ANALYSIS OF POWER LOSSES AND PERFORMANCE RATIO IN PRINGGABAYA SOLAR POWER PLANT

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Most of the electrical energy supply comes from fossil energy which sooner or later this energy will run out. Therefore, there is a need for alternative energy supplies, one of which is Solar Power Plants, however , many PLTS experience a decline in performance caused by internal and external factors, causing losses. This research aims to analyze the magnitude of power losses and the performance ratio of PLTS using secondary data analysis methods in the form of solar irradiation, temperature, current, voltage and power data obtained from the SCADA system at PLTS Pringgabaya. The results of this research obtained the highest average power loss due to changes in temperature, namely at 12:00 it was 1,129.12 W with an average sending power of 10,678.39 W and an average temperature of 51.43˚C. The highest average power loss on the line was found to be 8.70 kW with a sending power of 155.62 kW. The highest performance ratio for the position of the sun a year occurs in December with an average of 80%, this occurs because the generator location is at coordinates 8.52˚S, 116.63˚E.

Keywords : PLTS, DC Power Loss, DC Conductor, Performance Ratio.

ABSTRACT _

Most of the supply of electrical energy comes from fossil energy which sooner or later this energy will run out. Therefore, it is necessary to provide alternative energy supplies, one of which is Solar Power Plants, however, many PLTS experience a decline in performance caused by internal and external factors, causing losses. This research aims to analyze the magnitude of power losses and the performance ratio of PLTS using secondary data analysis methods in the form of solar irradiation, temperature, current, voltage and power data obtained from the SCADA system at PLTS Pringgabaya. The results of this research obtained the highest average power loss due to temperature changes, namely at 12:00 it was 1,129.12 W with an average sending power of 10,678.39 W and an average temperature of 51.43˚C. The highest average loss on the channel is 8.70 kW with a sending power of 155.62 kW. The highest performance ratio for the position of the sun a year occurs in December with an average of 80%, this occurs because the generator location is at coordinates 8.52˚S, 116.63˚E.

Keywords: Solar Power Plant, DC Losses, DC Conductor, Performance Ratio.

INTRODUCTION

Estimates of long-term electricity needs are very necessary in order to describe current and future electricity conditions. Therefore, there is a need for alternative energy supplies, one of which is new renewable energy (EBT), new renewable energy also has a low impact against environmental damage and ensure energy sustainability in the future. PT PLN (Persero) noted that the potential for new renewable energy (EBT) in West Nusa Tenggara (NTB) reached 102.74 megawatts (MW). Of the total power, one of them has been installed at PT Infrastruktur Terbarukan Adhyguna (ITA) PLTS Pringgabaya 7 MWp .

Generator Electricity Power Sun (PLTS) is something system generator electricity with use energy sun/light sun

Which absorbed by panel Sun through process *photovoltaic.* PLTS Pringgabaya is located in North Pringgabaya Village, Pringgabaya District, East Lombok Regency and operates on year 2019 with capacity as big 7 MWp connected to the PLN network. PLTS Pringgabaya stands on an area of 11 hectares and has 21,560 PV modules photovoltaic with type *polycrystalline* efficient as big 13.8%.

In PLTS, there are several aspects that affect the decrease in the performance of the PLTS, especially namely pollution on the PV surface such as dust, PV temperature, clouds, and shadow effects around the PV, which can affect current, voltage, and power generated by solar modules resulting in losses in total. big. Power losses or *power losses* are power leaks or loss of power generated during the electricity distribution process caused by internal and external factors.

This research aims to analyze the magnitude of power losses due to changes in temperature and due to different conductor sizes as well as analyzing the performance ratio of PLTS Pringgabaya .

RESEARCH METHODS

This research was conducted to determine the magnitude of power losses due to changes in temperature and due to different conductor sizes and to analyze the performance ratio. The research method used is secondary data analysis obtained from the PLTS Pringgabaya SCADA system with an hourly database for 7 days, starting from 5 December 2022 to 11 December 2022. Connect advisor is software used for site and scada monitoring at PLTS Pringgabaya. The data required is solar radiation, temperature, daily production, conductor type and size. These data will then be analyzed so that the losses and performance ratio of PLTS Pringgabaya are known.

