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Experimental Study an Effect of Photovoltaic (PV) Arrangement on Performance of 150 wp Solar Power Plant

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ABSTRACT: Due to depletion of conventional fuel and also due to increasing global warming in last several years, the search of alternative and renewable energy increases remarkably worldwide. Many sources of alternative energy have been explored to substitute conventional source of energy by numerous researchers. Nowadays, another promising alternative energy got increasing attention is solar energy. As a matter of fact, in renewable sources, solar power contribution is so high when compared with other sources. The present study aims to figure out an effect of photovoltaic (PV) arrangement on performance of the solar system at three different configurations solar panel, i.e. standalone 150 wp (Model I), 100 wp + 50 wp (Model II), and 3 x 50 wp (Model II). The results show that the model I able to generate average power about 121.57 W which means that the model has an efficiency of 83.05% respect to the capacity of the PV.

KEYWORDS: photovoltaic; arrangement; solar; energy; performance

I. INTRODUCTION

Due to depletion of conventional fuel and also due to increasing global warming in last several years, the search of alternative and renewable energy increases remarkably worldwide. Many sources of alternative energy have been explored to substitute conventional source of energy by numerous researchers. These alternative sources of energy are hydro power (Quaranta & Revelli, 2018; Vidali et al., 2016), biomass energy (Guangul et al., 2012; Susatriawan et al., 2019), wind energy (Sudarsono et al., 2019), and biofuel ([Porpatham *et al*., 2018; Qian *et al*., 2017; Verma *et al*., 2017; Reddy *et al*., 2016; Jatana *et al*., 2014).

Nowadays, another promising alternative energy got increasing attention is solar energy. As a matter of fact, in renewable sources, solar power contribution is so high when compared with other sources (Gupta, *et al*., 2021 studied experimentally a combined transparent solar panel and large Fresnel lens concentrator based hybrid PV/thermal sunlight harvesting system. Altuntepe *et al*., 2021 used hybrid transparent conductive electrode structure for solar cell application. Ghoshal & Gaidhane, 2021 analyzed a hybrid tandem solar cell using neural network. Liang, *et al*., 2021 conducted experimental analysis of the concentrated crystalline silicon solar cell-slicing cell. IoT based monitoring system for solar energy system has been also reported by Bhau *et al*., 2021. Meanwhile, Mishra, *et al*., 2021 proposed an expression for the electrical efficiency of photovoltaic modules in different photovoltaic thermal (PVT) configurations.

To increase performance of the solar energy system, many optimization effort have been conducted. Merino *et al.*, 2018 optimized energy distribution in solar panel array configurations by graphs and Minkowski's paths. Zhong & Tong, 2019 performed optimization on spatial layout for solar photovoltaic (PV) panel installation. Wang *et al*., 2020 worked on optimization of the areas of solar collectors and photovoltaic panels in liquid desiccant air-conditioning systems using solar energy in isolated low-latitude islands. Oon *et al*., 2020 reported an optimization study of solar farm layout for concentrator photovoltaic system on azimuth-elevation sun-tracker. Other works in enhancing performance of the solar energy system are performed by modification of solar cells with antireflection coatings (El-Khozondar *et al.*, 2021) and by using thermal control water spraying cooling in polycrystalline solar panel (Laseinde & Ramere, 2021).

Experimental studied of solar energy harnessing by 150 wp solar energy system is conducted in the present work. The study aims to figure out an effect of solar panel aranngement on performance of the solar system at three different configurations solar panel, i.e. standalone 150 wp, 3 x 50 wp, and 100 wp + 50 wp. Although many works have been reported in the area of solar energy system, none of those work analyzed an effect of solar panel arrangement so far.

