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Performance Analysis of 22 MWp Solar Power Plant (Case Study at PT Riau Andalan Pulp and Paper)

Arief Fachrozi[1*], Siti Anisah[2], Rahmaniar[3]
Universitas Pembangunan Panca Budi, Medan, Indonesia
Email: fachroziarief5@gmail.com[1*], sitianisah@dosen.pancabudi.ac.id[2], rahmaniar@dosen.pancabudi.ac.id[3]

*Correspondence

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ABSTRACT

The global transition towards sustainable energy sources is increasingly urgent as fossil fuel reserves decline and environmental concerns rise. Indonesia, with its significant potential for renewable energy, particularly solar power, has made substantial progress in integrating cleaner energy sources. However, the current utilization rate remains low, highlighting the need for effective strategies to harness this potential. This research examines the performance of the 22 MWp solar power plant at PT Riau Andalan Pulp and Paper (APRIL Group) as a case study to explore the role of solar energy in industrial applications. The study aims to analyze the efficiency, reliability, and overall contribution of the solar power plant to the company's energy demands while identifying operational challenges. Using historical data from the solar PV monitoring system, the research evaluates monthly energy production, performance trends, and CO2 emissions reductions over three months (April–June 2024). Key findings indicate that solar energy significantly contributes to reducing carbon footprints and improving energy sustainability. This research provides valuable insights into the optimization of solar power plants and underscores their critical role in advancing Indonesia's renewable energy agenda.

Introduction

Energy is a basic need that plays a very important role in all aspects of human life and must be managed efficiently (Boly et al., 2021). The need for energy continues to increase as the population grows and community activities increase (Anisah et al., 2023; Anisah & Tarigan, 2023). So far, energy needs are still dependent on energy sources from fossil fuels that rely on coal, petroleum and natural gas which will be increasingly depleted or even run out. The use of fossil fuels will have an impact on environmental problems and encourage humans to utilize renewable energy sources (Anisah et al., 2024).

In the midst of a changing global energy paradigm, Indonesia embraces a new era with a strong determination to replace the energy landscape dominated by fossil fuels with more sustainable solutions. In this perspective, government efforts to reduce dependence on petroleum and coal-based energy have become a major focus. However, major challenges arise in changing energy consumption patterns that have been firmly

embedded in the economic and social structure of society (Nugraha et al., 2024; Rahmadani, 2024).

The view of new and renewable energy as a catalyst for change shows the extraordinary potential that Indonesia has. With a potential of more than 417.8 GW, the country has an untapped treasure that can make Indonesia a global leader in the clean energy transition. However, despite this huge potential, the realization of the use of new and renewable energy is still far from optimal, with only about 2.5 percent having been utilized (EBTKE, 2023b). Concrete steps have been taken by the government, such as a ban on the construction of new coal-based Steam Power Plants (PLTU). However, behind the prohibition there is an exception that allows the construction of coal-fired power plants that have been listed in the Electricity Supply Business Plan before the regulation was enforced. This raises questions about the consistency and seriousness of implementing policies to reduce the use of fossil fuels (Karimi & Efendi, 2020).

Its commitment to global agreements such as the Paris Agreement is a tangible reflection of the government's determination to reduce carbon emissions (Amali, 2023). Indonesia has formulated its long-term strategy, which aims to create a sustainable and resilient society to climate change (Rahma et al., 2024). By reducing energy sector emissions by 358 million tons of CO2 by 2030, through various efforts such as energy efficiency, the use of new and renewable energy, and the use of clean technology, Indonesia strives to be a pioneer in protecting the earth for future generations (EBTKE, 2023a).

However, the implementation of the strategy is not easy. Major challenges in infrastructure, investment, and regulation are still obstacles in realizing this vision. Cross-sector cooperation and active participation from all stakeholders are needed to achieve the desired energy transformation. Through the synergy between progressive policies, sustainable investment, and public awareness of the importance of clean energy, Indonesia stands at a decisive crossroads in history on the road to a sustainable and environmentally friendly future.