To achieve the planned research objectives, the implementation of the research consists of several parts, namely:

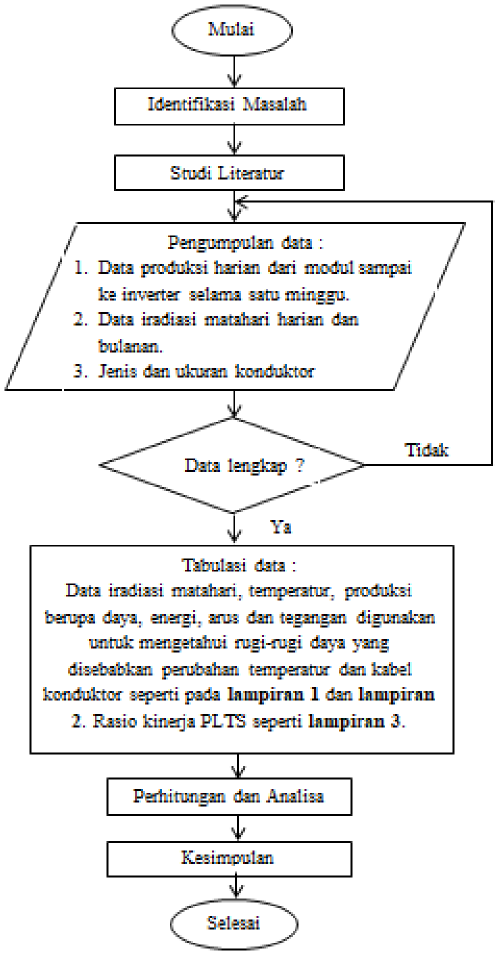

Figure 1. Research Flow Chart

Channel study started with stage preparation form identification problem, After obtaining it, formulate it, then look for literature studies regarding it things Which related with problem. Stage furthermore that is implementation, on stage This happen process collection data through studies field Which located at PLTS Pringgabaya 7 MWp PT. Adhiguna Renewable Infrastructure. data that used in this research is daily power *output data* with intensity hourly *database* for 7 days. Solar irradiation data, temperature, conductor type and size data to determine the magnitude of power losses that occur. Apart from that, a daily performance ratio analysis was also carried out to determine the feasibility of PLTS Pringgabaya operating. Then stage final that is settlement, on stage This done processing data, presentation And analysis data Then ended with

withdrawal conclusion and preparation of reports.

1. **Calculation of power losses due to changes in temperature.**

Changes in the temperature of these solar cells are caused by environmental temperature, cloud conditions and wind speed in the environment around the area where the solar panels are placed. Very rapid and extreme temperature changes can cause disruption to electricity production in a PLTS.

Temperature calculations are carried out by first calculating the power losses due to changes in temperature using Equation 1 and after knowing the power losses due to changes in temperature, calculating the efficiency of the solar panels using Equation 2.

Power loss due to temperature changes

$(Temp\ PV - Temp\ STC).\ 0.4\%\ .\ P_{out}$......... ...(1)

Information :

Temp PV **= solar panel surface temperature (°C)**
Temp STC **= test specification panel temperature (°C)**
0.4 = material specification coefficient value (***polycristaline*** **) (%)**
P_{out} **= solar panel output power (W)**

Solar panel efficiency

$\eta PV = \frac{V.I}{G.A}$... ....(2)

Information :

ηPV = solar panel efficiency (%)
V = voltage (V)
I = current (A)
G = solar radiation (W/m ^{2})
A = solar panel area (m ^{2})

2. **Calculation of power losses due to conductors .**

The DC loss in question is a factor that reduces the amount of direct current (DC) energy produced by solar panels before the energy is converted into alternating current (AC) by the inverter for use in the electricity grid. The electric power losses are the difference between the sending power and the receiving power on the line using Equation 3.

$P_{loss} = P_{AB} - \left(\frac{P_{AB}}{P_{ABtotal}}\right).\ P_{Inverter}$............. ..(3)

Information :

P_{loss} **= power loss(W)**
P_{AB} **= power delivered to 1** ***array box*** **(W)**
$P_{ABtotal}$**= total power of 5** ***array boxes*** **at 1 inverter (W)**
$P_{Inverter}$**= power received by 1 inverter (W)**

3. **Calculation of Performance Ratio (PR)**

If we normalize this value with the capacity stated on the name plate of the PLTS system, P $_{STC}$ (kW) and the irradiance value when the name plate capacity is measured in ***Standard Test Conditions*** **(STC), G $_{STC}$ (W/m ^{2}) is 1000 W/m ^{2} , obtained** ***the Performance Ratio*** **of a PLTS system in that period (KESDM, 2021)**

