

Analysis of Energy Losses in Medium Voltage Networks (20 Kv) at Numfor Airport Papua

Mahyal Hadi, Hamdani, Beni Satria

Abstract

In general, an electrical power system consists of four main components, namely power plants, distribution networks, transmission networks, and loads. The distribution process has several problems, one of which is power loss. The cause of this loss is resistance in the conductors and the distance to the load being too far, resulting in power loss in the conductors. This study aims to calculate the power losses that occur and to calculate the energy losses and financial losses that occur during peak load. In this study, the method used is a quantitative approach where data collection is carried out through literature studies, observations, and direct interviews. The results of the study show that the amount of power loss that occurs in the 20 kV high voltage transmission line during peak load for one month is 10.20204 kV. The amount of energy loss in the MPH transmission line to substations 3, 2, and 4 in one month was 122.42448 kWh, with financial losses borne by Numfor Airport in Papua in January 2025 amounting to IDR 190,207,242. From the results of the total rupiah electricity tariff in January 2021 amounting to Rp 1,171,777,914 compared to the total power loss of Rp 190,207,242, the loss incurred by Numfor Papua Airport was 16.2%

Keyword: *Losses, Medium Voltage Network (20 kV) at Numfor Airport*

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2nd International Conference on Islamic Community Studies (ICICS)

Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era

<https://proceeding.pancabudi.ac.id/index.php/ICIE/index>

Introduction

A distribution network is a channel or network that connects large power sources (main substations) to electrical equipment or users, including terminals, industries, and substations. This distribution system is useful for distributing electrical power from large power sources (bulk power sources) to equipment. The electrical power distribution system includes all 20 KV Medium Voltage Networks (MVN) and all 380/220 Volt Low Voltage Networks (LVN) up to the customer's KWh meter.

Electricity distribution at Numfor Papu Airport is carried out by pulling distribution cables through conductors to the ground. Underground conductors run from the main substation to the load centers in the system at Numfor Papu Airport. Therefore, this area continues to be supplied through 3-phase underground conductors. The distribution process has several problems, one of which is power loss and energy loss. The causes of these losses include several factors, such as insulator leakage, resistance in the conductors, and the distance to the load being too far, resulting in power loss in the conductors. Other factors affecting energy loss in the network include the length of the network and the cross-sectional area of the conductors, where the longer the network with a smaller conductor cross-sectional area, the greater the energy loss in the network.

Power losses in distribution lines must be taken into account as they can cause significant power losses. The amount of power lost during transmission must be analyzed and anticipated so that the power loss remains within acceptable limits. A shortage of electrical energy in an area can result in low voltage or power outages. Based on the background description above, this study will discuss power losses using manual calculations, calculate the energy losses caused by power losses, and calculate the cost losses due to energy losses in the electrical system of Numfor Airport in Papua

Literature Review

2.1 Electric Power Distribution System

The distribution system is the entirety of components in the electrical power system that directly connect large power sources with electricity consumers. It starts from the main substation and goes to the distribution substation. The electrical energy distribution system includes all 20kV medium voltage networks and all 220/380 V low voltage networks up to the distribution electricity customer meters, which are carried out by pulling underground distribution cables from the main substation to the load centers. Each element of the distribution network at a specific location is built with distribution substations that are lowered to a lower voltage level, namely from 20kV to 220/380 V. From these substations, low-voltage cables are then laid to electrical equipment serving the consumption centers. Several large customers can also be served specifically using either a 20kV high-voltage network or a 20kV medium-voltage network.

Based on their length, transmission lines can be divided into three types, as follows:

1. A short line transmission line is a transmission line that is less than or equal to 50 miles (80 km) in length. In this type of line, the capacitance to ground is very small, and therefore the leakage current is large
2. Medium transmission lines Medium transmission lines are defined as transmission lines with a length of 80 km to 250 km. In this type of line, the capacitance to ground is large enough that it cannot be ignored. Therefore, the entire shunt admittance of the line is concentrated on the shunt branch, where medium transmission lines are divided

into two types, namely Nominal T medium transmission lines, which are transmission lines with capacitance concentrated at one point and series impedance divided between the two series branches. Nominal π medium transmission lines, which are transmission lines with capacitance centered at two points and series impedance centered at one point on the series branch

3. Long transmission lines Transmission lines longer than 250 km are classified as long transmission lines. The magnitude of parallel capacitive reactance and conductance decreases, resulting in greater leakage current. Therefore, in these long lines, all parameters R, L, C, and G are calculated as distributed along the line.