At PT Riau Andalan Pulp and Paper (APRIL Group) has made changes to new and renewable energy, one of which is by investing in Solar Power Plants, currently the total installed capacity to provide electrical energy for factory needs is 22 MWp, which is quite large for a solar power plant. Currently, PT Riau Andalan Pulp and Paper (APRIL Group) is developing the potential of solar energy with a plan to add solar panels in the company's environment, this is in line with the company's program that supports environmental sustainability. The main target of PT Riau Andalan Pulp and Paper (APRIL Group) in the construction of this solar power plant is 50 MWp by 2030, and currently development is still being carried out to achieve this goal.

Research Methods

In this research, the researcher conducted a case study at the Power Side Department, Power Boiler Area of PT Riau Andalan Pulp and Paper (APRIL Group) in the period between April - June 2024. The data collection approach used in this study is

through the analysis of historical data available from the Solar Power Plant (PLTS) monitoring system installed at PT Riau Andalan Pulp and Paper. During this period, the author focused on certain aspects related to the operation and performance of solar power plants in the area. Historical data that has been recorded in the solar PV monitoring system is the main source of information for analysis and evaluation in this study.

In this research, there are several formulations of problems and research objectives that are of concern to the author to be raised in this journal as follows:

Problem Formulation:

1. How much electricity does a solar panel generate in MWh?
2. Where is electricity from solar power supplies flowing?
3. How much does C02 emission reduction be?

Research Objectives:

1. Conducting energy production analysis includes monthly energy production calculations from solar PV
2. Analyze performance trends using historical data from solar PV monitoring systems
3. Conduct an analysis of the efficiency and performance of solar PV.

Results and Discussion

The amount of daily electricity generated by solar panels in MWh

In an effort to understand and optimize the contribution of renewable energy in the industrial sector, this study examines the amount of electricity generated by solar panels based on data from the solar PV monitoring system at PT Riau Andalan Pulp and Paper. By analyzing real-time data from the monitoring system, this study provides in-depth insight into the potential for solar energy production in Megawatt Hours (MWh). The following is data obtained from the solar PV monitoring system at PT Riau Andalan Pulp and Paper in the period from April to June 2024: (Rais et al., 2024)

Table 1. Data on the amount of daily energy produced in April

Date	Actual (MWh)				Overal Actual (MWh)
	Phase 1	Phase 2	Phase 3	Pelalawan	
Installed Capacity	1 MW	10 MW	14.4 MW	0,5 MW	
1-Apr	5.42	55.68	59.06	2.20	122.36
2-Apr	3.88	39.00	55.57	2.35	100.81
3-Apr	4.82	48.08	67.21	1.96	122.06
4-Apr	4.10	41.17	47.09	2.20	94.57
5-Apr	4.98	49.67	69.61	1.95	126.22
6-Apr	4.31	44.65	53.96	2.31	105.22
7-Apr	4.66	44.60	60.95	2.03	112.25
8-Apr	4.32	46.45	46.37	1.91	99.06
9-Apr	5.13	51.75	68.85	2.04	127.77
10-Apr	5.81	58.45	79.79	2.01	146.07
11-Apr	2.47	24.22	29.48	1.38	57.55
12-Apr	4.49	43.35	53.48	2.01	103.68
13-Apr	5.19	54.56	74.05	2.29	136.09
14-Apr	4.07	41.02	49.38	1.78	96.24
15-Apr	3.99	40.38	34.72	1.77	80.85
16-Apr	5.18	52.04	57.54	1.58	116.33
17-Apr	3.98	39.29	59.21	1.77	104.25

18-Apr	4.64	46.27	73.96	1.86	126.73
19-Apr	3.77	35.78	79.53	2.24	121.32
20-Apr	4.03	40.71	57.16	1.72	103.63
21-Apr	5.74	60.01	76.25	2.03	144.03
22-Apr	5.62	56.10	71.85	2.49	138.06
23-Apr	4.02	42.00	51.97	1.95	99.93
24-Apr	2.65	28.51	47.41	1.85	80.42
25-Apr	2.79	48.38	45.74	2.31	99.22
26-Apr	4.31	38.26	60.07	2.41	105.06
27-Apr	3.50	39.51	52.62	2.03	97.65
28-Apr	3.93	37.56	68.14	1.86	111.49
29-Apr	3.38	36.35	54.58	2.34	96.65
30-Apr	3.98	44.00	68.86	2.39	119.23
Total	129.16	1327.80	1774.46	61.02	3292.44