In mathematical notation it can be written:

$PR = \frac{\left(\frac{E_{out}}{H_{POA}}\right)}{\left(\frac{p_{STC}}{G_{STC}}\right)}$...(4)

Information:

PR = ***Performance Ratio*** **(%)**
E $_{out}$ = actual output energy in a period (kWh)
H $_{POA}$ = incident solar energy in the same period (Wh/ m ^{2})
P $_{STC}$ = PLTS capacity (kWp)
G $_{STC}$ = irradiance value when measured in ***Standard Test Conditions*** **(STC) (under STC conditions the G $_{STC\ value}$ = 1000 W/m ^{2})**

RESULTS AND DISCUSSION

This research analyzes about research result covers data power losses and performance ratios at PLTS Pringgabaya. The power loss in question is the loss caused by changes in temperature and size of the conductor cable. The secondary data includes temperature, irradiation, current, voltage and power data with

hourly intensity for 7 days starting from 5 December 2022 to 11 December 2022.

Table 1. Results power loss calculation And efficiency

Waktu	Temperatur PV (˚C)	Iradians (W/(m²)	Arus (A)	Tegangan (V)	Daya (W)	Rugi Daya (W)	Efisiensi PV (%)
07.00	35,27	276,63	4,57	711,16	3.248,59	133,42	15,21
08.00	41,08	490,98	8,54	690,36	5.897,74	379,32	15,56
09.00	44,99	640,12	11,25	675,14	7.598,09	607,68	15,38
10.00	47,94	803,93	14,38	669,50	9.626,08	883,37	15,51
11.00	50,78	891,56	15,62	665,84	10.403,83	1.073,01	15,12
12.00	51,43	898,36	15,94	670,05	10.678,39	1.086,41	15,40
13.00	47,25	680,99	12,40	670,12	8.311,69	739,71	15,81
14.00	43,78	530,46	10,18	673,53	6.858,80	515,21	16,75
15.00	38,48	320,13	5,82	680,33	3.956,88	213,38	16,01
16.00	35,07	188,70	3,31	685,94	2.267,64	91,31	15,57
17.00	31,68	64,51	1,11	654,70	725,37	19,38	14,57

For explain comparison change solar irradiation (W/m ^{2}) and photovoltaic module temperature (˚C) from 07:00 – 17:00 WITA at point 1 can be seen on

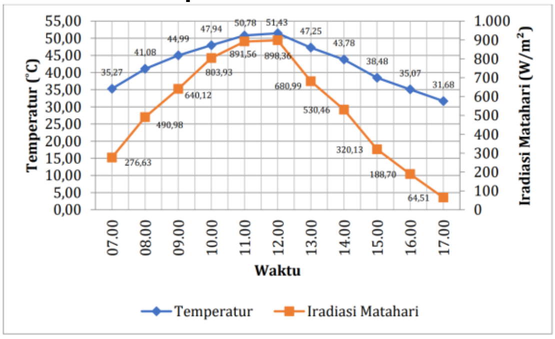

Figure 1. Comparison chart average change solar irradiation (W/m ^{2}) and average photovoltaic module temperature (˚C) from December 5 2022 to December 11 2022 from 07:00 – 17:00 WITA

Based on figure 1 it can be analyzed that solar irradiation and temperature have values that change every hour. At 07:00 the irradiation obtained was 276.63 W/m ^{2} and the temperature obtained is 35.27˚C. As time increases, the irradiation and temperature values will increase until the state *peak sun* (peak sun) that is at 12:00 the measured irradiation was 898.36 W/m ^{2} and a temperature of 51.43˚C. The irradiation and temperature values will decrease again after the *peak state sun* until 17:00 is 64.51 W/m ^{2} and 31.68˚C . This shows that there is a directly proportional relationship between the i value of solar radiation and the module temperature.

