Non-Technical Loss Analysis Based on kWh Meter Maintenance Aspects at PT. PLN (Persero) UP3 Situbondo

Rizka Danny Kireinawati,Rahmaniar, Hamdani

Abstract

During the process of electricity distribution, there is a loss of electrical energy that comes from the difference between the amount of energy produced and the amount sold. This is referred to as losses. Losses are classified into two types: technical losses and non-technical losses. Non-technical losses represent the loss of electrical energy due to unmeasured energy caused by disturbances in measuring instruments (kWh meters). These disturbances may include aged kWh meters, blurry meters, damaged or broken meter covers, blank LCD displays, non-rotating meter disks, and burned or lightning-struck meter terminals. This study employs both qualitative and quantitative methods. The collected data consists of the realization of kWh meter replacements experiencing disturbances from January to June 2024. Based on these data, the total percentage of non-technical losses experienced by PLN Situbondo is 0.65%. Meanwhile, the percentage contribution of kWh meter disturbances to non-technical losses is 0.0076%. During the disturbance period, electricity consumption was recorded at 244,871 kWh. However, after the kWh meter repairs, consumption increased to 274,648 kWh. Therefore, the improvement in losses reached 29,777 kWh, equivalent to Rp 20,758,691. Other benefits include improved operational efficiency for PLN and increased accuracy in customers' electricity billing readings. This minimizes meter reading errors. Thus, replacing kWh meters is an effective way to reduce such losses.

***Keywords*: kWh Meter Disturbances, Non-Technical Losses, Impact of kWh Meter Replacement.**

Rizka Danny Kireinawati[1]
[1]Electrical Engineering Study Program, Universitas Pancabudi Medan, Indonesia.
e-mail: rizkadanny20@gmail.com

Rahmaniar[2], Hamdani[3]
[2,3]Lecturer at the Faculty of Engineering, Universitas Pancabudi Medan, Indonesia.
e-mail: [2]rahmaniar@dosen.pancabudi.ac.id,[3]hamdani.stmt@dosenpancabudi.ac.id

Introduction

PT PLN (Persero) is one of the state-owned enterprises (BUMN) that focuses on the electricity sector. Currently, PLN is responsible for distributing electricity throughout all regions of Indonesia. In the electricity distribution process, PLN frequently encounters several challenges, one of which is losses. Losses refer to the loss of electrical energy that occurs due to the difference between the amount of energy produced and the amount of energy sold, and this becomes one of the sources of financial loss for PT PLN (Persero) because the energy that should be delivered to customers and recorded on the kWh meter becomes unaccounted for, ultimately reducing PLN's electricity sales [4].

In providing electricity distribution services, PLN divides the functions of its parent units into several main units based on the power system, namely generation, transmission, and distribution. Due to the vast operational coverage of PLN, these parent units are further divided into several regional units, such as UID JATIM, which serves as an extension of the central office in providing electricity distribution services. UID JATIM oversees 16 UP3 offices. UP3 is an implementing unit under the distribution parent unit and serves as a smaller operational division, enabling PLN to be more focused and directly reach the community. Among the 16 UP3 under UID JATIM, UP3 Situbondo is the focus of this research. UP3 Situbondo has five ULPs: ULP Panarukan, ULP Besuki, ULP Asembagus, ULP Bondowoso, and ULP Wonosari.

Based on data from PLN UP3 Situbondo in December 2023, losses amounted to 7.61%, consisting of 6.8% technical losses and 0.8% non-technical losses. From these realization data, PT PLN UP3 Situbondo is required to improve its performance to provide optimal service in terms of reliability, energy supply availability, and efficient electricity distribution to minimize losses or energy leakage. High loss realization has the potential to reduce revenue, whereas decreasing losses results in greater efficiency and increased revenue.

One cause of non-technical losses is the inaccuracy or malfunction of kWh meters [3]. On average, there are around 500 disturbances each month in 1-phase postpaid kWh meters for R1 (household) tariff customers that require meter replacement. Disturbances that require replacement include: aged meter program, special-case maintenance program, blurry kWh meters, damaged or broken covers, blank/defective LCD displays, non-rotating meter disks, and meter terminals that have burned or been struck by lightning.