Table 2. Data on the amount of daily energy produced in May

Date	**Actual (MWh)**				**Overall Actual (MWh)**
	Phase 1	**Phase 2**	**Phase 3**	**Pelalawan**	
Installed Capacity	**1 MW**	**10 MW**	**14.4 MW**	**0,5 MW**	
1-May	1.93	22.53	34.38	0.03	58.87
2-May	5.71	58.58	82.18	2.00	148.47
3-May	5.00	52.36	72.70	2.26	132.32
4-May	2.05	21.14	29.94	0.88	54.01
5-May	5.03	48.22	79.14	1.94	134.33
6-May	3.23	40.26	57.75	1.77	103.01
7-May	3.14	28.19	66.43	1.84	99.61
8-May	3.29	24.21	48.72	1.80	78.03
9-May	2.87	32.08	53.32	2.21	90.47
10-May	3.85	29.93	63.53	1.78	99.10
11-May	3.10	35.43	57.01	1.71	97.24
12-May	5.21	50.52	87.50	1.92	145.15
13-May	3.49	36.53	58.43	2.15	100.61
14-May	3.18	31.03	45.01	1.61	80.83
15-May	3.23	33.11	57.34	2.11	95.79
16-May	3.54	35.31	54.64	1.49	94.98
17-May	4.83	50.49	83.81	2.34	141.47
18-May	3.32	35.15	61.16	1.94	101.57
19-May	5.23	56.30	81.46	2.12	145.14
20-May	4.14	43.29	66.38	2.07	115.88
21-May	4.23	43.82	68.78	2.08	118.91
22-May	2.70	27.75	41.48	1.40	73.33
23-May	4.78	49.66	81.00	2.06	137.49
24-May	3.48	37.08	38.73	1.81	81.10
25-May	4.29	46.92	55.09	2.29	108.59
26-May	2.74	28.77	45.11	1.63	78.25
27-May	3.52	36.92	61.19	1.93	103.56
28-May	4.53	45.00	69.07	1.91	120.50
29-May	3.06	32.9	55.42	1.91	93.29
30-May	3.47	35.59	50.96	1.48	91.50
31-May	2.85	29.66	56.98	1.71	91.20
Total	115.02	1178.73	1864.64	56.18	3214.57

Table 3. Data on the amount of daily energy produced in June

Date	Actual (MWh)				Overall Actual (MWh)
	Phase 1	Phase 2	Phase 3	Pelalawan	
Installed Capacity	**1 MW**	**10 MW**	**14.4 MW**	**0,5 MW**	
1-Jun	2.72	27.37	43.82	1.17	75.08
2-Jun	2.93	27.66	52.83	1.48	84.89
3-Jun	3.90	44.22	54.83	2.14	105.09
4-Jun	2.89	33.82	39.24	1.72	77.68
5-Jun	4.84	48.17	86.92	2.04	141.97
6-Jun	3.15	33.29	60.05	1.73	98.21
7-Jun	4.40	47.92	67.46	2.17	121.96
8-Jun	3.48	36.50	57.15	1.66	98.79
9-Jun	2.82	28.85	45.47	1.55	78.70
10-Jun	3.62	35.13	70.16	2.02	110.93
11-Jun	5.06	54.75	78.94	2.25	141.01
12-Jun	3.36	33.93	57.70	2.24	97.24
13-Jun	4.41	46.09	58.79	2.32	111.61
14-Jun	4.75	50.84	74.80	2.13	132.53
15-Jun	4.66	50.00	64.52	2.14	121.32
16-Jun	3.48	32.05	59.24	1.84	96.62
17-Jun	5.56	59.55	82.52	1.94	149.57
18-Jun	3.32	35.06	51.00	1.58	90.97
19-Jun	3.08	35.80	47.94	1.71	98.53
20-Jun	3.93	41.49	66.04	1.26	112.71
21-Jun	3.87	42.49	60.12	1.69	108.17
22-Jun	2.58	26.75	42.09	1.25	72.67
23-Jun	3.65	39.91	64.47	1.86	109.89
24-Jun	4.45	48.79	76.07	2.17	131.48
25-Jun	3.81	43.70	77.59	1.96	127.06
26-Jun	2.18	27.21	42.15	1.70	73.25
27-Jun	3.17	21.78	40.44	1.84	67.24
28-Jun	2.13	22.19	35.91	1.86	62.09
29-Jun	3.94	30.95	76.99	1.98	113.83
30-Jun	1.36	12.67	27.54	0.97	42.45
Total	107.5	1118.93	1762.79	54.37	3043.59