II. METHODOLOGY

Fig. 1 shows schematic diagram of an experimental setup of the 150 wp solar energy system in the present work. The system is constructed by solar panel (PV), solar charger

controller MPPT, Battery 12V/100Ah, Inverter 1000 W, AC load, and MCBs. The PV absorbs solar irradiant and converts it into electrical energy. Solar charger controller to control the voltage and current to the battery. The inverter 1000 W is used to convert DC to AC prior to be supplied to the AC load of LED lamp. In the present work, an effect of three different PV arrangements on performance of 150 wp solar energy system is investigated. The PV arrangements are standalone 150 wp PV (Model I), 100 + 50 wp PCs (Model II), and 3x50 wp PVs (Model III) as given in insert of the Figure 1. Output voltage and current from each model of PV arrangement, temperature, and solar irradiance are measured every 1 hours from 9 am to 3 pm within 5 days. The performance of the PV model arrangement is evaluated in term of power output and calculated using Eq. (1).

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

Where V is the output voltage (Volt) and I is the output current (Ampere) of the PV arrangement models

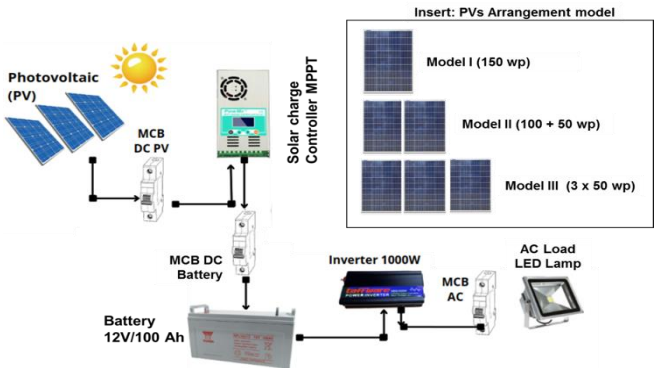

Figure 1. Schematic diagram of the 150 wp solar energy system

III.RESULTS AND DISCUSSION

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Figure 2 displays temperature profile from 9 am t0 15 pm within 5 days experimental work. The graph in Fig. 2 indicates that temperature increases from 9 am to 13 pm. After reaching maximum at about 13 pm, the temperature decline. This trend of the temperature profile can be seen for all 5 days. The graph also shows that the highest temperature occurs in day 4

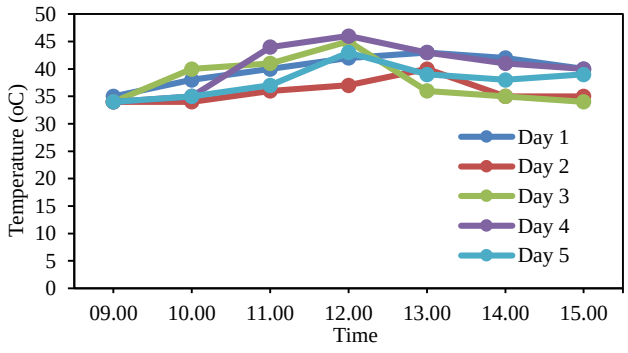

Figure 2. Temperature profile during experimental work

Figure 3 and Figure 4 present an effect of PV arrangement on output voltage and output current of the 150 wp solar energy system. Three PV arrangements are investigated in the present work, i.e. Model I (standalone 150 wp PV), Model II (100 wp + 50 wp PV), and Model III (3x50 wp PV). For particular solar irradiance impinging to the PV, the output voltage and current step up as increasing solar irradiance for all model as shown in Figure 3 and Figure 4. From Figure 3, the output voltage of model II is the highest. In contrast with output voltage, the output current of the model I is higher than model II and model III as indicated in Figure 4. The highest output current for particular solar irradiance occurs when the use of model I.

