak power is the maximum load operation, the amount of peak load is a reference to determine the amount of kVA capacity subscription to PLN Electricity producers. Determination of kVA capacity must be adjusted to the magnitude of the peak load in order to achieve an optimum between efforts to meet the capacity of the peak load with an effort to minimize the amount of Kva subscription

#### 2.5.2 Power Faktor

Power factor is the phase shift between voltage and current, obtained from the multiplication of complex numbers. Power factors can be leading and lagging PF leads are generally caused by capacitive loads, while lagging power factors are caused by inductive loads.

#### 2.5.3 Energy Depreciation in Distribution Networks

Loss - loss or commonly referred to as energy shrinkage is a common phenomenon where a system cannot have 100% efficiency. Energy depreciation in this distribution network can be divided into several parts, including:

1. Energy depreciation on the repeate
2. Energy depreciation in distribution transformers
3. Energy depreciation at the junctio

## Research Methodology

### 3.1 Medium Voltage Shrinkage

The shrinkage of the medium voltage network can be determined based on AMR measurements, namely the difference in energy (kWh) sent by the repeater and the amount of energy measured at each distribution substation. To find the voltage losses by using the following equation:

$$\Delta V = V_k - V_t \quad (1)$$

Dimana:

$V_k$ = Absolute value of send end voltage

$V_t$ = Absolute value of receive end stress

To calculate the amount of energy loss using the equation below:

$$kWh_{SET} = kWh_I - kWh_O \quad (2)$$

Where:

$S_{ET}$ = Total Energy Loss

$kWh_I$ = kWh Input

$kWh_O$ = kWh Output

To find the conductor shrinkage based on the basic power shrinkage formula, namely using the following equation:

$$P = 3\,x\,I^2\,x\frac{R}{3} \tag{3}$$

Where:
P = Power losses at the conductor (Watt)
R = Total resistance of the conductor (Ω)
I = Average load current (A)

### 3.2 Low Voltage Network Shrinkage

Low voltage network losses can be determined based on energy measurements on the outgoing TR rack using a Power Quality Analyzer (PQA) and the energy recorded on the customer's kWh Meter. Low voltage network shrinkage is the difference between the energy (kWh) delivered from the distribution substation and the amount of energy recorded in all kWh meters in the relevant department.

$$W_{JTR1} = W_{1TR} - W_{0TR}$$

$$W_{JTR3} = W_{1JTR}\,X\,\frac{W_3}{(W_3 + W_1}(kWh) \tag{4}$$

$$\%\Delta_{JTR} = \frac{W_{1JTR} - W_{0JTR}}{W_{1JTR}}x100\% \tag{5}$$

Dimana :
$W_{JTR\ 1}$ = Single-phase JTR energy
$W_{JTR\ 3}$ = 3-phase JTR energy
$W_{I\ JTR}$ = JTR Incoming Energy
$W_{OJTR}$ = JTR Outgoing Energy

### 3.3 Distribution substation shrinkage

Distribution substation shrinkage consists of two parts, namely TR rack shrinkage and transformer shrinkage. The total distribution substation shrinkage is the sum of the shrinkage on the TR rack and the transformer shrinkage. TR rack shrinkage can be determined based on the measurement results using a Power Quality Analyzer (PQA) installed on the incoming TR rack and all outgoing TR racks. The amount of TR rack shrinkage is the difference between the energy measured on the incoming TR rack and the total energy measured on all outgoing TR racks. Load Imbalance in Transformers Transformer power when viewed from the high voltage side (primary) can be formulated as follows:

$$S = \sqrt{3}x\,V\,x\,I \tag{6}$$

Where :
S = Transformer power (kVA)
V = Transformer primary side voltage (kV)
I = Mesh current (A)

$$\%\Delta_{TR} = \frac{W_{PTR} - W_{STR}}{W_{PTR}}x100\% \tag{7}$$

$$W_L = I^2 R$$

$$R = \frac{W_L}{I^2} \tag{8}$$

Where:
$W_{TR}$ = Rack energy, low voltage
$W_{P\ TR}$ = Low voltage primary energy
$W_{S\ TR}$ = Low voltage secondary energy
To find the losses of the transformer is simply written with the following equation:

$$P(Losses) = P_O + A^2.P_b \tag{9}$$

Where:
Po = Zero load loss
Pb = Losses due to energy transfer from the primary to the secondary side (Impedance loss) whose magnitude depends on the transformer loading.
A = Loading factor = load / nominal load

To find the 3-phase tarfo alternating current is as follows:

$$I = \frac{P}{\sqrt{3}.V_K.Cos\varphi} \tag{10}$$

Where:
I = Load current (Ampere)
P = Required power (Watt)
Cos φ = Power factor
$V_K$ = Maximum Working Voltage (Volt)
To calculate the full load current, you can use the following equation:

$$I_{FL} = \frac{S}{\sqrt{3}.V} \tag{11}$$

Where :
$I_{FL}$ = Full Load Current (A)
S = Transformer Power (KVA)
V = Transformer secondary side voltage

