*Journal of Renewable Energy, Electrical, and Computer Engineering*
Vol. 1, No. 2, September 2021, 85-93
e-ISSN: 2776-0049
*Research Original Article*
DOI: https://doi.org/10.29103/jreece.v1i2.5238

# Analysis of Technical Loss Calculation Using Load Curve Approach on 20 kV Distribution Network

**Rizky Rahmat Maulana[1], Salahuddin[1], Ezwarsyah[1], Baharuddin Ismail[2], Ashish Shrestha[3], & Dhiraj Vijayrao Astonkar[4,5]**

[1] Department of Electrical Engineering, Malikussaleh University, Bukit Indah, Lhokseumawe, Indonesia, 24351

[2] University Malaysia Perlis, Perlis, Malaysia

[3] University of South-Eastern Norway, Norway

[4] Dr. Sau Kamaltai Gawai Institute of Engineering and Technology, Darapur, Dist. Amravati, Maharashtra, India 444814

[5] Sant Gadge Baba Amravati University, Amravati, Maharashtra, India, 444702

rizky.160150119@mhs.unimal.ac.id; salahuddin@unimal.ac.id; ezwarsyah@unimal.ac.id; baha@unimap.edu.my; sthashish2010@gmail.com; dhirajastonkar@gmail.com

✉Corresponding Author: **rizky.160150119@mhs.unimal.ac.id** | Phone: **+6282277323572**

**Received: September 8, 2021** **Revision: September 20, 2021** **Accepted: September 27, 2021**

## Abstract

Energy loss (losses) is the loss of a certain amount of energy generated when it is distributed to consumers so that it affects the profitability of the company concerned. The size of the losses from an electric power system shows the level of efficiency of the system, the lower the percentage of losses that occur the more efficient the system. Energy losses in the distribution network are generally divided into two, namely technical and non-technical losses. The calculation of technical losses in the 20 KV medium distribution network of PT PLN (Persero) Ulp Matang Glumpang Dua is carried out using the load curve approach method and using the help of the Microsoft Exel program, while the technical losses calculated are technical losses on the Medium Voltage Network and Distribution Transformer. From the results of the analysis of the calculation of technical losses in 2020, the total technical loss value at MG-01 Matang City is in the range of 13.8% to 20.8% which consists of the average technical loss in the Medium Voltage Network feeder of 0.02%. and the loss of Distribution Transformer by 17.6%.

**Keywords:** technical loss; distribution system;

## Introduction

Electrical energy is one of the most vital needs for people's lives today. Because all activities related to daily needs cannot be separated from the need for electrical energy. This makes electrical energy a very important basic need for people's lives today. To overcome the need for electrical energy, the government has also thought about it, among others, through the construction of large and small-scale power plants. By managing and increasing natural resources that can be used as electricity generation. So that electrical energy can be distributed throughout the region through the transmission network and distribution network. The electrical system as a whole includes the generation, transmission, and distribution sections.

The distribution system that functions to distribute and distribute electrical energy to consumers needs adequate quality. In the distribution of electric power, not all of it can be distributed to consumers, because it will be lost in the form of energy loss.

The appearance of shrinkage is caused by technical and non-technical causes. The cause of technical shrinkage occurs because of the impedance in the electrical components so that power is lost in the form of heat. The causes of non-technical losses occur due to inaccuracies in measuring and using electrical energy on the customer side.

### Distribution System

Electricity is generated from generating centers such as Hydroelectric Power Plant, Steam Power Plant, Gas Power Plant or Gas Steam Power Plant. This electric power is then channeled through a transmission line, where the distribution voltage is first raised by a step-up transformer. This voltage increase serves to reduce the amount of power losses during distribution. Transmission lines in Indonesia generally have a voltage of 150 kV and 500 kV.

After the electricity is distributed through the transmission line, it will arrive at the Substation where the voltage will be lowered by a step-down transformer. Here the voltage will change to medium voltage. This network is called the Medium Voltage Network The primary distribution system in cities usually consists of 2 types, namely overhead lines and underground cables. The distribution voltage commonly used in Indonesia is 20 kV.