Based on data obtained from the solar PV monitoring system at PT Riau Andalan Pulp and Paper, this study found that the amount of electricity generated by solar panels reached 3292.44 MWh in April, 3214.57 MWh in May, 3043.59 MWh in June. These results demonstrate the significant potential of solar energy in its contribution to industrial electricity needs, as well as provide a solid basis for the development of further optimization strategies in the utilization of renewable energy in industrial environments.

Distribution of Electricity from Solar Power Plant (PLTS) at PT Riau Andalan Pulp and Paper

This study aims to examine the distribution of electricity generated by the Solar Power Plant (PLTS) at PT Riau Andalan Pulp and Paper in supporting factory operations. Based on the data obtained, the implementation of solar power plants is carried out in several phases: Phase 1 distributes electricity to the Paper Machine 1 plant, Phase 2 to the

Paper Machine 2 plant, and Phase 3 to the Board Machine plant. Each phase is designed to provide a stable and environmentally friendly additional energy source for the main production units, thereby supporting operational efficiency and reducing the burden on the Steam Power Plant (PLTU), which is the main energy source in the factory area (Musyafiq et al., 2023).

In addition to supporting the main production unit, the distribution of electricity from solar power plants also covers the Pelalawan estate area in a phase called Pelalawan. The distribution of electricity to the Pelalawan estate aims to support various operational and management activities in the region, including the provision of energy for employee housing, health facilities, and other supporting infrastructure. Thus, solar power plants not only play a role in supporting factory operations but also improving the quality of life in the environment around the factory.

This research highlights the importance of renewable energy integration strategies in the company's energy system. Although coal-fired power plants remain the main source of energy, the existence of solar power plants as an additional energy source provides greater flexibility and reliability in daily operations. The structured distribution from solar power plants to various production units and Pelalawan estates shows that PT RAPP has a holistic approach to energy management, which not only supports operational sustainability but also strengthens the company's commitment to carbon emission reduction and environmental sustainability. These findings provide a strong foundation for the development of renewable energy strategies in the pulp and paper industry and can serve as a model for other companies looking to implement green energy solutions.

Reduction of CO2 Emissions by the Use of Solar Power Plants at PT Riau Andalan Pulp and Paper

In a global effort to reduce carbon emissions and combat climate change, the use of renewable energy such as Solar Power Plants (PLTS) is becoming increasingly important. This study aims to measure the extent to which the use of solar power plants at PT Riau Andalan Pulp and Paper (PT RAPP) has succeeded in reducing CO2 emissions. Based on data obtained from the solar power plant monitoring system at PT RAPP, this study will analyze the number of CO2 emissions that have been successfully avoided (CO2 avoided) as a result of solar power plant operations. The results of this study are expected to provide in-depth insights into the positive impact of renewable energy use on the environment and provide a basis for the development of more sustainable energy policies. Here are some data obtained from the solar PV monitoring system at PT Riau Andalan Pulp and Paper from April to June 2024. The following is a table of the number of CO2 emissions that have been successfully avoided (CO2 Avoided).