2.2 Distribution Shrinkage

Losses are the amount of energy lost during the process of distributing electrical energy from the substation to the consumer. If there is no substation, losses begin from the distribution substation to the consumer. The value of power losses in the network is an indicator of the electrical network's performance in distributing electrical energy from power plants to load centers. There are several factors that cause losses, such as excessive distance of power lines, load imbalance, hot conductor connections, etc. Losses in high-voltage transmission systems are greatly influenced by the load level, conductor cross-section, and conductor resistance. Power losses are unavoidable, but they can be minimized.

Types of losses according to PT. PLN (Persero) Board of Directors Decision No. 217-1.K/DIR/2005 concerning Guidelines for Preparing Energy Balance Reports (kWh), types of electrical energy losses can be divided into two categories, namely:

1. Based on their nature, technical losses and non-technical losses Technical losses are the loss of electrical energy generated during transmission due to conversion into heat energy. These technical losses cannot be eliminated (natural phenomenon). Non-technical losses are the loss of electrical energy consumed by customers and non-customers that is not recorded in sales.
2. Based on where it occurs, transmission loss and distribution loss Transmission loss is the loss of electrical energy generated when it is distributed through the transmission network to the substation. Distribution loss is the loss of electrical energy distributed from the substation through the distribution network to customers.

Power losses reflect wasted power, resulting in the power received by the receiver being less than the power sent by the sender. This wasted power is converted into heat in the transmission system over a certain period of time. As a result, the energy received by the receiver is less than the energy sent. In general, these power losses are caused by resistance in the conductor.

2.2 Calculation of Losses in Distribution Lines

To determine the amount of shrinkage that occurs in the distribution channel, several calculations are used as follows:

1. Manual calculation of power losses In the process of transmitting electrical power, significant power losses are often experienced due to the conductor components themselves. The current flowing through conductors with resistance causes losses in the conductors, resulting in a reduction in the power transmitted from the substation to consumers. Power losses that occur due to power loss in the line affect the quality

of power supplied to the receiving side. Significant power losses cause financial losses for the electricity processing company. (Setyawan, 2018) The amount of power loss in a 3-phase line conductor can be calculated using the following equation:

$$P_{Losses} = 3I^2 R_{Total} \dots\dots\dots (1)$$

Dimana:

P_{loses} = Rugi-rugi daya (W)

I = Arus yang disalurkan (A)

R_{total} = Resistansi Total (Ω)

Untuk mencari nilai Resistansi Total, dapat menggunakan persamaan Berikut:

$$R_{Total} = R \times l \dots\dots\dots (2)$$

Where:

R = Resistance (Ω /km)

R_{total} = Total Resistance (Ω)

l = Conductor distance (km)

2. Calculation Energy Loss

Energy loss is a condition or situation where the amount of energy distributed is not equal to the energy received on the receiving side. Energy loss is equal to the average power loss for a certain period multiplied by the number of hours in the period concerned. Energy loss is the amount of kWh energy lost. Persero Angkasa Pura 1 will incur financial losses when energy loss increases. The factors that determine the amount of loss in the medium voltage network are the type or size of the channel used, the length of the electricity supply, and the amount of time the load is applied. This is because the power received is different from the power transmitted. As a result, the transmitted power cannot be sold in its entirety. Researchers calculate the amount of energy lost using the following equation:

$$E = P_{Losses} \times t \dots\dots\dots (3)$$

Where:

E = Energy loss (kWh)

P_{losses} = Power loss (W)

t = Usage time (hours)

3. Calculation of financial losses

Losses are a form of electrical energy loss resulting from the difference between the amount of electrical energy available and the amount of electrical energy sold. These losses are caused by two factors, namely technical factors in the form of network problems and non-technical factors in the form of inconsistencies in usage records or kWh calculations. In economic terms, these losses are closely related to the issue of cost efficiency, so it can be concluded that the more inefficient (high cost) it is, the smaller the profit from the income obtained. Cost inefficiency that occurs in the flow of electrical energy is closely related to problems in terms of technology and the role of human resources.

