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An Effect of Water Cooling on Performance of 300 Wp Solar Panel

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ABSTRACT: Solar energy is emerging as beneficial renewable energy sources and it is considered as the best choice to be implemented to realize net zero carbon emission target. Compare with other renewable energy systems, solar energy system is more proven technology which marking a pivotal shift in global power production technologies. Indonesia received average solar irradiation about 4.8 kW/m^2/day. This huge solar energy potential has to be optimized in order to fulfill energy demand. In the present work, an effect of water cooling on performance of 300 watt peaks solar panel is investigated at different solar irradiation. The performance of the panel evaluated in terms of output current, output voltage, output power, and conversion efficiency. It can be concluded that PV panel cooling gives negative impact on performance of PV panel. The highest output power and conversion efficiency were found at the highest solar irradiation when the panel operated without cooling. The values of maximum power and maximum conversion efficiency are 254.96 W and 84.99%, accordingly.

KEYWORDS: Cooling, solar panel, irradiation, watt peak, performance

I. INTRODUCTION

Shortage of fossil fuel and increasing global warming led the utilization of renewable energy sources. Solar energy is emerging as beneficial renewable energy sources [1, 2] and it is considered as the best choice to be implemented to realize net zero carbon emission target. Compare with other renewable energy systems, solar energy system is more proven technology which marking a pivotal shift in global power production technologies [3,4]. Solar electricity generation systems have some merits, such as energy-regeneration, cleanliness, no pollution, and safety [5]. Indonesia has various renewable energy source, such as solar, hydro, biomass, etc, as shown di Table 1. Indonesia has about 207.898 GW solar energy potential [6]. Indonesia received average solar irradiation about 4.8 kW/m^2/day. This huge solar energy potential has to be optimized in order to fulfill energy demand.

Table 1. Indonesia's renewable energy potential

No	Renewable energy	Potential (GW)
1	Bio energy	32.654
2	Wind energy	60.647
3	Solar energy	207.898
4	Hydro energy	75.000
5	Geothermal energy	25.800

Typically, PV modules convert only approximately 20% of the incident solar irradiance into electricity, and the rest is converted into heat [7]. Increasing temperature of the PV module may reduce degree of its conversion efficiency [8, 9]. Cooling of the PV surface is required to maintenance low surface temperature. One of various cooling techniques have been adopted for PV is water cooling. The use of water cooling can increase conversion efficiency of the PV module. Efficiency of the mono-crystalline PV module increased from 2.91 % to 12.76 % for the non-cooled and cooled panels [10]. Mostakim *et al.* [11] observed PV panel efficiency enhancement up to 16.78 %, at water flow rate of 1.56 L/min. Water injection cooling resulted in an energy output growth [12]. The use of water-cooled PV panels is an attractive and feasible option for a short-term and long-term efficiency improvement with great impact on the expansion and durability of PV power plants [13].

The high temperature effects may cause the negative issues on I–V characteristic of PV. PV modules showed the best performance at cooler temperature and degrade as temperature warm up [14]. PV modules' current output increases in high temperatures [15]. On the other hand, the voltage drops at the PV module's output terminals as the temperature rises. The total performance and power production of the PV system may be impacted by the drop voltage. Finally, because of the high temperatures, the overall power output decreased as a result of the reduced voltage output. This power loss affects the efficiency and performance of the PV system [16]. The I–V curve characteristics of 300 Watt PV panels at various temperatures and at 1000 W/m^2 solar irradiation is shown Figure 1. The figure indicates temperature (T) has a significant impact on voltage and current. The voltage (V) decreases as temperature rises. As temperature drops, PV current (I) marginally reduces while PV voltage sharply increases. Maximum power output is observed for temperature rises of up to 25°C [17, 18].