After the electrical energy is channeled through the primary distribution network, then the electric power will be lowered again at the distribution substations to a low voltage with a voltage of 380/220 Volts which will then be channeled through the low voltage network to customers' homes via a connection house

**Primary Distribution Network**

The primary distribution system is used to distribute electric power from the distribution substation to the load center. This system can use overhead lines, overhead cables, or ground cables according to the desired level of reliability and environmental conditions and situations. This distribution channel is stretched along the area to be supplied with electric power to the load center. Based on the function and use of a feeder, it can form several types of primary distribution network systems into four, namely, radial systems, loop systems, spindle systems and mesh systems.

**Secondary Distribution Network**

The secondary distribution system is used to distribute electric power from the distribution substation to the loads on the consumer. In the secondary distribution system, the most widely used channel form is the radial system. This system can use insulated cables or conductors without insulation. Looking at its location, this distribution system is the part that is directly related to consumers, so this system functions to receive electrical power from a power source (distribution transformer), will also send and distribute the power to consumers. considering that this section is directly related to consumers, the quality of electricity should be very concerned. Electrical power distribution systems on Low Voltage Networks can be divided into two, namely as follows:

- Low Voltage Air Line The type of conductor used is bare cable (without insulation) such as AAAC cable, ACSR cable.
- Low Voltage Air Cable Channels The type of conductor used is insulated cable such as LVTC cable (Low Voltage Twisted Cable). LVTC cable sizes are: 2x10 $mm^2$, 2x16 $mm^2$, 4x25 $mm^2$, 3x 3 5$mm^2$, 3x50 $mm^2$, 3x70 $mm^2$. According to SPLN No. 3 of 1987, low voltage network is a low voltage network that includes all parts of the network and its equipment, from low voltage distribution sources to limiting/measuring devices. which connects the STR with the limiter/measuring device).

**Electrical Energy Loss**

Losses is a form of loss of electrical energy that comes from the difference between the amount of electrical energy available and the amount of electrical energy sold.

Based on the decision of the Director of PT PLN (Persero) No. 217-1.JK/DIR/2005 concerning Guidelines for Preparation of Energy Balance Reports (kWh), the types of electrical energy losses can be divided into two, namely:

a. Based on his nature
- Technical loss

Technical losses are the loss of electrical energy at the time of distribution from the generator to the customer because it turns into heat. This technical loss cannot be eliminated because it is a congenital condition or shrinkage that occurs due to technical reasons where the energy shrinks turns into heat in High Voltage (JTT) networks, Substations (GI), Medium Voltage Networks (JTM), Distribution Substations (GD), Low Voltage Network (JTR), Home Connection (SR) and Measuring and Limiting Equipment (APP).

- Non – technical loss

Non-technical losses are the loss of electrical energy consumed by customers and non-customers because they are not recorded in sales. There are several causes of non-technical losses, including electricity theft, meter reading errors, measurement tool errors and others.

Meter reading errors cause a mismatch between the kWh used by the customer and the recorded one. If what is used turns out to be greater than what was recorded, the difference will certainly be reduced. There are efforts to overcome these problems, one of which is by providing guidance and training to human resources involved in the meter reading process up to the application of meter reading applications and methods.

The measurement tool error causes the measured energy does not match the energy used by the customer. This can be caused by kWh meter, wiring, CT/PT, and other factor errors. To overcome this, it can be done with periodic kWh replacement and routine inspections.

b. Based on the place of occurrence
- Transmission loss

Namely the loss of electrical energy generated when it is distributed through the transmission network to substations or technical losses that occur in the transmission network which includes losses in the High Voltage network (JTT) and at the Substation (GI).

- Distribution shrink

That is the loss of electrical energy distributed from substations through distribution networks to customers or technical and non-technical losses that occur in the distribution network which includes medium network losses, distribution substations, low voltage networks home connections and Limiting and Measuring Devices for high voltage, medium voltage and low voltage customers. If there is a high-voltage network that functions as a distribution network, this network loss is intended as a distribution loss.