Based on the above aspects and background, this research, titled "Analysis of Non-Technical Losses Based on kWh Meter Maintenance Aspects at PT PLN (Persero) UP3 Situbondo," is conducted with the expectation that the electricity consumed by customers can be accurately measured. This will help reduce non-technical losses resulting from unrecorded energy that is not sold to customers.

Literature Review

2.1 Losses (Susut)

Electrical energy loss is a phenomenon in which electrical energy disappears during the distribution process from the substation to the consumer (Issue & Kunci, 2023). This energy loss is caused by various distribution equipment losses such as transmission networks, substations, medium-voltage distribution networks, distribution transformers, and low-voltage distribution networks. In addition, illegal electricity usage and suboptimal measuring and limiting devices also contribute to electrical energy loss.

Electrical energy loss is categorized into two types: technical losses and non-technical losses. Technical losses refer to the loss of electrical energy caused by the conductivity quality of distribution equipment, such as transmission networks, substations, medium-voltage distribution networks, distribution transformers, and low-voltage networks. The better the conductivity quality, the smaller the technical losses (Surusa et al., 2024).

Meanwhile, non-technical losses refer to the loss of electrical energy due to unmeasured consumption by the metering device. This occurs due to several factors, including electricity theft, damaged kWh meters, aged kWh meters, wiring errors on the meter, and incorrect current transformer ratios.

2.2 kWh Meter

A Kilo Watt Hour (kWh) meter is a device used to measure electricity consumption and is commonly used by electricity customers. It also functions as an energy transaction device because it contains components that record the amount of energy consumed by consumers. The kWh meter directly measures the product of voltage, current, power factor, and time ($V \times I \times \cos\varphi \times t$). Electricity usage by consumers is measured in kilowatt-hours (kWh) (Wozali et al., 2023).

Method

3.1 Observation Technique

The observation technique is a direct observation method conducted by the researcher. This includes collecting data on the realization of 1-phase postpaid kWh meter replacement for R1 (Household) tariff customers in the UP3 Situbondo area during the period of January to June 2024, which will be used as evaluation material for the identified problems.

3.2 Interview Technique

The interview technique is an essential method for obtaining informational data. This technique includes conducting interviews with supervisors, senior employees, and field officers.

3.3 Document Study

This data collection technique involves using documents as one of the information sources to complement the research. The documents used may include written documents, photos, and videos.

Data Collection:

a. Collecting data on the realization of 1-phase postpaid kWh meter replacement for R1 (Household) tariff customers in UP3 Situbondo for the period of January to June 2024
b. Collecting electricity billing data for the period of January to June 2024
c. Collecting loss calculation data for the period of January to June 2024

3.4 Case Analysis Technique

Case analysis is a method used to investigate phenomena and events related to individuals. It focuses on customers whose electricity consumption decreased based on data grouping by type, as well as the realization data of technical and non-technical disturbances on 1-phase postpaid kWh meters.

Data Analysis:

a. Analyzing electricity consumption at PLN UP3 Situbondo for customers whose kWh meters experienced disturbances
b. Analyzing the financial losses experienced by PLN during kWh meter disturbances

3.5 Perpetrator Identification

Identifying the causes of disturbances in 1-phase postpaid household kWh meters across all ULPs (Customer Service Units). The basis for identifying disturbances is obtained from the realization data of postpaid kWh meter replacements.

3.6 Victim Losses

PT PLN (Persero) UP3 Situbondo is the victim, as the disturbances cause consumers' electricity usage to be inaccurately measured. As a result, PLN experiences losses known as "losses," which can be simply explained as the situation where the amount of electricity purchased by the distribution unit is greater than the amount measured on the consumer side.

3.7 Case Handling

Case handling in this study discusses disturbances found in 1-phase postpaid household kWh meters. These disturbances include the aged meter program, special-case meter maintenance program, blurry kWh meters, damaged/broken covers, blank/defective LCD displays, non-rotating meter disks, and meter terminals that burned or were struck by lightning. These issues reduce measurement accuracy and must be addressed in order to reduce losses at PLN.