Table 4. CO2 Avoided in April, May, June 2024

Date	April CO2 Avoided (ton)	Date	May CO2 Avoided (ton)	Date	June CO2 Avoided (ton)
1-Apr	24,810.31	1-May	7,312.14	1-Jun	15,347.96
2-Apr	17,566.03	2-May	18,119.02	2-Jun	20,033.19

3-Apr	21,765.08	3-May	16,341.38	3-Jun	35,518.15
4-Apr	13,756.36	4-May	6,642.81	4-Jun	25,350.84
5-Apr	16,075.42	5-May	14,549.51	5-Jun	38,730.37
6-Apr	10,872.01	6-May	11,372.58	6-Jun	26,602.51
7-Apr	14,924.01	7-May	8,746.31	7-Jun	38,691.29
8-Apr	14,231.44	8-May	6,509.02	8-Jun	29,344.15
9-Apr	16,763.88	9-May	16,140.22	9-Jun	23,197.09
10-Apr	18,814.08	10-May	13,932.19	10-Jun	28,758.44
11-Apr	8,170.81	11-May	20,325.92	11-Jun	44,022.06
12-Apr	14,746.65	12-May	27,880.39	12-Jun	27,277.39
13-Apr	17,304.57	13-May	20,454.40	13-Jun	37,053.63
14-Apr	13,311.18	14-May	16,928.22	14-Jun	40,872.06
15-Apr	13,345.92	15-May	12,480.65	15-Jun	40,201.61
16-Apr	17,012.96	16-May	16,370.97	16-Jun	25,767.88
17-Apr	12,671.76	17-May	19,803.24	17-Jun	47,875.95
18-Apr	12,266.79	18-May	2,821.80	18-Jun	28,190.17
19-Apr	4,123.23	19-May	4,483.35	19-Jun	28,785.93
20-Apr	4,937.77	20-May	3,503.67	20-Jun	33,354.18
21-Apr	7,399.61	21-May	3,548.29	21-Jun	28,765.51
22-Apr	7,255.70	22-May	2,217.11	22-Jun	18,057.84
23-Apr	5,122.77	23-May	4,096.86	23-Jun	27,065.21
24-Apr	6,960.79	24-May	2,937.74	24-Jun	33,056.70
25-Apr	13,772.84	25-May	3,571.93	25-Jun	29,538.24
26-Apr	11,394.53	26-May	2,302.01	26-Jun	18,523.60
27-Apr	15,407.61	27-May	2,954.70	27-Jun	14,987.61
28-Apr	15,794.74	28-May	3,675.89	28-Jun	15,158.54
29-Apr	13,748.00	29-May	2,520.38	29-Jun	21,151.39
30-Apr	13,959.45	30-May	2,810.30	30-Jun	5,719.50
-	-	31-May	2,307.16	-	-
Total	398,286.30	Total	297,660.16	Total	846,998.99

Based on data obtained from the solar PV monitoring system at PT Riau Andalan Pulp and Paper (PT RAPP) for the period April to June 2024, this study shows that the use of solar PV has succeeded in significantly reducing CO2 emissions. During the period, total CO2 emissions avoided reached 398,286.30 tons in April, 297,660.16 tons in May, 846,998.99 tons in June, showing the great potential of solar PV in reducing the company's carbon footprint. These findings confirm that the integration of solar power plants into the company's energy system not only supports operational sustainability but also contributes significantly to climate change mitigation efforts.

Analysis of Total Monthly Energy Production from Solar Power Plants (PLTS) at PT Riau Andalan Pulp and Paper

This research began by collecting monthly energy production data from solar power plants at PT Riau Andalan Pulp and Paper during the period of April to June 2024. This data includes the total amount of energy produced every month from Phase 1, Phase 2, Phase 3 and Pelalawan. The results of this analysis are expected to provide a comprehensive overview of the performance of solar power plants at PT Riau Andalan Pulp and Paper and provide a basis for future system improvements and optimizations.