The losses suffered by Numfor Papu Airport in recent years were caused not only by the lack of adjustments to the basic electricity tariff (TDL) but also by inefficiencies in its management, particularly in controlling electricity losses, which resulted in the company losing revenue opportunities due to unsold distributed energy. Losses are a source of

problems in generating revenue for the company. Losses have a very strong and positive influence because the level of losses is greatly affected by the basic electricity tariff (TDL), meaning that if losses increase, the company's revenue will increase, and vice versa. The level of losses is very important because, financially, the loss rate is synonymous with lost costs/revenue. The loss of electricity during transmission results in financial losses for Numfor Papu Airport because not all of the generated power is distributed. To calculate the financial losses caused by the loss of power, the author uses the following equation:

$$\text{Electricity cost} = E \times TTL \dots\dots\dots (4)$$

Where:

- E = Electrical energy (kWh)
- TTL = Electricity tariff (Rp/kWh)

Research methodology

3.1 Place and Time of Research

Data collection for this reduction was conducted on the Medium Voltage Network (20 kV) at Numfor Airport in Papua

3.2 Data Analysis Techniques

The data required for data analysis is as follows:

1. MPH 20kV Substation Distribution Channel Data
2. MPH 20kV Substation Daily Load Data
3. MPH 20kV Substation Single Line Diagram
4. 2025 Electricity Rates

The data obtained is converted into mathematical form and processed using existing equations. The calculations to be performed are as follows:

1. Power loss
To calculate the power loss value using equation (1), first calculate the total resistance value using equation (2)
2. Energy Loss
To calculate the amount of energy loss caused by power losses, equation (3) can be used
3. Financial Losses
To calculate the cost losses caused by power loss and energy loss, equation (4) can be used. In analyzing energy loss in 150 kV transmission lines, several procedures are carried out, namely:
 - a. Make all necessary preparations by familiarizing yourself with the research site and the topics to be studied
 - b. Conduct observations at the research site using existing data collection techniques to collect: peak load data for the substation at the main power house, transmission line data for the main power house substation, single line diagrams for the main power house substation, and electricity rates for May 2025
 - c. After data collection, process the data by manually calculating power loss values and energy losses, as well as the effects of power loss on the transmission lines of the main power house substation
 - d. Perform manual calculations with power loss simulations
 - e. Next, draw conclusions from the results of the analysis that has been carried out

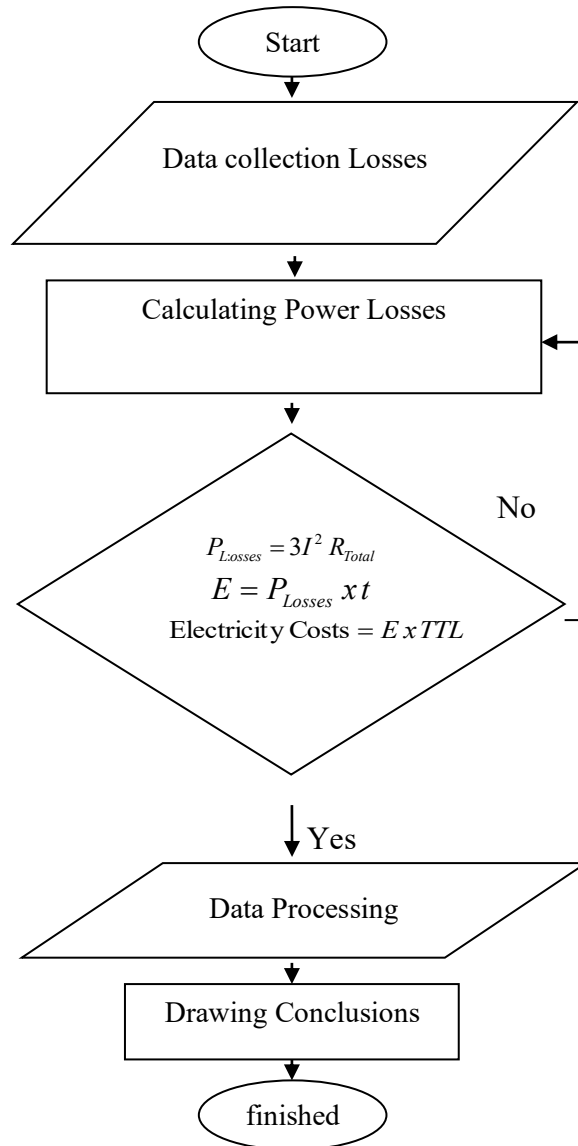


Figure 1 Research Flow

Results and Discussion

4.1 Distribution Channel Data

The distribution network from the main power house to the substation uses a looping system, namely 1 line from the main power house to Substation 3 with a line length of 3,254 km and using N2XSEBY 3 x 35mm² conductors with a resistance value of 0.0668 Ω/km. and from the Main Power House to Substation 2 with a line length of 1,381 km, then from the Main Power House to Substation 4 with a line length of 1,298 km. The transmission line data for these lines obtained from Numfor Airport in Papua can be seen in Table 1 below:

Table 1 Distribution channel data

Transmission Line Data	
Types of Conductors	N2XSEBY
Length of Cable Channel	Substation 3 = 3.254 Km
	Substation 2 = 1.381 Km
	Substation 4 = 1.298 Km
Conductive Resistance	0,0668 Ω/km
Cross-sectional Area	3 x 35mm ²

4.2 Peak Load Data

In this study, the load data used is only peak load data because during peak load, the distribution service consumes a large amount of electrical power, so it must obtain sufficient power distribution services for all existing load requirements, where during peak load there are greater power losses compared to outside peak load. Peak load is the maximum operation of a piece of equipment. Peak load itself occurs between 5:00 p.m. and 10:00 p.m. The peak load data used in this study is the night peak load data for the medium voltage transmission line from MPH to substations 3, 2, and 4, with a total of 31 days of data in January 2025. The peak load data obtained can be seen in the following table:

Table 2 Daily Peak Load Data for Substations

TGL	GT MAIN POWER HOUSE 20 KV								
	LINE SUBSTATION 3			LINE SUBSTATION 2			LINE SUBSTATION 4		
	JAM	KV	AMPERE	JAM	KV	AMPERE	JAM	KV	AMPERE
A	B	C	F	G	H	K	B	C	F
1	19:00	20	15,8A	19:00	20	15,8A	19:00	20	15,8A
2	19:00	20	15,2A	19:00	20	15,2A	19:00	20	15,2A
3	19:00	20	15,9A	19:00	20	15,9A	19:00	20	15,9A
4	19:00	20	14,8A	19:00	20	14,8A	19:00	20	14,8A
5	19:00	20	17,1A	19:00	20	17,1A	19:00	20	17,1A
6	18:38	20	16,4A	18:38	20	16,4A	18:38	20	16,4A
7	19:00	20	17,2A	19:00	20	17,2A	19:00	20	17,2A
8	18:35	20	17,3A	18:35	20	17,3A	18:35	20	17,3A
9	19:00	20	17,8A	19:00	20	17,8A	19:00	20	17,8A
10	19:00	20	17,5A	19:00	20	17,5A	19:00	20	17,5A
11	19:00	20	15,9A	19:00	20	15,9A	19:00	20	15,9A
12	19:00	20	14,7A	19:00	20	14,7A	19:00	20	14,7A
13	18:40	20	17,2A	18:40	20	17,2A	18:40	20	17,2A
14	19:00	20	17,5A	19:00	20	17,5A	19:00	20	17,5A
15	19:00	20	17,2A	19:00	20	17,2A	19:00	20	17,2A
16	19:00	20	17,2A	19:00	20	17,2A	19:00	20	17,2A
17	19:00	20	17,4A	19:00	20	17,A	19:00	20	17,4A
18	19:00	20	16,5A	19:00	20	16,5A	19:00	20	16,5A
19	19:00	20	16,1A	19:00	20	16,1A	19:00	20	16,1A
20	19:00	20	15,8A	19:00	20	15,8A	19:00	20	15,8A
21	19:00	20	15,4A	19:00	20	15,4A	19:00	20	15,4A
22	19:00	20	15,2A	19:00	20	15,2A	19:00	20	15,2A
23	19:00	20	15,4A	19:00	20	15,4A	19:00	20	15,4A
24	19:00	20	14,8A	19:00	20	14,8A	19:00	20	14,8A
25	19:00	20	16,8A	19:00	20	16,8A	19:00	20	16,8A
26	19:00	20	17,1A	19:00	20	17,1A	19:00	20	17,1A
27	19:00	20	17,2A	19:00	20	17,2A	19:00	20	17,2A
28	19:00	20	17,4A	19:00	20	17,4A	19:00	20	17,4A
29	19:00	20	17,3A	19:00	20	17,3A	19:00	20	17,3A

30	19:30	20	17,5A	19:30	20	17,5A	19:30	20	17,5A
31	19:00	20	18,2A	19:00	20	18,2A	19:00	20	18,2A

From the table above, we can see the daily peak load during the study period. The table shows that the highest current occurred on January 31, 2025, at 18.2A, while the lowest current occurred on January 12, 2025, at 14.7A.