Figure 1. Data Analysis Flow Chart

Results and Discussion

Case Analysis

Data Analysis:

a. Conducting an analysis of the causes of disturbances in 1-phase postpaid kWh meters for R1 (Household) tariff customers.
b. Conducting an analysis of electricity consumption recorded by disturbed kWh meters.
c. Conducting an analysis of PLN's financial losses during the kWh meter disturbances.

4.1 Types of kWh Meter Disturbances per Month (January–June 2024)

Table 1. kWh Meter Disturbance Data – January 2024

Type of Disturbance	Quantity
Blurry meter cover	2
Damaged / broken meter cover	1
LCD display blank/defective/dead	5
Meter considered excessive (high usage)	1
Meter disk not rotating	4
Aged meter program	599
Special-case meter maintenance program	256

Burned meter terminal	2
Total Disturbances	870

Table 2. kWh Meter Disturbance Data – February 2024

Type of Disturbance	Quantity
Blurry meter cover	21
Damaged / broken meter cover	6
LCD display blank/defective/dead	12
Meter disk not rotating	25
Meter damaged due to natural disaster	1
Aged meter program	317
Special-case meter maintenance program	86
Burned meter terminal	3
Total Disturbances	471

Table 3. kWh Meter Disturbance Data – March 2024

Type of Disturbance	Quantity
Blurry meter cover	8
Meter ex-P2TL	2
Meter disk not rotating	1
Meter burned/lightning strike	1
Aged meter program	58
Special-case meter maintenance program	39
Total Disturbances	109

Table 4. kWh Meter Disturbance Data – April 2024

Type of Disturbance	Quantity
LCD display blank/defective/dead	6
LCD showing error/abnormal	4
Edrum register not rotating	3
Meter ex-P2TL	4
Meter disk not rotating	2
Aged meter program	36
Special-case meter maintenance program	39
Burned meter terminal	2
Total Disturbances	96

Table 5. kWh Meter Disturbance Data – May 2024

Type of Disturbance	**Quantity**
LCD display blank/defective/dead	8
Aged meter program	787
Special-case meter maintenance program	26
Relay failure	2
Burned meter terminal	1
Total Disturbances	**824**

Table 6. kWh Meter Disturbance Data – June 2024

Type of Disturbance	Quantity
Blurry meter cover	7
LCD display blank/defective/dead	5
Meter disk not rotating	1
Meter damaged due to natural disaster	3
Broken meter communication port	1
Aged meter program	771
Special-case meter maintenance program	24
Total Disturbances	**812**

Table 7. Recap of Disturbances January–June 2024

Type of Disturbance	Quantity	%
Blurry meter cover	38	1.19%
Damaged / broken meter cover	7	0.22%
LCD display blank/defective/dead	36	1.13%
LCD showing error	4	0.13%
Meter considered excessive	1	0.03%
Edrum register not rotating	3	0.09%
Meter ex-P2TL	6	0.19%
Meter disk not rotating	33	1.04%
Meter damaged due to natural disaster	4	0.13%
Meter burned/lightning strike	1	0.03%
Broken communication port	1	0.03%
Aged meter program	2,568	80.70%
Special-case maintenance program	470	14.77%
Relay failure	2	0.06%
Burned meter terminal	8	0.25%
Total Disturbances	3,182	100%