## Research Methods

The methods used in this research include:

a. Data collection technique

- Study of literature

Literature study, namely obtaining information through reference books related to the object of research, journal articles, internet access and guidance from teaching staff in order to obtain the necessary data.

b. Field Data Collection

**Table 1.** Feeder data for MG-01 Department of Matang City

| Month | kWH Input |
|---|---|
| January | 5106421 |
| February | 3768410 |
| March | 4304169 |
| April | 5513829 |
| May | 4468877 |
| June | 4901392 |
| July | 4962027 |
| August | 5674748 |
| September | 4899906 |
| October | 4463278 |
| November | 5103452 |
| December | 4987642 |

**Table 2.** Parameter Data for medium voltage Grid and Distribution Transformer

| Parameter | | | |
|---|---|---|---|
| Medium Voltage Network | | Transformer | |
| Amount feeder | 1 | Iron loss | 0.6 kW |
| Factor Burden | 0.34 | Copper loss | 3 kW |
| Power Factor | 0.83 | Transformer Load Factor | 0.4 |
| Correction Factor | 1 | Power Factor | 0.83 |
| Amount Transformer | 33 | Correction Factor | 1 |
| Medium Voltage Network length | 7.530 km | Number of Transformers | 33 buah |
| Prisoner delivery | 0.0043 Ω | Total Capacity Installed | 1345 kVA |

**Research Steps**

In the preparation of the final project, research steps are made so that the results in the preparation are achieved, while the research steps are as follows:

1. Collect data.
2. Create a research flow diagram.
3. Calculating technical losses on medium voltage networks.
4. Calculating the technical losses of distribution transformers.
5. Calculate the total loss.

In the object of this research, it is known that the single line diagram of the 20 kV medium distribution network system is as shown below:

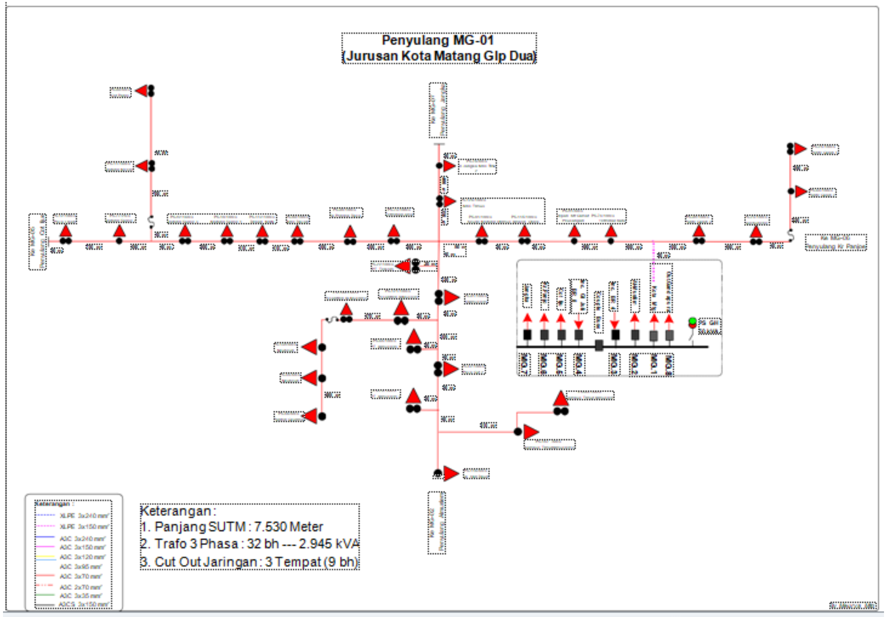


**Figure 1.** Single Line Diagram MG-01 Matang City

**Assumption Data**

For the calculation of this technical loss, the following assumption data are taken:

1. The value of the medium voltage network load factor for each month is the same.
2. It is assumed that the conductor resistance value for all cables is the conductor resistance value for the 3×150 mm^2 AAAC type cable
3. The value of transformer losses for all transformers uses the value of the transformer loss with a capacity of 250 kVA, for the value of transformer losses, namely Iron Loss and Copper Loss using the provisions of SPLN No. 50 of 1997.