Table 5. Total Energy Production Data for April, May and June

Date	Energy Production in April (MWh)	Energy Production for May (MWh)	Energy Production in June (MWh)
1	122.36	58.87	75.08
2	100.81	148.47	84.89
3	122.06	132.32	105.09
4	94.57	54.01	77.68
5	126.22	134.33	141.97
6	105.22	103.01	98.21
7	112.25	99.61	121.96
8	99.06	78.03	98.79
9	127.77	90.47	78.70
10	146.07	99.10	110.93
11	57.55	97.24	141.01
12	103.68	145.15	97.24
13	136.09	100.61	111.61
14	96.24	80.83	132.53
15	80.85	95.79	121.32
16	116.33	94.98	96.62
17	104.25	141.47	149.57
18	126.73	101.57	90.97
19	121.32	145.14	98.53
20	103.63	115.88	112.71
21	144.03	118.91	108.17
22	138.06	73.33	72.67
23	99.93	137.49	109.89
24	80.42	81.10	131.48
25	99.22	108.59	127.06
26	105.06	78.25	73.25
27	97.65	103.56	67.24
28	111.49	120.50	62.09
29	96.65	93.29	113.83
30	119.23	91.50	42.45
31	-	91.20	-
Total	3292.44	3214.57	3043.59

Based on the total energy production data from the Solar Power Plant (PLTS) at PT Riau Andalan Pulp and Paper for April, May, and June, here are some analyses that can be done:

a. Total Energy Production

April: 3292.44 MWh

May: 3214.57 MWh

June: 3043.59 MWh

From this, it can be seen that energy production is declining every month from April to June.

b. Average Daily Production

April: 3292.44 MWh / 30 days = 109.75 MWh/day

May: 3214.57 MWh / 31 days = 103.70 MWh / day

June: 3043.59 / 30 days = 101.45 MWh/day

Average daily energy production decreased slightly from April to June. This indicates the possibility of a decrease in efficiency or lower intensity of sunlight.

c. Daily Production Fluctuation

April: Daily energy production ranges from 57.55 MWh to 146.07 MWh

May: Daily energy production ranges from 54.01 MWh to 148.47 MWh

June: Daily energy production ranges from 42.45 MWh to 141.97 MWh

The variation in daily energy production is quite significant every month, indicating the presence of external factors such as weather that affect energy production.

d. Highest and Lowest Production:

April: Energy production was highest on the 10th (146.07 MWh) and lowest on the 11th (57.55 MWh)

May: Energy production was highest on the 2nd (148.47 MWh) and lowest on the 4th (54.01 MWh)

June: Energy production was highest on the 5th (141.97 MWh) and lowest on the 30th (42.45 MWh)

From this analysis, we can conclude that although there are significant daily fluctuations in energy production from solar PV, April showed the most consistent performance with the highest total production and daily average. Large fluctuations indicate that factors such as weather greatly affect the daily energy production of solar PV.

Analysis of Solar Power Plant Performance Trends Using Historical Data of the Monitoring System at PT Riau Andalan Pulp and Paper

The use of renewable energy, especially Solar Power Plants (PLTS), is increasingly recognized as a sustainable solution to meet energy needs while reducing environmental impact. At PT Riau Andalan Pulp and Paper (PT RAPP), PLTS has been implemented as part of the company's efforts to support its sustainability commitments. To understand and optimize the performance of solar PV, analysis of performance trends using historical data from the monitoring system is very important. This study aims to evaluate the performance trend of solar PV based on historical data obtained from the monitoring system, identify factors that affect energy production efficiency, and provide recommendations for future performance improvement. Through this analysis, it is hoped that a deeper insight into the operational dynamics of solar PV and more effective optimization strategies can be obtained.