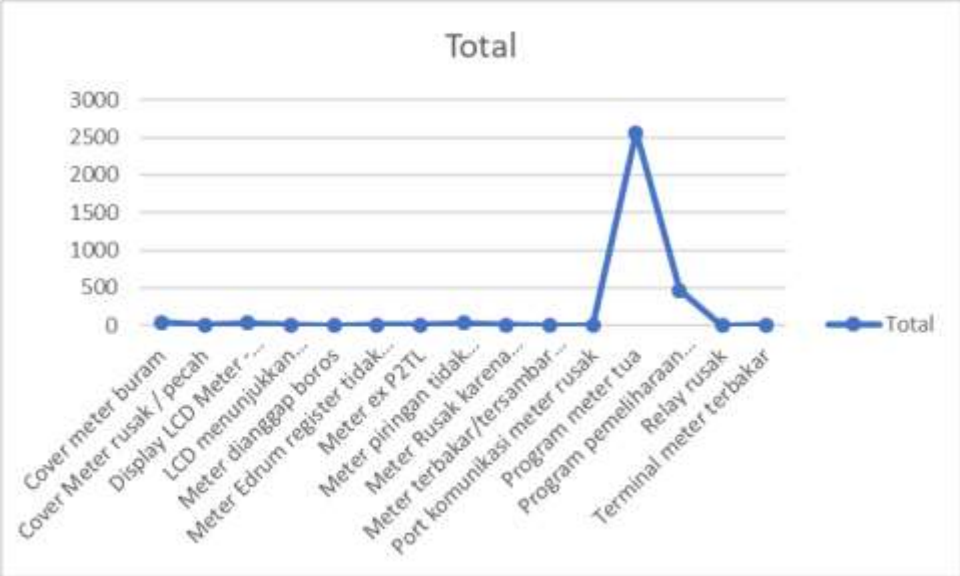

Figure 2. Summary Graph of kWh Meter Interruptions from January to June 2024

The highest disturbance recorded from January to June 2024 is the Aged Meter Program, totaling 2,658 cases, representing 80.70% of all disturbances.

4.2 Electricity Consumption Data of Customers Affected by kWh Meter Disturbances

Table 8. Electricity Usage of Customers Experiencing kWh Meter Disturbances

Item	Jan	Feb	Mar	Apr	May	Jun	Total
Number of disturbed customers	870	471	109	96	824	812	3,182
kWh usage during disturbance	75,648	33,820	5,710	3,240	57,112	69,341	244,871
kWh usage after replacement	79,139	35,029	11,310	6,880	67,525	74,765	274,648
Electricity bill during disturbance (Rp)	64,051,008	23,262,270	7,036,149	3,236,036	39,247,311	57,557,540	194,390,314
Electricity bill after replacement (Rp)	64,466,567	24,062,751	11,248,360	8,375,392	46,138,141	60,857,794	215,149,005
PLN losses (kWh)	3,491	1,209	5,600	3,640	10,413	5,424	29,777
PLN losses (Rp)	415,559	800,481	4,212,211	5,139,356	6,890,830	3,300,254	20,758,691

In the table above, it can be seen that there is a significant value in the use of electrical energy during the disruption and after the repair of the kWh Meter. At the time of the disruption, electricity usage was 244,871 kWh, while after the repair it reached 274,648 kWh. Likewise with the electricity bill paid, at the time of the disruption, the electricity bill was Rp. 194,390,314 but after the repair it reached Rp. 215,149,005. So according to the calculation, the loss experienced by PLN was Rp. 20,758,691 for 1 (one) Semester 2024. This loss only includes the losses caused by the disruption of the Postpaid 1 Phase kWh Meter Tariff R1 (Household).

4.3 Non-Technical Losses

Table 9. Non-Technical Losses – December 2023

Region	kWh Purchased	kWh Sold	Non-Technical Loss (kWh)	Non-Technical Loss (%)
UP3 Situbondo	66,060,547	66,177,325	529,925	0.80

Table 10. Non-Technical Losses – Semester 1, 2024

Region	kWh Purchased	kWh Sold	Non-Technical Loss (kWh)	Non-Technical Loss (%)
UP3 Situbondo	389,798,889	354,485,748	2,543,962	0.65

In the two tables above, it can be explained that there was a decrease in non-technical losses between December 2023 (conditions when the kWh Meter disruption occurred) and in the period from January to June 2024 (conditions after repairing the kWh Meter affected by the disruption). In the table above, it can be explained that non-technical losses in December 2023 reached the equivalent of 0.80% but in semester 1 (one) 2024 there was a decrease in losses reaching 0.65% of the total losses. The percentage of kWh Meter disruption to Non-Technical Losses of PT. PLN UP3 Situbondo Semester 1 (one) is 0.0076%.