4.3 Calculation of Power Losses

Calculation of Total Resistance of Conductors

The resistance value (R) obtained is per 1 kilometer, so the total resistance of the conductor in the MPH distribution line to the substation, which is 5,933 km away, can be found using equation (1), where the type of conductor used is N2XSEBY 3 x 35mm² with a resistance value of 0.0668Ω/km as shown in Table 1, so that the total resistance can be obtained

$$R_{Total} = R \times l$$

$$R_{Total} = 0,0668\Omega / Km \times 5.933 Km$$

$$R_{Total} = 0.396324\Omega$$

Calculation of Power Losses

Based on the peak load data for the distribution lines in the table above, power losses can be calculated using equation (2). The following is an example of power loss calculations for substation lines 3, 2, and 4 with the highest current of 18.2A occurring on January 31, 2025, and the lowest current of 14.7A occurring on January 12, 2025.

Substation 3

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (18,2)^2 \times 0.39383 kW$$

Substation 2

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (18,2)^2 \times 0.396324\Omega = 393.835 Watt$$

$$P_{Losses} = 0.39383 kW$$

Substation 4

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (18,2)^2 \times 0.396324\Omega = 393.835 Watt$$

$$P_{Losses} = 0.39383 kW$$

$$P_{Losses} Total = P_{Losses} Subtation 3 + P_{Losses} Subtation 2 + P_{Losses} Subtation 4$$

$$P_{Losses} Total = 0.39383 + 0.39383 + 0.39383$$

$$P_{Losses} Total = 1.18149 kW$$

Substation 3

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (14,7)^2 \times 0.396324\Omega = 256.924 Watt$$

$$P_{Losses} = 0.25692 kW$$

Substation 2

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (14,7)^2 \times 0.396324\Omega = 256.924Watt$$

$$P_{Losses} = 0.25692kW$$

Substation 4

$$P_{Losses} = 3I^2 R_{Total}$$

$$P_{Losses} = 3 \times (14,7)^2 \times 0.396324\Omega = 256.924Watt$$

$$P_{Losses} = 0.25692kW$$

$$P_{Losses} Total = P_{Losses} Subtation 3 + P_{Losses} Subtation 2 + P_{Losses} Subtation 4$$

$$P_{Losses} Total = 0.25692 + 0.25692 + 0.25692$$

$$P_{Losses} Total = 0.77076kW$$

Table 3. Manual Power Loss Calculation Results

TGL	Line Substation 3		Line Substation 2		Line Substation 4		Total Power Losses (kW)
	I	Plosses (kW)	I	Plosses (kW)	I	Plosses (kW)	
A	B	C	D	E	F	G	H
1	15,8	0,29681	15,8	0,29681	15,8	0,29681	0,89043
2	15,2	0,2747	15,2	0,2747	15,2	0,2747	0,8241
3	15,9	0,30058	15,9	0,30058	15,9	0,30058	0,90174
4	14,8	0,26043	14,8	0,26043	14,8	0,26043	0,78129
5	17,1	0,34766	17,1	0,34766	17,1	0,34766	1,04298
6	16,4	0,31978	16,4	0,31978	16,4	0,31978	0,95934
7	17,2	0,35174	17,2	0,35174	17,2	0,35174	1,05522
8	17,3	0,35584	17,3	0,35584	17,3	0,35584	1,06752
9	17,8	0,37671	17,8	0,37671	17,8	0,37671	1,13013
10	17,5	0,36412	17,5	0,36412	17,5	0,36412	1,09236
11	15,9	0,38095	15,9	0,38095	15,9	0,38095	1,14285
12	14,7	0,25692	14,7	0,25692	14,7	0,25692	0,77076
13	17,2	0,35174	17,2	0,35174	17,2	0,35174	1,05522
14	17,5	0,36412	17,5	0,36412	17,5	0,36412	1,09236
15	17,2	0,35174	17,2	0,35174	17,2	0,35174	1,05522
16	17,2	0,35174	17,2	0,35174	17,2	0,35174	1,05522
17	17,4	0,35997	17,4	0,35997	17,4	0,35997	1,07991
18	16,5	0,32369	16,5	0,32369	16,5	0,32369	0,97107
19	16,1	0,30819	16,1	0,30819	16,1	0,30819	0,92457
20	15,8	0,29681	15,8	0,29681	15,8	0,29681	0,89043
21	15,4	0,28197	15,4	0,28197	15,4	0,28197	0,84591
22	15,2	0,2747	15,2	0,2747	15,2	0,2747	0,8241
23	15,4	0,28197	15,4	0,28197	15,4	0,28197	0,84591
24	14,8	0,26043	14,8	0,26043	14,8	0,26043	0,78129