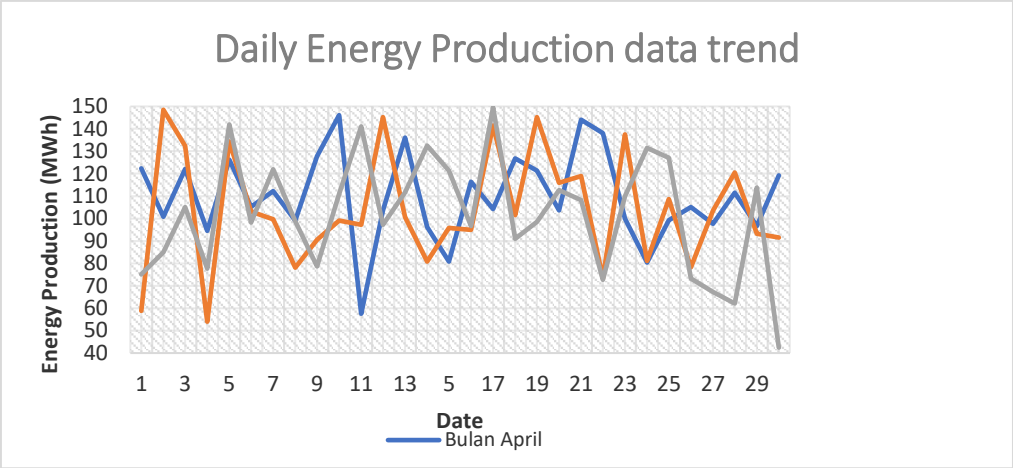

Figure 1. Daily Energy Production data trend

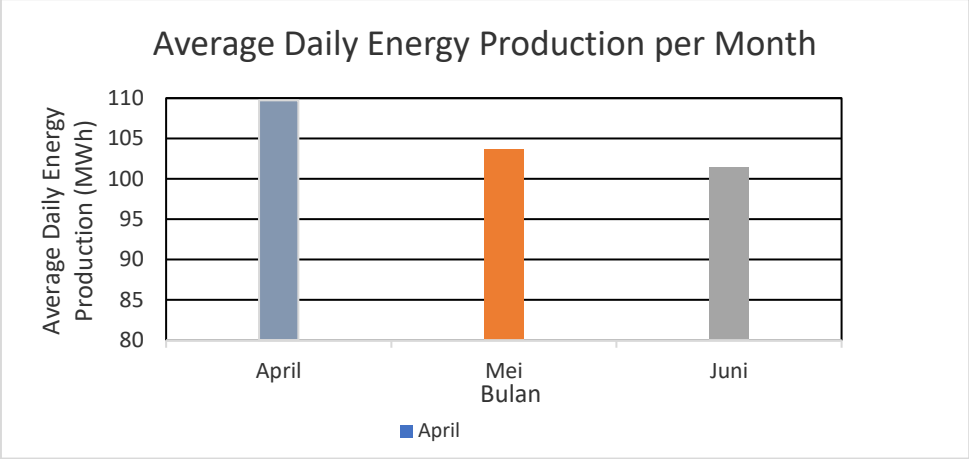

Figure 2. Average Daily Energy Production per Month

Here is a graph showing daily energy production and average daily energy production for the months of April, May, and June:

a. Daily Energy Production Graph

The first graph shows daily energy production (in MWh) for the months of April, May, and June. There are fluctuations in energy production from day to day for each month.

b. Average Daily Energy Production per Month Chart

The second graph shows the average daily energy production for each month. Here is the average daily production per month:

April: 109.75 MWh/day

May: 103.70 MWh/day

June: 101.45 MWh/day

c. Analysis

Monthly Trends: There was a decrease in average daily energy production from April to May and from May to June.

Daily Fluctuations: Daily energy production experiences significant fluctuations on a daily basis, which may be due to factors such as weather conditions and system maintenance.

Based on energy production data for April, May, and June, here are some key conclusions regarding solar PV performance trends:

a) Monthly Energy Production Decline:

There was a decrease in total energy production from April to May and from May to June.

Total energy production:

April: 3292.44 MWh

May: 3214.57 MWh

June: 3043.59 MWh

This decline shows an overall decline in performance during the three months.

b) Average Daily Energy Production Decline:

Average daily energy production declined from April to May and continued to decline from May to June.

Average daily production:

April: 109.75 MWh/day

May: 103.70 MWh/day

June: 101.45 MWh/day

This decrease in average daily production may indicate consistent problems, such as decreased efficiency or less favorable weather conditions.

c) Days with Highest and Lowest Production:

The highest production was recorded on April 10, May 2, and June 17.

The lowest production was recorded on April 11, May 4, and June 30.