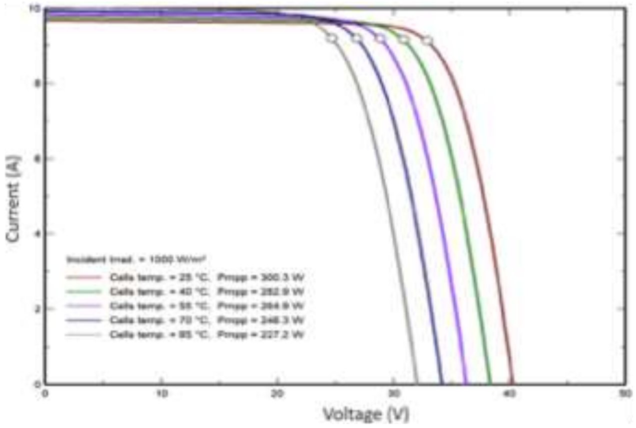

Figure 1. I–V properties of a PV panel at different temperatures [18].

In the present work, an effect of water cooling on performance of 300 watt peaks solar panel is investigated at different solar irradiation. The performance of the panel evaluated in terms of output current, output voltage, output power, and conversion efficiency.

II. MATERIAL AND METHOD

The experimental work is conducted on the top roof of a main building of Akprind University. The experiment setup consists or 2x150 Wp PV panels, water cooling unit, MPPT, battery, inventor, and load of a 150 W glue gun. The specification of the panel is displayed in Table 2.

Table 2. Specification of the PV panel

Polycrystalline PV panel	Specification
Rated maximum power (Pm)	150 W
Voltage at Pmax(Vmp)	18.1 V
Current at Pmax (Imp)	8.29 A
Open-circuit voltage (Voc)	22.1 V
Short-circuit current (Isc)	8.89 A

The tests are performed for 5 days from 9 am to 3 pm. The data taken are solar irradiation (Ir), panel's temperature (T), voltage (V) and current (I). The data are use to calculate output power (P) and conversion efficiency (η) of the panels using Eq. (1) and (2), respectively.

$$P = V \times I \quad (1)$$

$$\eta = \frac{P}{Wp} \times 100\% \quad (2)$$

III. RESULT AND DISCUSSION

Figure 2 presents the average temperature of the panel without and with cooling at average solar irradiation for 5 days investigation. The cooling can reduce the temperature of the panel. The temperature of the panel increases as solar irradiation increases.

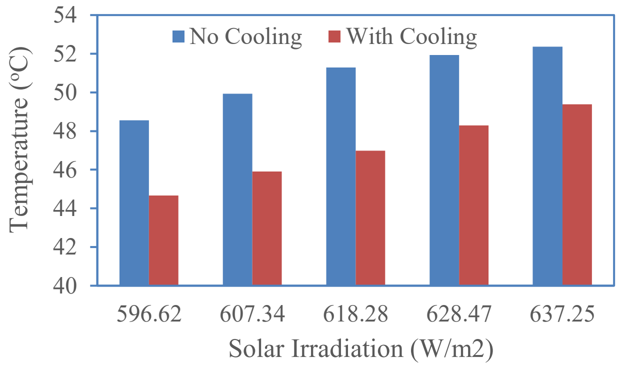

Figure 2. Temperature of the PV panel

Figure 3 and Figure 4 show an effect of cooling on average output current and voltage of the panel during the test. Both current and voltage increase as solar radiation increases. The highest current and voltage are obtained at the highest solar irradiation of 637.25 W/m^2. The highest currents are 4,63 A with no cooling and 4.52 A with cooling. Meanwhile, the voltage are 55.97 V and 52.91 V for without and with cooling, respectively.