25	16,8	0,33557	16,8	0,33557	16,8	0,33557	1,00671
26	17,1	0,34766	17,1	0,34766	17,1	0,34766	1,04298
27	17,2	0,35174	17,2	0,35174	17,2	0,35174	1,05522
28	17,4	0,35997	17,4	0,35997	17,4	0,35997	1,07991
29	17,3	0,35584	17,3	0,35584	17,3	0,35584	1,06752
30	17,5	0,36412	17,5	0,36412	17,5	0,36412	1,09236
31	18,2	0,39383	18,2	0,39383	18,2	0,39383	1,18149
Total		10,2020	Total	10,2020	Total	10,20204	30,60612
		4			4		

By looking at the table, it can be seen that the largest power loss occurred on January 31, 2025, amounting to 0.39383 kW, and the smallest power loss occurred on January 12, 2025, amounting to 0.25692 kW. The total daily power loss on January 31 was 1.18149 kW, and the total power loss on January 12 was 0.77076 kW. From the results of the power loss calculations, it can be seen that the greater the current in the conductor, the greater the power loss. This is because there is resistance in the conductor, which is one of the causes of power loss in the line. When current flows through a conductor, heat energy loss occurs in the conductor due to its resistance.

Energy Loss Calculation

Based on the results of power loss calculations, the depreciation value can be found using equation (3), where the peak load time recorded at the main power house is 4 hours, starting from 6:00 p.m. to 10:00 p.m. The following is the energy depreciation calculation for one of the peak loads that occurred on January 31, 2025

$$E = P_{Losses} Total \times t$$

$$E = 1.18149kW \times 4 Jam$$

$$E = 4.72596kWh$$

The results of energy loss calculations for one month during peak load due to power losses in the distribution lines are shown in the following table:

Table 4. Energy Loss Calculation Results

Date	Total power loss per day (kW)	Energy Loss (kWh)
A	B	C
1	0.89043	3.56172
2	0.82410	3.29640
3	0.90174	3.60696
4	0.78129	3.12516
5	1.04298	4.17192
6	0.95934	3.83736
7	1.05522	4.22088
8	1.06752	4.27008
9	1.13013	4.52052
10	1.09236	4.36944
11	1.14285	4.57140
12	0.77076	3.08304
13	1.05522	4.22088

14	1.09236	4.36944
15	1.05522	4.22088
16	1.05522	4.22088
17	1.07991	4.31964
18	0.97107	3.88428
19	0.92457	3.69828
20	0.89043	3.56172
21	0.84591	3.38364
22	0.82410	3.29640
23	0.84591	3.38364
24	0.78129	3.12516
25	1.00671	4.02684
26	1.04298	4.17192
27	1.05522	4.22088
28	1.07991	4.31964
29	1.06752	4.27008
30	1.09236	4.36944
31	1.18149	4.72596
Total	30.60612	122.42448

By looking at the table above, it can be seen that the largest energy loss occurred on January 31, 2025, amounting to 4.72596 kWh, and the smallest energy loss occurred on January 12, 2025, amounting to 3.08304 kWh, with a total energy loss during the peak load in January 2025 amounting to 122.42448 kWh. The factors that determine the amount of loss in the medium voltage network are the type or size of the channel used, the length of the electricity supply, and the amount of time the load is applied. The energy loss that occurs in this distribution channel can cause financial losses at Numfor Airport in Papua.

