

Performance Ratio Evaluation of Rooftop Solar Power Plant 32 KWp On Grid, Study Case in PT. KPJB Office Jepara Indonesia

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Abstract

In connection with Republic of Indonesia government regulation No. 79 of 2014 that mentioned 23% portion of Renewable Energy Usage Plan in 2025, PT KPJB as Operation and Maintenance of Tanjung Jati B Unit 3&4 CFPP has been implementing Solar Power Plant with capacity 32 KWp. It is used to supply daily office load likes computer, air conditioner, water pump, dispenser and lighting. However the electricity energy that produced is still not optimal yet due to weather condition. This is shown by the performance ratio calculation which is only worth 74.67% in April 2022. The power production average is 2,511.69 KWh per month, this is so far from total capacity installed and not sufficient for daily electricity energy used at the KPJB office.

Keywords: Solar Power Plant, Performance Ratio, Electricity Energy

1. Introduction

Republic of Indonesia government regulation No. 79 of 2014 stated that targeting the use of renewable energy should be at least 23% in 2025. In line with these gelationon, PLN is obliged to start energy transition steps as son as possible. In other, dependence on oil and coal is targeted to decrease with a respective percentage of 20% and 25% [1]. Based on Indonesia outlook energy 2019, solar energy is the most potential energy that can be utilized as renewable and environmentally friendly alternative energy. It can be used as alternative solution to reduce fossil energy compared to other alternative energies where solar power has a potential up to 207 GWp [2].

Solar Energy is an energy that comes from solar radiation. Indonesia has a very large intensity of solar energy because its territory stretches across the equator with 4.80 kWh/m² of light radiation every day. Solar Energy can be used directly with applications that are devided into two types, that are solar thermal for heating application and solar power plant [3-5].

With the proper use of technology, solar energy can produce electrical or thermal energy. Electrical energy is the result of energy conversion from solar radiation with various wavelengths, ranging from ultraviolet, visible light, to infrared from the electromagnetic spectrum. The use of of solar energy as one of the 10

renewable energies relies on the Paris Agreement as an International legal instrument that has been adopted by Indonesia. This is to support reducing the amount of carbon emissions through the energy transition program in order to achieve a reduction in the global warming level. Currently, earth condition are getting worse due to global warming that caused of continuous use of fossil fuels such as petroleum, coal, gas, and others. So it necessary to start the transition process to renewable energy, like wind energy, water energy, microhydro, solar energy, geothermal energy, etc.

Solar Power Plant are expected to ber more in demand because of flexibility in a use. Solar Power Plant can be applied for any purpose and anywhere, such as in buildings, factories, housing, to water locations such as reservoirs. In addition to its abundant supply, the solar energy released does not have a negative impact on the environment compared to other energy sources. Based on monitoring for 2 months, Solar Power Plant On Grid in SMP N 3 Purwodadi could generate power till 361 kWh with daily average production 5.92 kWh and performance ratio 83% [6]. In 2021 Ali studied planning solar power plant on Pondok Pesantren Tanhibul Ghofilin, Kabupaten Banjarnegara. In their result, Solar Power Plant with 11,700 Wp could produce 16,136 kWh within 1 year with performance ratio score 79.6%. [7].

2. Methods

• Location and Time Research

The research will be carried out at PT. KPJB office building, Tanjung Jati B Unit 3 and 4 Coal Fired Power Plant, Kabupaten Jepara. The geographical coordinates is on Latitude $06^{\circ}26'48''$ and longitude $110^{\circ}44'18''$ [8]. The data which will be used are from April 2022 till December 2022.



Figure 1. PT KPJB Office Location [8]

• Solar Panel Specification

Solar panel installed are 80 pcs of monocrystalline silicon for generate 32 kWp electrical energy. They are devided to be 4 string with 20 series solar module per string. The detail specification is as bellow :

Table 1. 400 Wp Solar Panel Specification

Parameter	Value
Number of cell	144
Output Power Max (Pmax)	400 Wp
No Load Voltage (Voc)	49.0 VDC
Peak Voltage (Vmpp)	41.2 VDC
Short Circuit Current (Isc)	10.21 A
Max Current (Imax)	9.71 A
Efficiency (η)	19.63 %

