Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra

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Abstract. PV system utilize the photovoltaic effect to generate electricity directly from the energy brought by the sunrays. However, the normal ground installation of PV panel is prone to several effect reducing the power output and efficiency, such as the overheated panel surface that can lead to malfunction of a cell. The alternative for ground installation is installing the PV panel on the surface of a water body such as river or lake, and called Floating Solar Panel. This paper presents the pilot project for application of floating solar panel in Palembang. This setting is also functioning as passive or natural cooling for the panel and increase the power output. The pilot project was conducted on August 2-8, 2019 by comparing two 100 Wp Poly-crystalline PV panels. The passive cooling of floating solar panel can reduce surface temperature by 2°C compared to ground installation. The experiment shows the most effective time to harvest the power from the sun is from 11.00 AM to 02.00 PM. The average output power generated by Floating Solar Panels is 51.6 Watts, compared to 42.9 Watt Ground Solar panels.

Keywords: Floating solar panel, photovoltaic, ground solar panel, renewable energy, output efficiency.

1. Introduction

The data from Ministry of Energy and Mineral Resources of the Republic of Indonesia for 2014 stated that Indonesia dependence on fossil energy, especially oil, is still high at 96% (petroleum 48%, gas 18%, and coal 30%) of total consumption [1]. The high consumption of fossil energy sometimes due to over-consumed energy, while on the other hand, Indonesia is facing a decline in fossil energy reservation. This declination is a continuous trend that the Indonesian government has to address the need to find the alternative to maintain the stability of electricity supply relative to the increment of electricity demand.
Indonesia is considering energy alternatives or renewable energy which can be replenished in a short time and unlimited. By utilizing Indonesia location in the equator, energy from the sun is one of the most promising alternatives whereas a tropical region, and it receives an average solar irradiation potential of 4.8 kWh/m² per day [2][3].

Palembang is located in South Sumatra and is very near to equator line, situated in 2° 59’27.99” South and 104° 45’24.24” East. The total area of Palembang city is 358.55 km². Palembang enjoys a tropical climate with high humidity and wind speeds ranging from 2.3 km/h - 4.5 km/h. The average city temperature ranges from 23.4 - 31.7 °C, with average solar radiation of 45%[2].

The condition of the abundance of solar radiation for all the year-long also become a challenge for electricity generation using Photovoltaic (PV) effect since the high temperature of Palembang increases the PV panel surface temperature. This high heat, known as overheating, can significantly reduce the power output of PV panel electrical energy conversion. PV panel performance is very dependent on the operating temperature. Most of the energy absorbed by the PV panel is converted to heat. In general, PV panels only convert 4-17% of solar radiation into electrical energy [4]-[12]. One of the most affected by this increase in temperature is a decrease in working voltage, output power and Fill Factor, but on the other hand there is a slight increase in shortcircuit current [6]; however with the price of voltage drop.

This challenge can be overcome by installing a cooling system; however, it also comes with difficulty due to active cooling needs power. The passive cooling which is utilizing nature is preferable than active cooling, and one of them is by floating the PV panel on the surface of waterbody, such as river and lake[13][14].

This paper discusses the pilot project of floating PV panel on the waterbody and compares the produced output power with the standard ground installation. The floating and ground installation PV panels are placed nearby to each other, and the data was taken for seven days simultaneously. The output power of both installations is measured and compared to show the effectiveness of the proposed method.

2. Methodology

PV system is a power plant that uses sunlight through solar cells (photovoltaic) to convert solar photon ray radiation into electrical energy. Solar cells are thin layers made of pure silicon (Si) semiconductor material, or other semiconductor material. Based on the installation location, the PV system is divided into three types; Ground, Roof, and Floating [7].

Meanwhile, based on the application and configuration, in general, the PV system is classified into two; connected to the utility or on-grid, and standalone or off-grid PV
plant. If in its use PV system is combined with other types of power plants, it is called a hybrid system.

The main factors influencing variations in PV system electricity production are solar irradiation, solar module temperature, and shading that occur during operation time. Irradiation affects the electric current generated by the solar power plant, module temperature affects the voltage generated by the solar power plant, and shading affects solar irradiation received by solar modules in the generation process, which at the same time affects the performance of solar power plant [8] [9] [10]. In previous years, many theoretical and experimental studies have been carried out to design cooling systems for PV panels. One solution that is currently developing in developed countries is Floating Solar panels. When the solar power plant is built on waterbody, the air on the surface is cooler and overcome the problem of overheating solar panel surface. Floating Solar Panels are known to be about 11% more efficient than Ground Solar Panels [11].