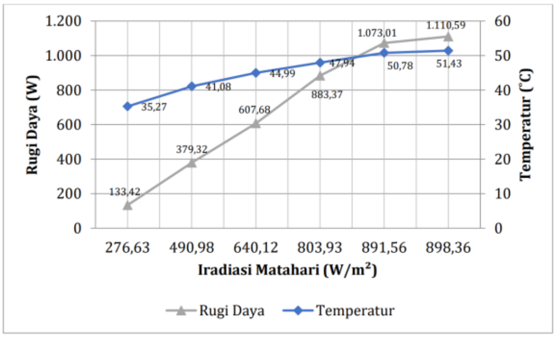

Figure 2. Comparison chart average change solar irradiation (W/m ^{2}) and average photovoltaic module temperature (˚C) against power loss (W) at point 1

Based on figure 2 it can be analyzed that increasing changes in solar irradiation result in increasing temperature values. This increasing temperature value causes the power loss to increase. This shows that there is a directly proportional relationship between these three parameters. The power loss value obtained is quite large, this is because the temperature measured on the module is above the *Standard Test Condition* (STC) value. worth 25˚C The smallest temperature value is 35.27˚C , this results in quite large power losses, namely 133.42 W. This shows that if the temperature value exceeds the STC value, it will result in power losses whose value can increase as it increases. the temperature value of the STC condition.

Table 2. Results power loss calculation due to different conductor sizes.

Inverter	Array Box	Jumlah String	Ukuran konduktor			Arus (A)	Tegangan (V)	Daya kirim (*Array box*) (kW)	Total daya kirim (kW)	Daya terima (Inverter) (kW)	Rugi Daya (kW)	Total Rugi Daya (kW)	Persentase rugi-rugi (%)	Efisiensi (%)
			Penampang (mm²)	Panjang (m)	Resistansi (Ohm)									
GB/IS01/1_E01-DC	AB_E01_D01_A01-DC	13	185	231	0,0209	201,36	650,13	130,90	718,56	683,73	6,34	34,83	5	95
	AB_E01_D01_A02-DC	13	185	197	0,0178	197,68	653,53	129,15			6,26			
	AB_E01_D01_A03-DC	13	185	145	0,0131	233,72	647,64	151,34			7,34			
	AB_E01_D01_A04-DC	13	185	166	0,0150	234,96	651,57	153,07			7,42			
	AB_E01_D01_A05-DC	14	185	125	0,0113	235,86	653,45	154,10			7,47			
GB/IS01/1_E02-DC	AB_E02_D02_A01-DC	14	185	162	0,0146	221,44	680,71	150,82	726,93	699,16	5,76	27,77	4	96
	AB_E02_D02_A02-DC	13	185	173	0,0156	217,12	682,96	148,36			5,67			
	AB_E02_D02_A03-DC	13	185	195	0,0176	188,46	681,32	128,48			4,91			
	AB_E02_D02_A04-DC	14	185	68	0,0061	218,75	681,58	149,17			5,70			
	AB_E02_D02_A05-DC	14	185	12	0,0011	221,87	676,28	150,11			5,73			
GB/IS01/1_E03-DC	AB_E03_D03_A01-DC	14	150	100	0,0111	206,11	705,68	145,56	730,19	693,05	7,40	37,14	5	95
	AB_E03_D03_A02-DC	14	150	57	0,0063	208,17	698,18	145,44			7,40			
	AB_E03_D03_A03-DC	14	150	34	0,0038	209,26	701,35	146,86			7,47			
	AB_E03_D03_A04-DC	14	150	44	0,0049	208,57	700,54	146,18			7,44			
	AB_E03_D03_A05-DC	14	150	100	0,0111	209,16	698,44	146,15			7,43			
GB/IS01/1_E04-DC	AB_E04_D04_A01-DC	13	150	111	0,0124	235,82	656,50	154,77	705,21	671,23	7,46	33,98	5	95
	AB_E04_D04_A02-DC	13	150	132	0,0147	202,35	650,51	131,60			6,34			
	AB_E04_D04_A03-DC	13	185	182	0,0164	201,54	651,87	131,34			6,33			
	AB_E04_D04_A04-DC	13	185	232	0,0209	237,84	654,37	155,60			7,50			
	AB_E04_D04_A05-DC	12	185	266	0,0240	202,20	652,51	131,90			6,36			
GB/IS02/1_E05-DC	AB_E05_D05_A01-DC	13	150	133	0,0148	223,10	679,60	151,55	734,67	704,68	6,19	29,99	4	96
	AB_E05_D05_A02-DC	13	150	107	0,0119	196,82	669,89	131,81			5,38			
	AB_E05_D05_A03-DC	14	185	76	0,0069	212,50	675,17	143,43			5,85			
	AB_E05_D05_A04-DC	13	185	101	0,0091	227,34	672,78	152,87			6,24			
	AB_E05_D05_A05-DC	14	185	80	0,0072	231,53	669,78	155,01			6,33			
GB/IS02/1_E06-DC	AB_E06_D06_A01-DC	13	150	224	0,0249	201,05	670,57	134,77	735,41	694,46	7,50	40,96	6	94
	AB_E06_D06_A02-DC	13	150	203	0,0226	233,91	665,56	155,62			8,67			
	AB_E06_D06_A03-DC	13	185	203	0,0183	199,92	668,58	133,61			7,44			
	AB_E06_D06_A04-DC	14	185	123	0,0111	236,26	661,65	156,27			8,70			
	AB_E06_D06_A05-DC	13	185	169	0,0153	236,12	657,16	155,14			8,64			
GB/IS02/1_E07-DC	AB_E07_D07_A01-DC	14	150	57	0,0063	212,92	702,89	149,66	732,99	696,94	7,36	36,05	5	95
	AB_E07_D07_A02-DC	14	150	33	0,0037	208,72	696,25	145,32			7,15			
	AB_E07_D07_A03-DC	14	185	79	0,0071	211,47	698,56	147,72			7,27			
	AB_E07_D07_A04-DC	14	185	41	0,0037	207,81	698,20	145,09			7,14			
	AB_E07_D07_A05-DC	14	185	86	0,0078	207,74	699,02	145,21			7,14			
GB/IS02/1_E08-DC	AB_E08_D08_A01-DC	14	150	121	0,0135	225,73	678,67	153,14	737,86	707,30	6,34	30,56	4	96
	AB_E08_D08_A02-DC	13	150	142	0,0158	224,47	674,48	151,34			6,27			
	AB_E08_D08_A03-DC	14	185	89	0,0080	225,06	683,05	153,68			6,36			
	AB_E08_D08_A04-DC	13	185	99	0,0089	192,74	673,02	129,67			5,37			
	AB_E08_D08_A05-DC	14	185	109	0,0098	223,27	672,28	150,04			6,21			
Rata-rata		13	172	125	0,01				727,73	693,82		33,91	5	95