Days with the highest production may indicate optimal conditions, while days with the lowest production may be caused by disturbances or adverse weather conditions.

d) Factors Affecting Energy Production

Fluctuations in energy production can be caused by a variety of factors, including weather conditions, solar panel efficiency, and duration of sunlight. For example, days with low energy production may be caused by cloudy weather or rain.

The increase in energy production in March could be due to an increase in the duration of sunlight or an improvement in operational efficiency.

e) Sustainability and Optimization

The trend of increasing energy production in April shows that the solar PV system is operating well and its efficiency is improving over time. However, it is important to continuously monitor and optimize system performance to ensure sustainability and high efficiency.

There was a downward trend in both total monthly production and average daily production from April to June. This may indicate an issue that needs further investigation, such as a technical issue or a change in environmental conditions. From the analysis that has been carried out on the daily energy production data of solar power plants at PT Riau

Andalan Pulp and Paper from April to June, it can be seen that there is a downward trend in energy production. Despite daily fluctuations caused by various external factors such as weather, overall, the performance of solar power plants showed positive and promising results.

In the future, it is important to continue to monitor and analyze energy production data on a regular basis. This step is not only aimed at ensuring optimal operations, but also to identify areas that need further improvement. Thus, PT Riau Andalan Pulp and Paper can continue to improve its efficiency and contribution in the provision of clean and sustainable energy. This study provides a good initial picture of the performance of solar PV, but further research is needed with a longer period of time and involves a more detailed analysis of external factors. This will help in making more appropriate decisions to improve the overall performance of the solar system.

Analysis of the Efficiency and Performance of Solar Power Plants

Analysis of the efficiency and performance of Solar Power Plants (PLTS) is becoming increasingly crucial in an effort to increase the contribution of renewable energy to the overall energy supply. In this context, this study aims to examine in depth the efficiency and performance of solar power plants at PT Riau Andalan Pulp and Paper. By analyzing daily energy production data during the period from April to June.

Daily efficiency can be calculated using the following formula:

$$\text{Efisiensi} = \frac{\text{Produksi Energi (kWh)}}{\text{Global Irradiation (kWh/m}^2\text{) x Luas Module (m}^2\text{)}} \times 100\%$$

Performance Ratio (PR) is an indicator that shows how well the solar PV system is operating compared to ideal conditions. The Performance Ratio can be calculated using the following formula: (Rahmaniar et al., 2022, 2023)

$$PR = \frac{\text{Produksi Energi (kWh)}}{\text{Global Irradiation (kWh/m}^2\text{) x Luas Module (m}^2\text{) x Efisiensi Nominal}} \times 100\%$$

For information, the nominal efficiency of modules at PT Riau Andalan Pulp and Paper Solar Power Plant is as follows:

Phase 1 : 17.7%
Phase 2 : 21.1%
Phase 3 : 21.4%
Pelalawan : 21.2%

Conclusion

This research analyzed the performance of the solar power plant at PT Riau Andalan Pulp and Paper, which generated 3292.44 MWh in April, 3214.57 MWh in May, and 3043.59 MWh in June 2024. The plant significantly contributes to meeting industrial energy needs while reducing reliance on fossil fuels. The phased implementation supplies electricity to various production units and the Pelalawan estate, supporting operational efficiency and regional infrastructure.

The use of solar PV avoided substantial CO2 emissions—398,286.30 tons in April, 297,660.16 tons in May, and 846,998.99 tons in June—highlighting its role in reducing the company's carbon footprint. However, a declining trend in energy production and efficiency over the observed months indicates potential issues requiring further investigation, such as technical challenges or environmental factors.

Performance varied across phases, with Phase 3 showing the highest efficiency and Performance Ratio in April (31.38% and 146.29%, respectively). Conversely, Phase 1 and the Pelalawan estate recorded the lowest efficiency and Performance Ratio in June (11.56% and 65.34%). These variations underline the impact of factors like weather, technology, and maintenance on solar plant performance. Overall, the plant demonstrates promising results with opportunities for optimization to enhance energy output and efficiency.

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