As a result of the load imbalance between each phase on the secondary side of the transformer (phase R, phase S, phase T) the current flows in the transformer neutral. The current flowing in the neutral conductor of this transformer causes losses. Losses on the neutral conductor of this transformer can be calculated by the following equation:

$$P_N = I_N{}^2 x R_N \tag{12}$$

Where :
$P_N$ = Transformer neutral conductor losses (Watt)
$I_N^2$ = Neutral current in the transformer (A)
RN = Transformer neutral conductor resistance (Ω)

While the losses caused by the neutral current flowing to the ground (ground) can be calculated with the following equation:

$$P_G = I_G{}^2 x R_G \tag{13}$$

Where:
$P_G$ = Losses due to neutral current flowing to ground (Watt)
$I_G$ = Neutral current flowing to ground
$R_G$ = Transformer neutral earth resistance (Ω)

## Conclusion

From the results of the research that has been done, it can be concluded as follows:

a. The average load current measured for approximately one month in April to May 2025 shows the highest average load at 14:00, namely Phase R = 405 A, Phase S = 351 A and Phase T = 448 A.
b. Percentage of WBPs loading based on connected power from PLN reaches up to 80%.
c. Percentage of Peak Load Time (WBP) loading on the transformer reaching up to 70%.

## References

[1] Repka Cipta Pramudita, Hamdani, Rahmaniar, 2025 "Analysis of the Effect of Ordering Electricity Usage on Reducing Non-Technical Shrinkage at PT PLN (Persero) ULP Tapaktuan" Journal of Engineering Research Volume.4, Number.1April2025E-ISSN : 2829-016X; P-ISSN: 2829-0178, Page 333-33.

[2] Rahmat Pandapotan Siagian, Muhammad Erpandi Dalimunthe , Parlin Siagian, 2024 "Performance Analysis of Modification of One Phase Measuring and Limiting Devices in Customers That Cause Non-technical Shrinkage at Pt.Pln Ulp Meulaboh" JITET (Journal of Applied Informatics and Electrical Engineering) Vol. 12 No. 3, pISSN: 2303-0577 eISSN: 2830-7062 http://dx.doi.org/10.23960/jitet.v12i3.5098.

[3] Nico Ewaldo Fan Gulo, Pristisal Wibowo, Ahmad Dani, 2025 "Analysis of Voltage Drop and Power Losses on 275 Kv Transmission Lines with 5 Buses Using Matlab Simulation" Journal of Artificial Intelligence and Digital Business (RIGGS) Vol. 4 No. 2 (2025) pp: 1392-1399 P-ISSN: 2963-9298, e-ISSN: 2963-914X.

[4] Renaldi Bayu Pratama, Pristisal Wibowo, Siti Anisah, 2025 "Analysis of the Effect of Conductor Replacement on 20kV Medium Voltage Air Lines on Voltage Drop at PT. PLN (Persero) UP3 Bangkinang" Journal of Innovative Research (JUPIN) Vol. 5, No. 2, May 2025, Pp. 803-812 p-ISSN: 2808-148X e-ISSN: 2808-1366.

[5] Fitria Anis, Dicky Lesmana, Parlin Siagian, 2024 "Analysis of the Effect of Preventive Maintenance of the 20kV Distribution Network on the Gu.03 Extension to the Network Reliability Index at PT PLN (Persero) ULP Medan Timur" Journal of Serambi Engineering Volume IX, No.4, October 2024 p-ISSN: 2528-3561 e-ISSN: 2541-1934.

[6] Henrey Daniel Dalam, 2021 Seminar Nasional Informatika 2021 "Analysis of Energy Shrinkage in the Distribution Network System at Pt. Pln Apj Yogyakarta Upj Wonosari Unit Semanu" (semnasIF 2021) ISSN: 1979-2328.

[7] Sugianto, Puspa Untara, 2020 "Study of Energy Shrinkage in Electric Power Distribution Systems Through Measurement and Calculation Analysis" Sinusoida E-Journal ISTN Vol. XXI No. 2, April 2019 ISSN 1411 - 4593.

[8] Nadhila Sharfina, Syukriyadin , Suriadi, 2024 "Analysis of Medium-Term Energy Shrinkage Prediction of 20 kV Distribution System Through the Reasonableness of Customer Energy Consumption, Case Study at PT. PLN (Persero) UP3 Langsa" Journal of Computers, Information Technology, and Electrical Vol.9 No.2 2024: 92-99 e-ISSN: 2252-7036.

[9] Mohammad Wozali, Usman, Purwito, 2023 "Analysis of Non-Technical Electric Energy Shrinkage on Prepaid Kwh Meters at PT PLN (Persero) Palopo Kota Customer Service Unit (ULP)" Journal of Elekterika Technology Volume 20 (2): 80-86 e- ISSN 2656-0143.

[10] Syukri, Muliadi, dan Ali Akbar, 2024 "Analysis of Technical Shrinkage Calculation at Pt. Pln (Persero) Rayon Singkil" Jurnal Elektrika Vol. 16 No. 1 April 2024 P-ISSN 2085-0565 | E-ISSN 2580-8486.