Based on Table 2, it can be analyzed that the power loss at 12:00 is found to vary in size for each DC

conductor, this is because the cross-sectional area and length of the conductor are different as well as the number of strings installed in each array box. The calculation results show that the average value of power loss in 1 week at 12:00 with a sending power of 727.73 kW and a receiving power of 693.83 kW, a power loss of 33.91 kW and a loss percentage of 5% and a conductor efficiency of 95% with an average cross-sectional area of 172 mm ^{2} and an average conductor length of 125 m.

The largest power loss was in inverter 6 (GB/IS02/1_E06-DC) of 40.96 kW with an average cross-sectional area of 171 mm ^{2} and a conductor length of 922 m with a loss percentage of 6% and a conductor efficiency of 94%. Meanwhile, the lowest power loss was inverter 2 (GB/IS02/1_E02-DC) of 27.77 kW with an average cross-sectional area of 185 mm ^{2} and a conductor length of 610 m with a loss percentage of 4% and a conductor efficiency of 96%, this is because the cross-sectional area used is larger than inverter 6 and the length of the conductor used is shorter than inverter 6 so the resulting power loss is smaller.

Based on this, it can be said that the larger and shorter the conductor used, the smaller the power loss, conversely, if the smaller and longer the conductor used, the greater the power loss. Apart from that, the greater the number of circuits installed, the greater the power loss because it will increase the amount of current and cause the conductor to heat up, thus causing power loss in the form of heat.

Table 3. Results calculation of PLTS performance ratio.

The data used for the following calculations are solar irradiation data (H_{POA}) and inverter energy (E_{out}) on March 1, 2022. $P_{STC}$and $G_{STC}$is a constant, where $P_{STC}$is the Pringgabaya PLTS capacity of 7 MWp or 7,000 kWp while G_{STC}it is the irradiation value when measured in *Standard Test Conditions* (STC) is 1000 W/m ^{2} .