Calculating Financial Losses

The losses suffered by Numfor Airport in Papua in recent years were caused not only by the lack of adjustments to the basic electricity tariff (TDL) but also by inefficiencies in its management, particularly in controlling electricity losses, which resulted in the company losing revenue opportunities due to distributed energy. Power loss in the transmission lines has resulted in financial losses for the company supplying electricity to Numfor Airport in Papua. To determine the amount of financial loss caused by power losses, we can look at the electricity tariff (TTL) for January 2025. The TTL provided by wd consists of three tariff categories, three of which follow the tariff adjustment mechanism. The electricity tariffs provided by Numfor Papua Airport refer to Ministerial Regulation (Permen) Per ESDM No. 28 of 2016 with Amendment No. 03 of 2020. This ministerial regulation also regulates the adjustment of electricity tariffs for 3 tariff categories, namely tariff category B3, B3, and R2, where the electricity tariff for medium-voltage equipment with a capacity of 5,540,000 VA is Rp 1,553.67/kWh during peak load hours.

The author calculated the financial losses that occurred in the transmission lines between MPH and substations 3.2 and 4 using equation (4). The following is one of the calculations of cost losses due to energy losses that occurred in the distribution lines

$$\text{Electricity costs} = E \times TTL$$

$$\text{Electricity costs} = 4.725,96 \text{ kWh} \times \text{Rp.}1553.67 / \text{kWh}$$

$$\text{Electricity costs} = 7.342,582$$

The calculation of electricity costs is based on data collected over a period of one month. The results of the electricity cost savings can be seen in the following table:

Table 5 Electricity cost losses

Date	Energy Loss (kWh)	Cost Loss (Rp)
A	B	C
1	3,56172	5.533.738
2	3,2964	5.121.518
3	3,60696	5.604.026
4	3,12516	4.855.467
5	4,17192	6.481.787
6	3,83736	5.961.991
7	4,22088	6.557.855
8	4,27008	6.634.295
9	4,52052	7.023.396
10	4,36944	6.788.668
11	4,5714	7.102.447
12	3,08304	4.790.027
13	4,22088	6.557.855
14	4,36944	6.788.668
15	4,22088	6.557.855
16	4,22088	6.557.855
17	4,31964	6.711.295
18	3,88428	6.034.889
19	3,69828	5.745.907
20	3,56172	5.533.738
21	3,38364	5.257.060
22	3,2964	5.121.518
23	3,38364	5.257.060
24	3,12516	4.855.467
25	4,02684	6.256.381
26	4,17192	6.481.787
27	4,22088	6.557.855
28	4,31964	6.711.295
29	4,27008	6.634.295
30	4,36944	6.788.668
31	4,72596	7.342.582
Total	122,42448	190.207.242

The table above shows that the energy loss that occurred during the transmission process from MPH to Substations 3, 2, and 4 over one month (31 days) amounted to 122,424.48 kWh. Power losses in the transmission system are power losses that result in material losses. The

cost of the loss can be calculated from the power loss in one month (kWh) multiplied by the cost per kWh of the electricity tariff, so that the loss incurred by Numfor Airport in Papua due to energy loss in the transmission line from MPH to Substations 3, 2, and 4 can be determined to be IDR 190,207,242 in one month. Power losses cannot be avoided but can be minimized by making improvements during peak loads, thereby ensuring good service when peak loads/excess loads occur. Good service is due to the power being transmitted being distributed effectively because of minimal power losses experienced

Conclusion

Based on the results of research and calculations of power losses and energy losses in the 20 kV medium voltage transmission lines at Substations 3, 2, and 4 that occurred during peak load in January 2025, the following conclusions can be drawn:

1. The total power loss occurring in the 20 kV medium voltage transmission lines of Substations 3, 2, and 4 during peak load for one month (January 2025) was manually calculated to be 10.20204 kW
2. The amount of energy loss in the MPH transmission line to substations 3, 2, and 4 during one month at peak load was 122.42448 kWh, with financial losses borne by Numfor Papua Airport in January 2025 amounting to IDR 190,207,242
3. For medium-voltage transmission at 20 kV, data collection should be conducted over several months to allow for a detailed analysis of fluctuations in power losses. This approach will enable more effective decision-making
4. It is necessary to maintain the continuity of electrical power by increasing routine monitoring and maintenance of equipment at the main substation, including transmission lines and main substation transformers, so that losses and energy depletion can be minimized, thereby reducing financial losses

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