This research was conducted at Pier 12 Marine Pertamina in Palembang, South Sumatra, Indonesia as shown in figure 3 (2°59’27.99” S and 104°45’24.24” E). This study
Figure 3. Palembang location in Sumatra island.

Table 1. PV panel specifications

| Parameters                     | Variable Value |
|--------------------------------|----------------|
| Nominal maximum power          | $P_{\text{max}}$ 100 W |
| Optimum operating voltage      | $V_{\text{max}}$ 18.74 V |
| Optimum operating current      | $I_{\text{pm}}$ 6.20 A |
| Open circuit voltage           | $V_{\text{oc}}$ 22.04 V |
| Short circuit voltage          | $I_{\text{sc}}$ 6.57 V |
| Maximum system voltage         | 1000 V |
| Maximum series fuse rating     | 10 A |

implements two polycrystalline 100 WP (W-peak) PV panels. One panel is installed on the river and another one is installed on the ground. Data is taken for seven days (August 2-8, 2019) from 08:00 AM to 04:00 PM. Table 1 shows the technical specification of both panels. Figure 1 shows the research design while Figure 2(a) and 2(b) show the installation design of the PV panel research.

3. Result and Discussion

Data was taken on August 2-8, 2019 with average sunny days during dry season in Indonesia. Figure 4(a) shows the experimental setup for floating solar panel and figure 4(b) shows the ground installation to compare the effectiveness of the proposed floating installation.

Figure 5 shows data taken on August 2, 2019 when a 100 W load (DC lamp) is connected to the terminals of each PV panel. Irradiance begins to increase at 9:00 AM, this will affect the output power generated by the PV Panel. The maximum power generated occurs at 12:00
where the Floating Solar Panel produce output power of 55.3 Watt higher than the Ground Solar Panel which only produces an output power of 44.04 Watt with Irradiance 1147 W/m². Irradiance gradually drops at 15:00 to 350 W/m².

The effect of PV panel temperature on output power can be seen in Figure 6, as a 100 W DC lamp load is connected to the terminals of each PV panel. The difference in heat on the surfaces of the two PV panels affects the output power produced. The temperature of a Floating Solar panel is lower than an average 1.5°C Ground Solar panel.

Figure 7 is data taken on August 3, 2019, PV panels produce an effective electric current from 10:00 AM to 3:00 PM indicated by a 100 W DC-lamp. This range of electricity highest production points are called efficiency points.

The maximum power generated occurs at 12.00 PM, where the Ground Solar panel produced power of 44.08 Watts and the Floating Solar Panel produced an output power of 53.68 Watt with Irradiance 1158 W / m. Irradiance was reduced to 740 W/m² which resulted in a decrease in output power at 01.00 PM due to cloudy conditions as shown in figure 8.
Figure 6 shows the effect of the PV panel surface temperature on the output power when a 1.5 ohm load (DC lamp) is connected to the PV panel terminal. When the PV panel surface temperature is lower, it will produce more effective performance. The average output power of a Floating Solar Panel is 51.4 watts, higher than the 42.6 watt Ground Solar Panel.

Figure 7 shows the output power produced by the PV panel. The study was conducted for 7 days from August 2 to August 8, 2019. The average daily data was taken from 11:00 AM to 02:00 PM to show the effectiveness of the proposed method. Table 2 shows a recapitulation of the output and efficiency comparison of measurements for 7 days.

The maximum power from the PV panel occurs at 12.00 when the sun is right on the surface of the PV panel. Irradiance and PV panel temperature will greatly affect the
output power generated. Based on the experimental results the Floating Solar Panel produce an average power of 51.6 Watt higher than the Ground Solar Panel which only produces an output power of 42.9 Watt with irradiance 1035 W/m$^2$.

Indonesia is experiencing a dry season during the experiment. Therefore, the weather is very conducive for PV systems. Figure 10 shows the efficiency of the output power produced for 7 days, where $\eta$ is the efficiency. The average efficiency of Floating Solar Panel is 7%, and 5.8% for Ground Solar Panel. The green line in figure 10 shows the difference in efficiency, and the average difference is 1.2%.