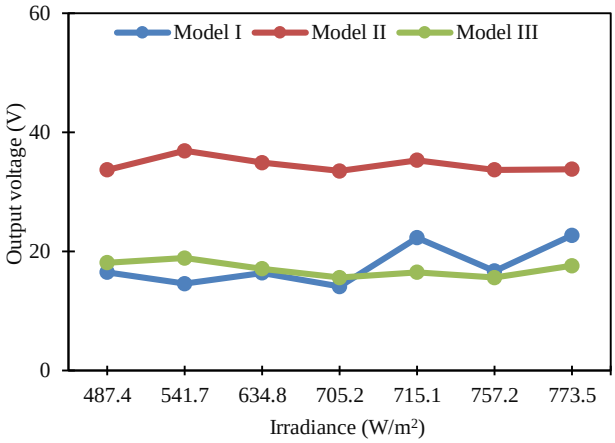

Fig. 3. Output voltage

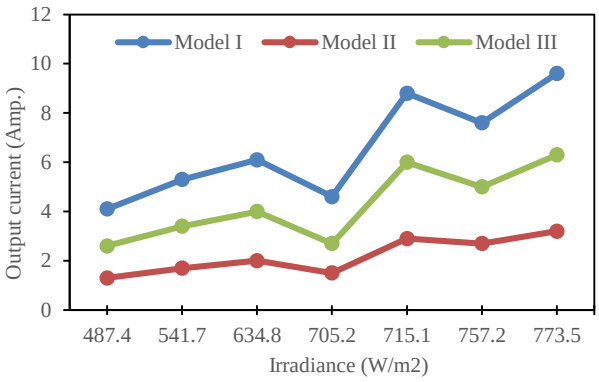

Figure 4. Output current

The output voltage and current data are used to obtain output power of the model using Eq. (1) and the results are plotted in Fig. 5. Fig. 5 reveal that the output power of the PV is proportional to the solar irradiant. The output power rises up as increasing solar irradiant to the PV. From Fig. 5, it can be stated that the model I is the most suitable arrangement for 150 wp solar energy system in the present work. Meanwhile, Fig. 6 shows the average output power and efficiency of the model. In average, model I, II, III generate actual power of 121.57 W, 75,44 W, and 75.82 W, accordingly. Comparing average output power to the PV capacity, the model I give the highest efficiency, i.e. 81.05%. Whereas, model II and III have an efficiency of 50,30% and 48,54 %, respectively

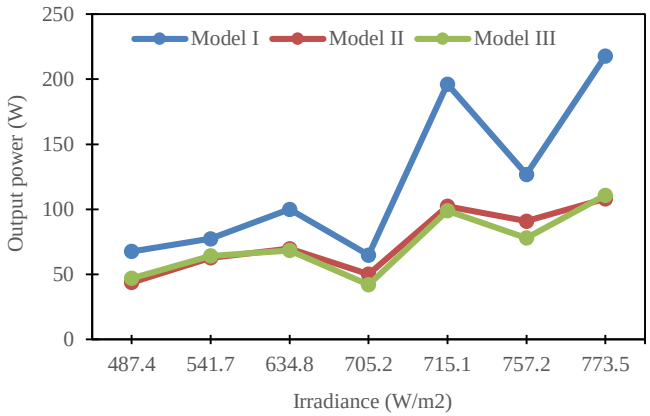

Figure 5. Output power

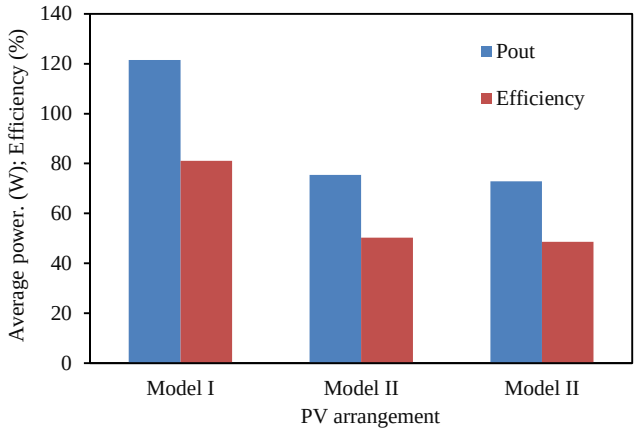

Fig. 6. Average power and efficiency

IV. CONCLUSION

The investigation an effect of PV arrangement on performance of the 150 wp solar energy system has been carried out. It can be concluded that the Model I (standalone 150 wp PV) has the best performance in the present work. The model I able to generate average power about 121.57 W which means that the model has an efficiency of 81.05% respect to the capacity of the PV.

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