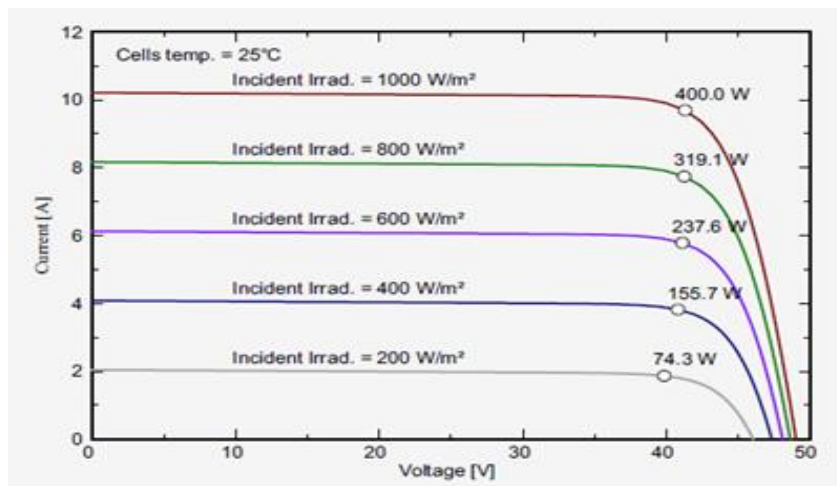


Figure 2. Solar Panel Characteristic

• **Inverter Specification**

Inverter that installed on this solar power plant is On Grid type with capacity 30 KW. The detail specification is as bellow :

Table 2. Inverter Specification

Parameter	Value
AC nominal output power	30 KW
AC nominal output voltage	400 VAC
Output Voltage	323 - 480 VAC
Output Current	43.3 - 47.6 A
Frequency	50 – 60 Hz
MPPT Tracker	3
Power Factor	0.8
Efficiency (η)	max 98.2 %

• **Daily Load**

KPJB as operation and maintenance company of Tanjung Jati B CFPP need electrical energy around 32 KWp during office work time (8 am to 5 pm) to supply some electronic devices like PC, dispenser, Air Conditioner, etc. The daily load is supplied from self used energy of CFPP.