The experiment results shows that the application of Floating Solar Panel is effective in reducing PV panels surface temperature, and increase the output power and efficiency of a PV System.

Table 2. Recapitulation and comparison of Floating and Ground Solar Panel
| Date       | Time | P     | P Floating | Irradiance | Ground | Floating |
|------------|------|-------|------------|------------|--------|----------|
| 02- Aug 0 -19 | 11.0 | 45.37 | 53.375     | 1106       | 6.1    | 7.2      |
|            | 5    |       |            | 4          | 2      |          |
|            | 12.0 | 44.04 | 53.2       | 1147.4     | 5.9    | 7.2      |
|            | 3    |       |            | 6          | 0      |          |
|            | 13.0 | 41.46 | 51,944     | 1038       | 5.6    | 7.0      |
|            | 0    | 3     |            | 1          | 3      |          |
|            | 14.0 | 42.74 | 52,073     | 994.8      | 5.7    | 7.0      |
|            | 0    | 4     |            | 8          | 4      |          |
| 03- Aug 0 -19 | 11.0 | 44.93 | 52,722     | 1102       | 6.0    | 7.1      |
|            | 6    |       |            | 8          | 3      |          |
|            | 12.0 | 44.08 | 53.68      | 1158.4     | 5.9    | 7.2      |
|            | 0    | 2     |            | 6          | 6      |          |
|            | 13.0 | 43.4  | 46.781     | 740        | 5.8    | 6.3      |
|            | 0    | 5     |            | 8          | 3      |          |
|            | 14.0 | 42.62 | 51,813     | 994.8      | 5.7    | 7.0      |
|            | 0    | 5     |            | 7          | 1      |          |
| 04- Aug 0 -19 | 11.0 | 43.4  | 51.772     | 1045.1     | 5.8    | 7.0      |
|            | 5    |       |            | 8          | 0      |          |
|            | 12.0 | 45.47 | 54.384     | 1153.4     | 6.1    | 7.3      |
|            | 0    | 7     |            | 5          | 6      |          |
|            | 13.0 | 39.93 | 47.759     | 846.1      | 5.4    | 6.4      |
|            | 0    | 2     |            | 0          | 6      |          |
|            | 14.0 | 41.46 | 53.277     | 1067.7     | 5.6    | 7.2      |
|            | 0    | 3     |            | 1          | 1      |          |
| 05- Aug 0 -19 | 11.0 | 42.00 | 49.896     | 979.8      | 5.6    | 6.7      |
|            | 5    |       |            | 8          | 5      |          |
|            | 12.0 | 42.58 | 51.813     | 1172.6     | 5.7    | 7.0      |
|            | 0    | 8     |            | 6          | 1      |          |
|            | 13.0 | 43.88 | 52.116     | 1167.8     | 5.9    | 7.0      |
|            | 0    | 4     |            | 4          | 5      |          |
|            | 14.0 | 42.00 | 51.129     | 1013.5     | 5.6    | 6.9      |
|            | 0    | 5     |            | 8          | 2      |          |
| 06- Aug 0 -19 | 11.0 | 42.00 | 52.116     | 1048.1     | 5.6    | 7.0      |
|            | 5    |       |            | 8          | 5      |          |
|            | 12.0 | 42.58 | 54.208     | 1153.4     | 5.7    | 7.3      |
|            | 0    | 8     |            | 6          | 3      |          |
4. Conclusion

This paper presents Development and Feasibility Analysis of Floating Solar Panel Application in Palembang, South Sumatra. Experiment was conducted at Pier 12 Marine Pertamina Palembang, Indonesia in August 2-8, 2019 by installing two 100 WP poly-crystalline PV panels. The Floating Solar panel installation application can reduce the average surface temperature of the PV panel by 2°C. The decrement of PV panel surface temperature prevent the overheated surface and increase the output power (51.6 Watt) compared to a Ground Solar Panel (42.9 watts). The experiment data shows that the effective points of harvesting solar power in Palembang is from 11:00 AM to
Figure 10. Floating and ground solar panel efficiency comparison.

2:00 PM. The Floating Solar Panels also improves the efficiency of output power by 1.2% greater than a Ground Solar panel. The Floating Solar Panel acts as a passive cooling system when temperatures rise. Floating Solar Panels is proven to have a better performance when compared to Ground Solar Panels; therefore, it can be concluded that the development of Floating Solar Panel Applications in Palembang, South Sumatra is feasible to be applied.

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