## Results and Discussion

Calculation of Technical Losses in Medium Voltage Networks

1) Calculation of Technical Loss of medium voltage network in January 2020 :

| | |
|---|---|
| kWH input Medium voltage network | : 5106421 kWH |
| Number of Feeders | : 1 |
| Medium Voltage Network Load Factor | : 0.34 |
| Medium Voltage Network Power Factor | : 0.83 |
| Number of Transformers | : 33 |
| Medium Voltage Network Correction Factor | : 1 |
| Medium voltage network length | : 7,530 Km |
| Conductor Resistance/Km | : 0.0043 (Ω) |

kWH input/feeder :

$$\mathrm{E_{JTM}} = \frac{\mathrm{kWH_{InJTM}}}{\mathrm{J_{Node}}} = \frac{5106421\ \mathrm{kWH}}{1} = 5106421\ \mathrm{kWH}$$

Many transformers/feeders :

$$\mathrm{R_{Node}} = \frac{\mathrm{J_{Trafo}}}{\mathrm{J_{Node}}} = \frac{33}{1} = 33$$

Peak load /feeder :

$$E_{in} = \frac{E_{JTM}}{(t \times LF_{JTM} \times PF_{JTM})}$$

$$\mathrm{E_{in}} = \frac{5106421}{(\mathrm{t} \times \mathrm{LF_{JTM}} \times \mathrm{PF_{JTM}})}$$

$$= \frac{5106421}{24 \times 30 \times 0{,}34 \times 0{,}83}$$

$$\mathrm{E_{in}} = \frac{5106421}{203{,}184}$$

$$= 25132{,}003\ \mathrm{kWH}$$

Peak load/ transformer:

$$E_{out} = \frac{E_{in}}{Node \times FK} = \frac{25132{,}003}{33 \times 1} = 761{,}57 \text{ kWH}$$

Equivalent feeder load :

$$E_{ek} = \sqrt{\frac{{E_{in}}^2 \times E_{in} + E_{out} \times {E_{out}}^2}{3}}$$
$$= \sqrt{\frac{25132{,}003^2 \times 25132{,}003 + 761{,}57 \times 761{,}57^2}{3}}$$
$$E_{ek} = 23003{,}08 \text{ kVA}$$

Average/feeder medium voltage Network Length :

$$L_{JTM} = \frac{J_{tot\,JTm}}{J_{Node}} = \frac{7{,}530}{1} = 7{,}530 \text{ Km}$$

Peak/feeder load loss :

$$P_{JTM} = \frac{L_{JTM} \times R_{JTM}}{1000} \times \left(\frac{E_{EkJTM}}{1{,}732 \times 20}\right)^2$$
$$= \frac{7{,}530 \times 0{,}0043}{1000} \times \left(\frac{23003{,}08}{1{,}732 \times 20}\right)^2$$
$$= 14{,}27 \text{ kW}$$

Loss factor in medium voltage network:

$$LLF_{JTM} = 0{,}3 \times LF_{JTM} + 0{,}7 \times (LF_{JTM})^2$$
$$= 0{,}3 \times 0{,}34 + 0{,}7 \times 0{,}34^2$$
$$= 0{,}18292$$

Medium-voltage Network Shrink (kWH) :

$$S_{JTM} = t \times J_{Node} \times P_{JTM} \times LLF_{JTM}$$
$$= 24 \times 30 \times 1 \times 14{,}27 \times 0{,}18292$$
$$S_{JTM} = 1879{,}39 \text{ kWH}$$

Medium-voltage Network Shrink (%) :

$$S_{JTM}(\%) = \frac{S_{JTM}}{kWH_{Input}} \times 100\%$$
$$= \frac{1879{,}39}{5106421} \times 100\%$$
$$= 0{,}03\%$$

For other month calculations the same as the above method. So that the results of technical losses onmedium voltage networks can be seen as in table 3 below:

Table 3.Technical Losses on Medium Voltage Networks

| Month | KWHin (kWH) | kWH feeder input | Equivalent Feeder Load | Peak/feeder load loss | Medium-voltage Network Shrink (kWH) | Medium-voltage Network Shrink (%) |
|---|---|---|---|---|---|---|
| January | 5106421 | 5106421 | 23003,08 | 14,27 | 1879,39 | 0,03% |
| February | 3768410 | 3768410 | 14583,04 | 5,73 | 723,21 | 0,01% |
| March | 4304169 | 4304169 | 17801,02 | 8,55 | 1126,05 | 0,02% |
| April | 5513829 | 5513829 | 25810,18 | 17,9 | 2357,4 | 0,04% |
| May | 4468877 | 4468877 | 18832,25 | 9,57 | 1260,39 | 0,02% |
| June | 4901392 | 4901392 | 21631,67 | 12,6 | 1659,45 | 0,03% |
| July | 4962027 | 4962027 | 22034,31 | 13,1 | 1725,3 | 0,03% |
| August | 5674748 | 5674748 | 26948,26 | 19,5 | 2568,1 | 0,04% |
| September | 4899906 | 4899906 | 21621,83 | 12,6 | 1659,45 | 0,03% |

| | | | | | | |
|---|---|---|---|---|---|---|
| October | 4463278 | 4463278 | 18797,04 | 9,53 | 1255,12 | 0,02% |
| November | 5103452 | 5103452 | 22982,9 | 14,2 | 1870,17 | 0,03% |
| December | 4987642 | 4987642 | 22205,1 | 13,3 | 1751,64 | 0,03% |

**Calculation of Technical Losses on Distribution Transformers**

When the calculation of technical losses is carried out systematically, the calculation of technical losses on the Distribution Transformer can be completed as follows:

1. Technical losses on distribution transformer in january 2020

kWH Input transformer : 5106421 kWH
Number of Feeders : 1
Iron Loss : 0,6
Copper Loss : 3
Number of Transformator : 33
Correction Factor : 1
Transformer Load Factor : 0,4
Transformer Power Factor : 0,83
Total Installed Capacity : 1345 kVA

kWH input / Transformer :

$$E_{Trafo} = \frac{kWH_{In\ Trafo}}{J_{node}} = \frac{5106421}{33} = 154740{,}03 \text{ kWH}$$

Transformer average capacity

$$R_{Trafo} = \frac{Q_{tot}}{J_{node}} = \frac{1345\ kVA}{33} = 40{,}75$$

Peak Load / Transformer

$$kVA_{Trafo} = \frac{E_{Trafo}}{t \times LF_{Trafo} \times PF_{Trafo}} = \frac{154740{,}03}{24 \times 30 \times 0{,}4 \times 0{,}83} = 647{,}33 \text{ kVA}$$

Transformer Load Loss Factor

$$LLF_{Trafo} = 0{,}3 \times LF_{Trafo} + 0{,}7 \times (LF_{Trafo})^2 = 0{,}3 \times 0{,}4 + 0{,}7 \times 0{,}4^2 = 0{,}23$$

Transformer Load Loss

$$P_{Trafo} = P_{Besi} + \left(\frac{kVA_{Trafo}}{R_{Trafo}}\right)^2 \times P_{cu} \times LLF_{Trafo} = 0{,}6 + \left(\frac{647{,}33}{40{,}75}\right)^2 \times 3 \times 0{,}23 = 174{,}71$$

Transformer Shrink(kWH)

$$S_{Trafo} = t \times J_{node} \times P_{Trafo} \times LLF_{Trafo} \times FK = 24 \times 30 \times 33 \times 174{,}71 \times 0{,}23 \times 1 = 954755{,}2 \text{ kWH}$$

Transformer Shrink(%)

$$S_{Trafo}(\%) = \frac{S_{Trafo}}{kWH_{Input}} \times 100\% = \frac{954755{,}2}{5106421} \times 100\% = 18{,}6\%$$

For other months the calculation is the same as above. So that the results of technical losses on Distribution Transformers can be seen as in **Table 4.**