Waktu	Pringgabaya-Irradiation HI (Wh/m²)	Daya inverter (kWh)	Pringgabaya-Performance ratio PR (%)
1 maret 2022	5.596,70	30.357,68	77
2 maret 2022	5.499,21	29.351,29	76
3 maret 2022	4.419,82	24.587,39	79
4 maret 2022	3.751,93	21.087,94	80
5 maret 2022	6.657,21	35.711,03	77
6 maret 2022	6.056,25	32.392,67	76
7 maret 2022	6.125,06	17.649,18	41
8 maret 2022	5.457,04	30.553,34	80
9 maret 2022	6.555,86	34.457,26	75
10 maret 2022	3.470,75	19.691,43	81
11 maret 2022	5.077,96	28.219,91	79
12 maret 2022	7.345,82	38.085,53	74
13 maret 2022	6.979,25	36.638,95	75
14 maret 2022	5.756,37	30.399,65	75
15 maret 2022	7.572,18	40.012,74	75
16 maret 2022	7.513,54	39.101,22	74
17 maret 2022	7.102,90	37.486,41	75
18 maret 2022	4.592,50	25.303,11	79
19 maret 2022	3.207,07	18.249,30	81
20 maret 2022	4.250,08	24.345,94	82
21 maret 2022	5.353,34	29.204,90	78
22 maret 2022	6.853,32	36.509,95	76
23 maret 2022	4.534,15	24.398,08	77
24 maret 2022	6.150,47	33.091,99	77
25 maret 2022	5.495,20	29.225,97	76
26 maret 2022	5.927,54	31.036,30	75
27 maret 2022	4.282,22	22.571,04	75
28 maret 2022	3.698,08	20.247,00	78
29 maret 2022	3.312,53	18.174,33	78
30 maret 2022	5.263,70	28.280,29	77
31 maret 2022	6.069,44	32.193,96	76
Rata-rata	5.481,53	28.987,61	76

To explain the daily performance ratio of Pringgabaya PLTS in March can seen on Picture 3

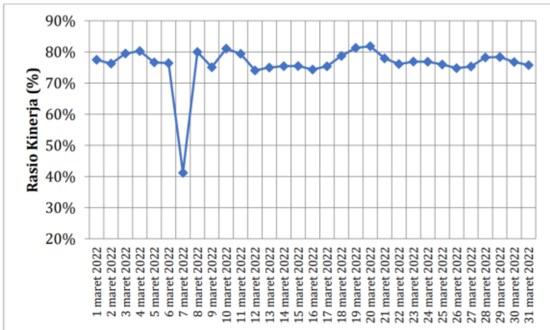

Figure 3. Graph of the daily performance ratio of PLTS Pringgabaya in March

Based on Figure 4.14, it can be analyzed that the ratio value is obtained performance The average solar module in March was 76% with solar irradiation of 5,481.83 Wh/m ^{2} and energy production of 28,987.61 kWh. The highest performance ratio was on March 20 at 82%, then the lowest performance ratio was on March 7 at 41%. The highest performance ratio is due to the comparison between real energy and theoretical energy, the difference obtained is small. Then the lowest performance ratio occurs due to the inverter not operating even though radiation hits the PV. This causes the total daily energy production to be very small compared to the available energy. Incidents like this are a concern because apart from *losses occurring* in the PV system, the occurrence of *an off time* on the inverter can cause a huge loss of electrical energy. However from results ratio performance Which got it in March stillis said to be good because it reaches an average figure of 76% so it can be said that system PLTS operating properly.

CONCLUSION

Based on the results of the analysis carried out, namely the analysis of power losses and performance ratios PLTS Pringgabaya, it can be concluded that:

1. Results of analysis of power loss calculations due to temperature changes with a time span of 7 days, obtained The highest average power loss at each point is at 12:00. The average *input power* is 10,678.39 W and the average power loss is 1,129.12 W with an average temperature of 51.43˚C.
2. The results of the analysis of power loss calculations due to varying conductor sizes with data intensity per hour in 1 week showed that the highest average power loss at 12:00 was in the inverter 6 *array box AB_E06_D06_A04-DC* with a number of strings of 14, a conductor cross-sectional area of 185 mm^2, a length of 123 m, and a resistance of 0.01 Ω produces a power loss of 8.70 kW.
3. The results of the performance ratio analysis of PLTS Pringgabaya are in accordance with the annual apparent motion of the sun. In March, June, September and December 2022, an average performance ratio of 76%, 77%, 78%, 80% was obtained. The highest performance ratio occurred in December, this happened because PLTS Pringgabaya was located at coordinates 8.52˚S, 116.63˚E. So in December, the sun is in the southern hemisphere, causing the days to feel longer as well as the sun's radiation time.

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