Table 11. Work Contract for 1-Phase Postpaid kWh Meter Replacement

No	Item	Qty	Unit Price
1	Replacement of 1-phase postpaid kWh meter (Situbondo)	1	Rp 50,700
2	Basket for used kWh meters (capacity 750 meters)	1	Rp 1,254,000

Table 12. Material Prices (Electronic 1-Phase kWh Meter)

No	Item	Unit Price
1	1-Phase electronic postpaid kWh meter	Rp 175,852
2	1-Phase electronic prepaid kWh meter	Rp 338,350

Table 13. Total Material and Service Costs

No	Item	Unit Price
1	1-Phase electronic postpaid kWh meter	Rp 175,852
2	kWh meter replacement service	Rp 52,372
	Total Material Cost	**Rp 228,224**

VAT (11%)	**Rp 25,105**
Grand Total	**Rp 253,329**

The table above explains that the replacement price for a single-phase postpaid kWh meter is Rp. 253,329 per customer. Based on the Regulation of the Minister of Trade of the Republic of Indonesia Number 68 of 2018 concerning the Calibration and Re-Calibration of Measuring, Dosing, Weighing Instruments and Their Equipment, it states that the Electromechanical/Dynamic kWh Meter has a Re-Calibration Period of 15 years. Meanwhile, the Electronic/Static kWh Meter has a Re-Calibration Period of 10 years.

Table 14. Cost Comparison: Replacement vs. Losses

Item	Value
kWh Meter Replacement Cost	Rp 253,329 per customer
Maintenance cost	Rp 2,111 per month per customer
PLN Losses (1 Semester)	Rp 20,758,691
Loss per customer	Rp 6,524

The table above shows that the cost of maintaining a kWh meter is less than the losses incurred by PLN. Another advantage of replacing a kWh meter is that it saves PLN money and improves operational efficiency and the accuracy of customer electricity bill readings. This minimizes meter reading errors.

Conclussion

Based on this research, data on kWh meter disturbances were collected on 1-phase postpaid customers with R1 (Household) tariffs, with the largest indication being an old kWh meter. In 1 (one) semester, PLN's losses reached Rp. 20,758,691, so the solution to this problem is to replace the kWh meter for customers affected by the disturbance because this is considered more effective in reducing PLN's losses. Further research is recommended to examine the causes of losses caused by kWh meters in medium voltage power customers (>200kva). This is because large power customers have high energy consumption, so even though the percentage of losses is the same as small power customers, the energy lost is much greater. In addition, for large power customers (Medium Voltage), the electricity network is directly connected to the PLN TM (Medium Voltage) network so that the current flowing is greater, this causes more significant electrical energy losses. This conclusion is expected to provide better knowledge regarding the topic of non-technical loss analysis in terms of kWh meter repair.

Reference

[1] S. Andaresta, A. Prof, I. Hermansyah, S. Kom, and D. Ph, ‘ANALISIS GANGGUAN PADA KWH METER DI PT PLN (PERSERO) ULP TALUK KUANTAN DENGAN METODE FAULT TREE ANALYSIS (FTA) ANALISIS GANGGUAN PADA KWH METER DI PT PLN (PERSERO) ULP TALUK KUANTAN DENGAN METODE FAULT TREE ANALYSIS (FTA)’.

[2] T. T. Seno, N. M. F. A. Putri, and H. E. Patoding, ‘Analisa Gangguan Teknis Pada Kwh Meter Prabayar 1 Phasa Guna Menjaga Kualitas Pelayanan Pelanggan di PT PLN (PERSERO) ULP Jayapura’, *Nucleus*, vol. 5, no. 02, pp. 212–222, 2024, doi: 10.37010/nuc.v5i02.1874.

[3] N. M. Tanjung, A. Yuana, D. Rachman, and A. Syofian, 'Analisa Perhitungan Susut di PT PLN (Persero) ULP Talang Padang', vol. 5, pp. 355–370, 2025.