**Table 4**. Technical Losses on Distribution Transformer

| Month | KWHin (KWH) | kWH input/ Transformer | Peak Load /Transformer | Transformer Load Loss | Transformer Shrink(kWH) | Transformer Shrink (%) |
|---|---|---|---|---|---|---|
| January | 5106421 | 154740,03 | 647,33 | 174,71 | 954755,2 | 18,6% |
| February | 3768410 | 114194,24 | 477,72 | 95,42 | 521451,21 | 13,8% |
| March | 4304169 | 130429,36 | 545,63 | 124,3 | 679274,64 | 15,7% |
| April | 5513829 | 167085,72 | 698,98 | 203,61 | 1112687,9 | 20,17% |
| May | 4468877 | 135420,51 | 566,51 | 133,95 | 732009,9 | 16,3% |
| June | 4901392 | 148527,03 | 621,34 | 161,01 | 879887,4 | 17,9% |
| July | 4962027 | 150364,4 | 629,03 | 165,01 | 901746,6 | 18,1% |
| August | 5674748 | 171962,06 | 719,38 | 215,6 | 1178210,8 | 20,7% |
| September | 4899906 | 148482 | 621,15 | 160,9 | 879286,3 | 17,9% |
| October | 4463278 | 135250,8 | 565,80 | 133,6 | 730097,2 | 16,3% |
| November | 5103452 | 154650,06 | 646,96 | 174,5 | 953607,6 | 18,6% |
| December | 4987642 | 151140,6 | 632,28 | 166,7 | 910982,1 | 18,2 % |

**Calculating of Total Technical Losses**

The calculation of the total technical loss is carried out at intervals of every onemonths. Systematically, the calculation of the total loss between the medium voltage network and the Distribution Transformer can be done as follows:

1. Total loss in January 2020

kWh input : 5106421 kWH
Technical Losses on Medium Voltage Networks : 1879,39kWH
Installed Average Capacity: 954755,2kWH
Total Loss (kWH)

$$S_{total} = \text{Technical Losses on} + \text{Installed Average Capacity}$$
$$= 1879,39 + 954755,2$$
$$= 956634,59 \text{ kWH}$$

Total Loss (%)

$$S_{Total}(\%) = \frac{S_{Total}}{kWH_{Input}} \times 100\%$$
$$= \frac{956634,59}{5106421} \times 100\%$$
$$= 18,7\%$$

For other months the calculation is the same as above. So that the results of total shrinkage can be seen as in **Table 5.**

**Table 5.** Total Technical Loss

| Month | kWHin (kWH) | Medium-voltage Network Shrink (kWH) | Susut Trafo (kWH) | Transformer Shrink(kWH) | Transformer Shrink (%) |
|---|---|---|---|---|---|
| January | 5106421 | 1879,39 | 954755,2 | 956634,59 | 18,7% |
| February | 3768410 | 723,21 | 521451,21 | 522174,42 | 13,8% |
| March | 4304169 | 1126,05 | 679274,64 | 680400,69 | 15,8% |
| April | 5513829 | 2357,4 | 1112687,9 | 1115045,3 | 20,2% |
| May | 4468877 | 1260,39 | 732009,9 | 733270,29 | 16,4% |
| June | 4901392 | 1659,45 | 879887,4 | 881546,8 | 17,9% |

| | | | | | |
|---|---|---|---|---|---|
| July | 4962027 | 1725,3 | 901746,6 | 903471,9 | 18,2% |
| August | 5674748 | 2568,1 | 1178210,8 | 1180778,9 | 20,8% |
| September | 4899906 | 1659,45 | 879286,3 | 880945,7 | 17,9% |
| October | 4463278 | 1255,12 | 730097,2 | 731352,32 | 16,3% |
| November | 5103452 | 1870,17 | 953607,6 | 955477,77 | 18,7% |
| December | 4987642 | 1751,64 | 910982,1 | 912733,7 | 18,2% |

**Technical Shrinkage Composition**

From the analysis of the data above, a graph of the composition of technical losses at PT PLN (Persero) ULP MatangGlumpangDua can be made as follows:

**Table 5**. Technical Shrinkage Composition PT PLN (Persero) ULP MatangGlumpangDua

| Month | kWH Input (kWH) | Medium Voltage Grid Loss | | Transformer Loss | | Total Loss | |
|---|---|---|---|---|---|---|---|
| | | kWH | % | Kwh | % | kWH | % |
| January | 5106421 | 1879,39 | 0,03% | 954755,2 | 18,6% | 956634,59 | 18,7% |
| February | 3768410 | 723,21 | 0,01% | 521451,21 | 13,8% | 522174,42 | 13,8% |
| March | 4304169 | 1126,05 | 0,02% | 679274,64 | 15,7% | 680400,69 | 15,8% |
| April | 5513829 | 2357,4 | 0,04% | 1112687,9 | 20,1% | 1115045,3 | 20,2% |
| May | 4468877 | 1260,39 | 0,02% | 732009,9 | 16,3% | 733270,29 | 16,4% |
| June | 4901392 | 1659,45 | 0,03% | 879887,4 | 17,9% | 881546,8 | 17,9% |
| July | 4962027 | 1725,3 | 0,03% | 901746,6 | 18,1% | 903471,9 | 18,2% |
| August | 5674748 | 2568,1 | 0,04% | 1178210,8 | 20,7% | 1180778,9 | 20,8% |
| September | 4899906 | 1659,45 | 0,03% | 879286,3 | 17,9% | 880945,7 | 17,9% |
| October | 4463278 | 1255,12 | 0,02% | 730097,2 | 16,3% | 731352,32 | 16,3% |
| November | 5103452 | 1870,17 | 0,03% | 953607,6 | 18,6% | 955477,77 | 18,7% |
| December | 4987642 | 1751,64 | 0,03% | 910982,1 | 18,2 % | 912733,7 | 18,2% |
| Average | 4846179,3 | 1652,97 | 0,03% | 869499,7 | 17,68% | 871152,7 | 17.74% |

## Load Curve

After calculating the technical losses on the Medium Voltage Network and Distribution Transformer, the writer then modeled the calculation results with a load curve approach. From the load curve profile, it can be seen that the input kWH and the composition of the technical losses in the Medium Voltage Network and Distribution Transformer have been calculated.

Based on Table 5, a load curve for the Technical Loss Composition of Medium Voltage Networks and Distribution Transformers at PT PLN (Persero) ULP Matang Glumpang Dua can be made as shown in **Figure 2.**