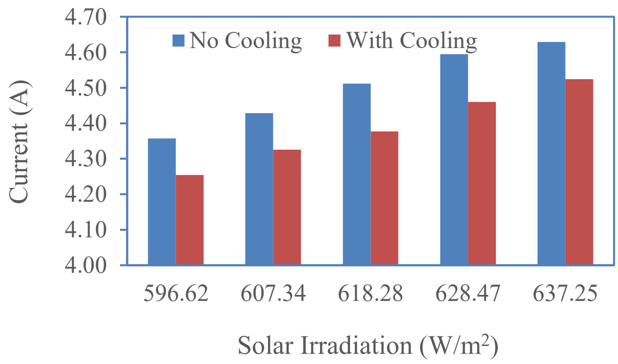

Figure 3. Output current of the PV panel

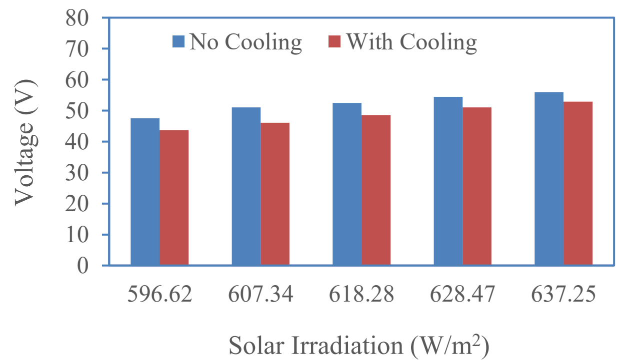

Figure 4. Output voltage of the PV panel

Meanwhile, output power and conversion efficiency of the panel are given Figure 5 and Figure 6. The anomaly of power is observed as an effect of cooling. In the present work, output power of the panel is lower when using cooling. Hence, the conversion efficiency is also lower when using cooling. This phenomenon in contrast with theory where performance of PV panel can be increased by cooling. This is may due to the operating temperature of the panel is still in the range of it maximum operation temperature. Thus, the cooling give negative impact on the PV panel performance in the present work. The highest output power and conversion efficiency were found at the highest solar irradiation when the panel operated without cooling. The values of maximum power and maximum conversion efficiency are 254.96 W and 84.99%, accordingly.

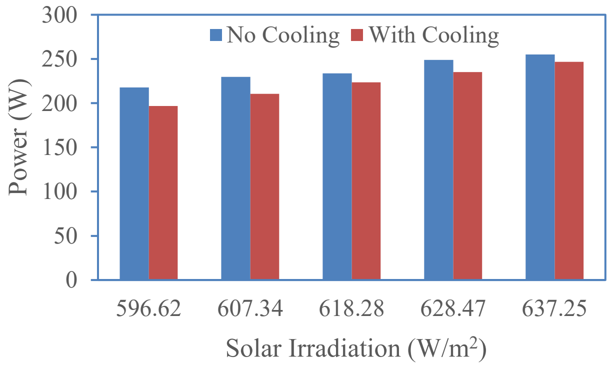

Figure 5. Output power of the PV panel

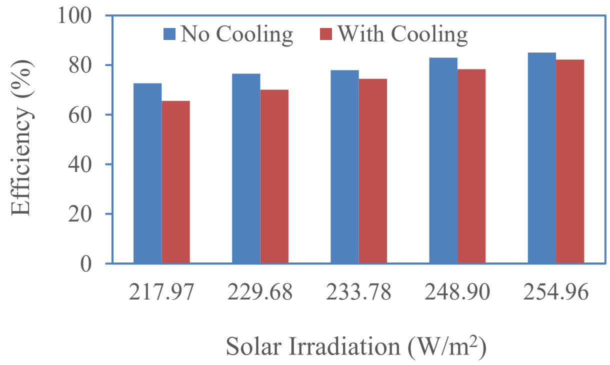

Figure 6. Conversion efficiency voltage of the PV panel

IV. CONCLUSION

An effect of PV panel on 2x150 wp solar panel is investigated in the present work. The tests are conducted for 5 day which various average solar irradiation. It can be concluded that PV panel cooling gives negative impact on performance of PV panel. The highest output power and conversion efficiency were found at the highest solar irradiation when the panel operated without cooling. The values of maximum power and maximum conversion efficiency are 254.96 W and 84.99%, accordingly.

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