Figure 3. Daily Electrical Load in KPJB Office

• **Layout Drawing Solar Power Plant 32 KWp**

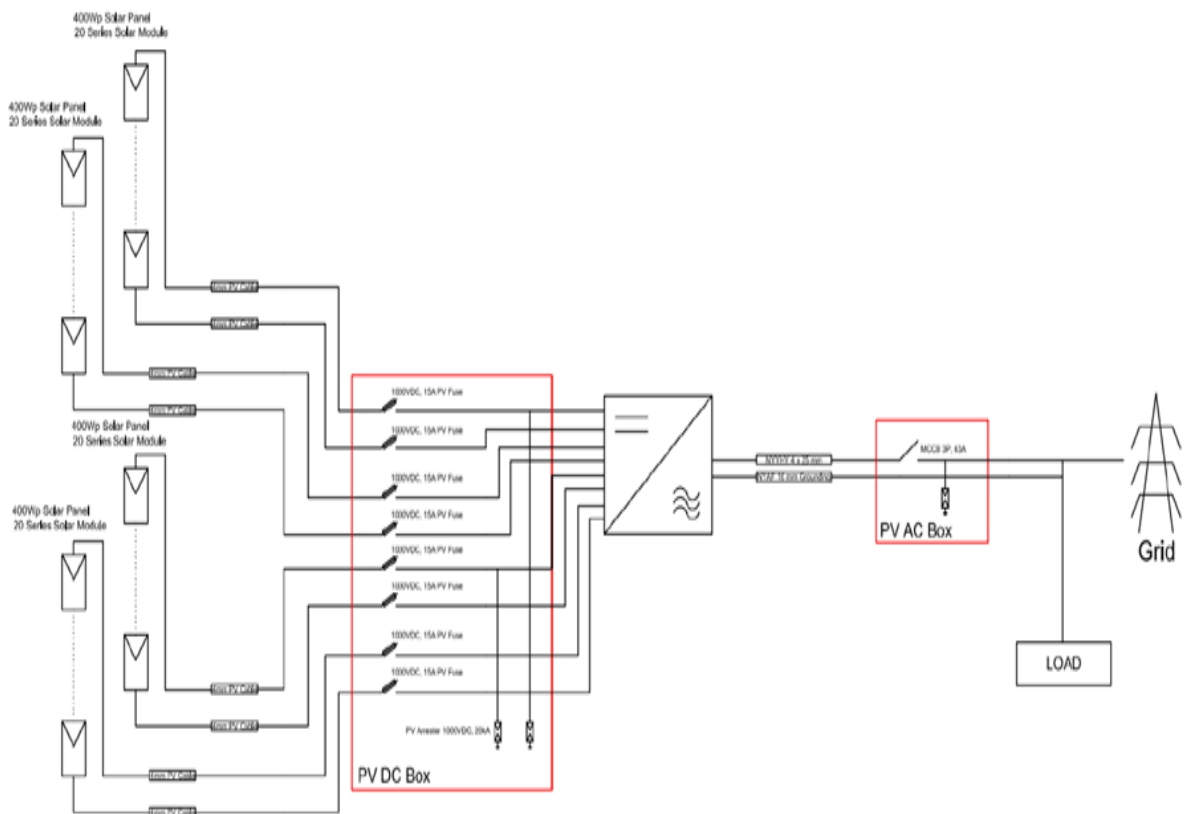


Figure 4. Layout Solar Power Plant 32 KWp

• **Performance Ratio (PR)**

Performance of Solar Power Plant can be analyzed by performance ratio method. The calculation is a ratio between actual energy production with the energy prediction. Herewith the calculation formula as bellow [9] :

$$PR = \frac{\text{Actual Power Production}}{GHI \times A \times \eta} \quad (1)$$

Where ;

- PR = Performance Ratio (%)
- Actual Power Production (KWh)
- GHI = Global Horizontal Irradiance (KWh/m²)
- A = String Area (m²)
- η = Efficiency of Solar Module (%)

3. Result and Discussion

• **KWh Production**

In Tanjung Jati B Unit 3&4, selling price of electricity energy is IDR. 1,082.82 / KWh. We assumed the supply energy from Solar Power Plant to KPJB Office building will decrease own used energy that usually supplied from Coal Fired Power Plant.

Table 3. KWh Production April till December 2022

Month	Production KWh	Anticipated Yield (IDR)
APR	3,736.57	4.046.032,73
MAY	3,357.49	3.635.557,32
JUN	3,458.42	3.744.846,34
JUL	3,819.85	4.136.209,98
AUG	2,998.57	3.246.911,57
SEP	3,567.36	3.862.808,76
OCT	3,193.52	3.458.007,33
NOV	2,861.30	3.098.272,87
DEC	2,511.69	2.719.708,17