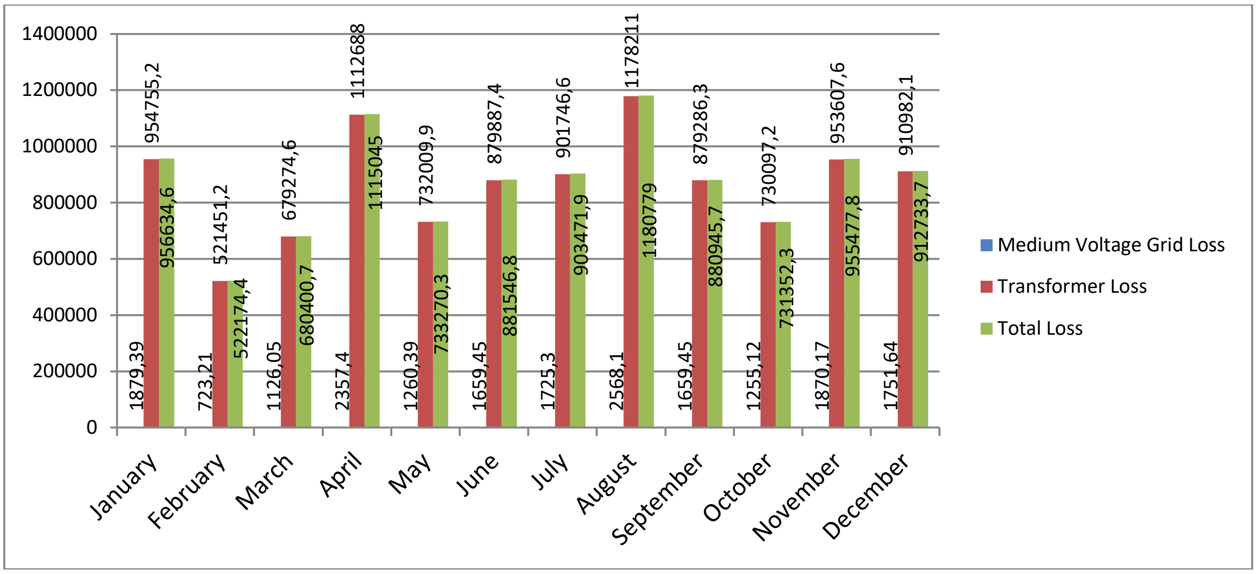

**Figure 2**. Technical Shrinkage composition load curve graph PT PLN Matang Glumpang Dua

From the above, it can be seen that the total losses at PT PLN (Persero) ULP Matang Glumpang Dua ranged from 522174.42 kWH to 1180778.9 kWH or 13.8% to 20.8% with the description of Technical Losses in the JTM feeder ranging from 723.21 kWH to 2568.1kWH or 0.01%, up to 0.04%. Meanwhile, technical losses in distribution transformers are in the range of 521451.21 kWH to 1178210.8 kWH or 13.8% to 20.7% in 2020.

## Conclusion

1. The greater the burden on the network, the greater the technical loss
2. The composition of average technical losses in 2019 consisted of medium voltage grid losses of 16662.08 kWH or 0.02% and transformer losses of 871034.43 kWH or 17.6%.
3. The relationship between the total energy input and the amount of technical loss per month is relatively up and down with the difference in the ratio of the increase in the average kWH input of 1167259.72 kWH and the decrease in the average kWH input of 522174.42 kWH so that the total technical loss varies - change according to the incoming kWH input.

## Reference

[1] Zuhal, Dasar Teknik Tenaga Listrik dan Elektronika daya, Jakarta: Gramedia, 2004.

[2] Z. Arifin, Panduan Pengendalian Susut, Bandung: PT PLN (Persero), 2007.

[3] A. Handoyo, *Analisa Perhitungan Susut Teknik pada PT. PLN (Persero) UPJ Semarang Tengah,* pp. 1-7, 2005.

[4] W. S. dan A. Akbar, "Jurnal Sains dan Teknologi EMAS," *Perhitungan Susut Daya pada Sistem DIstribusi Tegangan Menengah Saluran Udara dan Kabel,* Vol. 17, No.3, pp. 169-182, 2017.

[5] B. P. Putra Purba dan E. Warman, *Analisa Perhitungan Susut Teknis dengan Pendekatan Kurva Beban pada Jaringan Distribusi PT PLN (Persero) Rayon Medan Kota,* vol. VOL. 6 NO.2, pp. 60-64, 2014.

[6] D. A. S dan . E. Ervianto, *Analisa Perhitungan Susut Daya dan Energi dengan Pendekatan Kurva Beban pada Jaringan Distribusi PT. PLN (Persero) Area Pekanbaru,* vol. Volume 3 No.2, pp. 1-6, 2016.

[7] H. D. Dalam, "Analisa Susut Energi pada Sistem Jaringan Distribusi di PT. PLN APJ Yogyakarta UPJ Wonosari Unit Semanu," dalam *Seminar Nasional Informatika 2013 (semnasIF 2013) UPN "Veteran"*, Yogyakarta, 2013.

[8] "SPLN 50. Spesifikasi Transformator Distribusi," 1982.

[9] Shadri, "Analisa Perhitungan Susut Teknis dengan Pendekatan Kurva Beban pada Jaringan Distribusi PT PLN (Persero) Rayon Bireuen," *Tugas Akhir pada Jurusan Teknik Elektro Universitas Malikussaleh*, Lhokseumawe, 2018.

[10] Muhammad Taufik Akbar, "Analisa Perhitungan Susut Teknis dengan MetodePendekatan Kurva Beban pada Jaringan Distribusi PT PLN (Persero) Rayon Gandapura," *Tugas Akhir pada Jurusan Teknik Elektro Universitas Malikussaleh*, Lhokseumawe, 2019.