[4] S. Syukri, M. Muliadi, and A. Akbar, 'Analisa Perhitungan Susut Teknis Di Pt. Pln (Persero) Rayon Singkil', *Elektrika*, vol. 16, no. 1, p. 20, 2024, doi: 10.26623/elektrika.v16i1.8854.

[5] Adekayanti Yuniar, Adiasa Iksan, and Mashabai Ismi, 'Analisis Gangguan Pada Kwh Meter Pelanggan Di Pt. Pln (Persero) Up3 Sumbawa Menggunakan Fishbone Dan Pdca (Plan, Do, Check, Action)', *jurnal Industri & Teknologi Samawa*, vol. 2, no. 1, pp. 22–31, 2021.

[6] A. Pranata, 'Fakultas teknik universitas tridinanti palembang 2020', *Muhammad Agus Mauladi*, vol. 2019, 2020, [Online]. Available: http://repository.univ-tridinanti.ac.id/id/eprint/756%0Ahttp://repository.univ-tridinanti.ac.id/756/6/Bab I - Pendahuluan.pdf

[7] S. Sugianto and P. Untara, 'Studi Susut Energi Pada Sistem Distribusi Tenaga Listrik Melalui Analisis Pengukuran Dan Perhitungan', *Sinusoida*, vol. 21, no. 2, pp. 39–56, 2019, doi: 10.37277/s.v21i2.686.

[8] Salahuddin, 'Perbandingan energi listrik kwh prabayar dengan pascabayar 1', *Jurnal Energi Elektrik*, vol. 5, no. 2, pp. 11–20, 2016.

[9] K. P. Widiatmika, Penurunan Susut Non Teknis pada Jaringan Distribusi menggunakan Sistem Automatic Meter Reading di PT. PLN (Persero) , *Etika Jurnalisme Pada Koran Kuning : Sebuah Studi Mengenai Koran Lampu Hijau*, vol. 16, no. 2, pp. 39–55, 2015.

[10] R. W. Pratama, 'UPAYA PENURUNAN SUSUT NON TEKNIS DENGAN PEMELIHARAAN KWH METER MACET DI PT. PLN (PERSERO) ULP PAMEKASAN', Pamekasan, 2023.

[11] M. F. Ikanov and M. Haddin, 'Perhitungan Susut Energi Pada Pemeliharaan APP Prabayar dan Pascabayar di PT PLN (Persero) ULP Anambas', *Jupiter (Jurnal Pendidikan Teknik Elektro)*, vol. 9, no. 2, p. 56, 2024, doi: 10.25273/jupiter.v9i2.20906.

[12] A. H. Fadhilah, 'Susut Non Teknis Pada Kwh Meter 1 Phasa Di PT. PLN ULP Brebes', *Jurnal Ilmiah Wahana Pendidikan, Juli*, vol. 9, no. 14, pp. 78–84, 2023, [Online]. Available: https://doi.org/10.5281/zenodo.8170416

[13] V. Issue and K. Kunci, 'JUTIN : Jurnal Teknik Industri Terintegrasi Studi Analisa Susut Energi Listrik Non Teknis dengan Cara Optimalisasi Peremajaan Kwh Meter Pascabayar 1 Phasa Di PT . PLN (Persero) ULP Painan', vol. 6, no. 1, 2023, doi: 10.31004/jutin.v6i1.18022.

[14] F. Surusa, Q. Aini, A. I. Pratiwi, and Y. Mohamad, 'Analisis Susut Non Teknis Akibat Gangguan pada kWh Meter PT. PLN UP3 Gorontalo', *Jambura Journal of Electrical and Electronics Engineering*, vol. 6, no. 1, pp. 32–38, 2024, doi: 10.37905/jjeee.v6i1.22380.

[15] M. Wozali, U. Usman, and P. Purwito, 'Analisis Susut Energi Listrik Non Teknis Pada Kwh Meter Prabayar Di PT PLN (Persero) Unit Layanan Pelanggan (ULP) Palopo Kota', *Jurnal Teknologi Elekterika*, vol. 20, no. 2, p. 80, 2023, doi: 10.31963/elekterika.v20i2.4514.