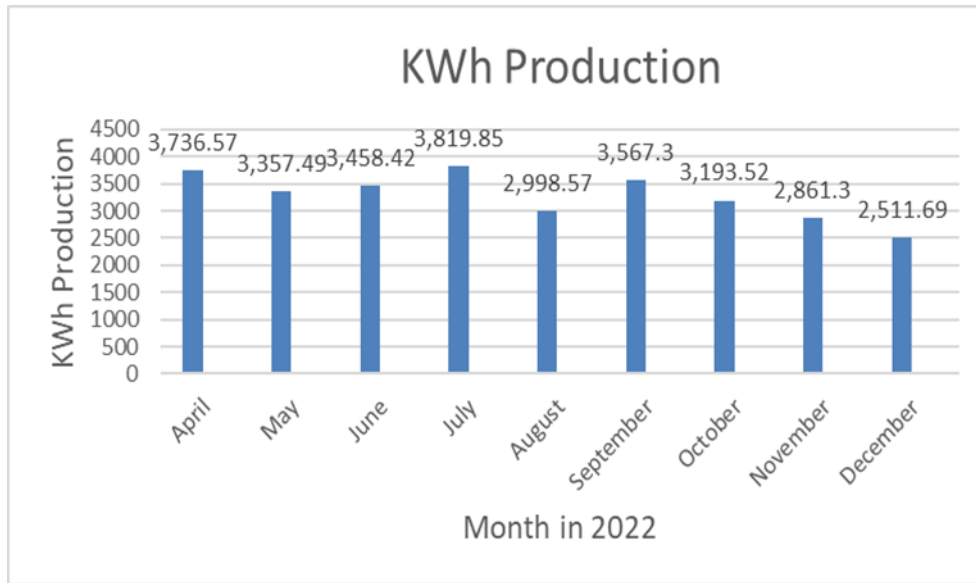


Figure 5. KWh Production period of April till December 2022

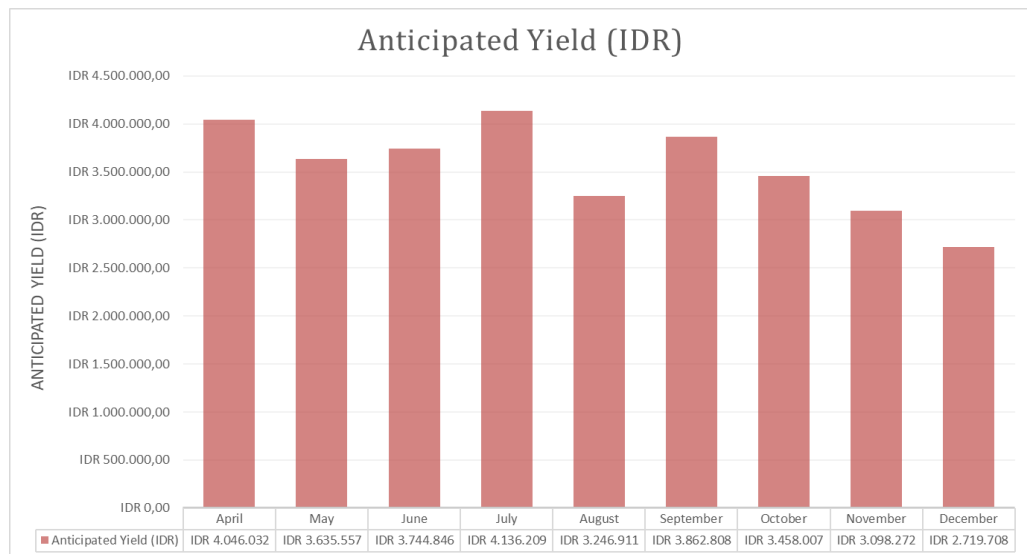


Figure 6. Anticipated Yield period of April till December 2022

• **Performance Ratio**

During 2022, the global horizontal irradiance in Tanjung Jati B CFPP is 5.077 KWh/m² per day and the total area of string solar panel is 163.42 m². If the manual from manufacturer said that the efficiency per solar panel is 19.63%, the performance ratio on April 2022 can be calculated with equation (1) as explored below :

$$PR = \frac{\text{Actual Power Production}}{GHI \times A \times \eta} \quad (1)$$

$$PR = \frac{3,736.57}{152.31 \times 163.42 \times 19.63\%}$$

$$PR = 76.47 \%$$

Table 4. Performance Ratio period of April till December 2022

Month	Production (kWh)	GHI / month	Prediction (kWh)	PR (%)
APR	3736,57	152,31	4886,01	76,47%
MAY	3357,49	157,387	5048,87	66,50%
JUN	3458,42	152,31	4886,01	70,78%
JUL	3819,85	157,387	5048,87	75,66%
AUG	2998,57	157,387	5048,87	59,39%
SEP	3567,36	152,31	4886,01	73,01%
OCT	3193,52	157,387	5048,87	63,25%
NOV	2861,30	152,31	4886,01	58,56%
DEC	2511,69	157,387	5048,87	49,75%



Figure 7. Performance Ratio period of April till December 2022

Based on performance ratio calculation on the table 6., it found that the PR value is not stable. The highest performance got in April 2022 with 76.47% and the worst in December 2022 with 49.75%. This was caused by the weather condition in Tanjung Jati B area is always changed, even more the rainy season period usually start on October 2022. So, KPJB team need to prepare more effort to maintain the Solar Panel surface and other parts to get more performance.

4. Conclusion

The Rooftop Solar Power Plant 32 KWp in PT. KPJB Office Building was implemented and operated well. The solar panel used have good specification with efficiency 19.63 %. However, after study with sample data during April 2022 till December 2022, the electricity energy that produced is still not optimal yet. This is shown by the performance ratio calculation which is only worth 74.67% in April 2022. The power production average is 2,511.69 KWh per month, this is so far from total capacity installed and not sufficient for daily electricity energy used at the KPJB office. So KPJB team need to plan a Preventive Maintenance to keep the performance of Solar Panel and also minimize the breakdown time, even more during the weather condition uncertainly at present.

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