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Investigation on Solar Panels with and Without Shading Effects in Series and Parallel Connections

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Abstract*: Solar power is the change of vitality from daylight into power, either directly utilizing photovoltaic (PV), or in a roundabout way utilizing concentrated solar power. Since solar panels are the major alternate source of energy a survey has been taken to find out the impacts created by even small disturbances. Based on the survey results, it has been found that the performance of the solar panel is mostly affected due to the effects of shading caused by the trees and nearby buildings. Due to the shading in solar module hot spots are developed which may cause permanent damage to the cells that are shaded, hence affecting the performance of solar PV cells to a greater extent. With the help of available prototype model, an investigation has been done to find out the impacts created by shading. Results shows that the potential of solar cells is more without shading pattern and on further analysis a very small impact created by shading even partially on single solar cell totally affects the performance of solar PV panels. The power of the solar panel decreased when the load is increased. Thus, this paper describes the effect of shading on solar module with load conditions and also the shading effect was observed in both series and parallel connections. The output power of the series and parallel connection was compared.

***Index Terms*: Solar Panels, PV Modules, Shading Effects, Non-Renewable Energy Sources**

I. INTRODUCTION

Energy can be generally categorized into several types i.e. Primary and Secondary energy, Commercial and Noncommercial energy, Renewable and Non-Renewable energy, Conventional and Non-conventional energy. Among them, this work mainly focus on Renewable energy sources because, this can be an efficient replacement for fossil fuels. Mainly nowadays more research work has been done based on renewable energy sources because of their surplus availability and furthermore there is no pollution to the environment [1]. Solar energy is one of the main source for Renewable energy sources, this work mainly focus on it. Even though solar energy is available in abundance the effective utilizing of solar energy is very important in order to meet the growing demand.

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Photovoltaic cells that are present in the photovoltaic array of Photovoltaic modules are responsible for the generation and supply of solar energy for commercial and domestic purposes [2, 3]. Unfortunately, we have two major issues (i) conversion efficiency of electric power generation particularly at low irradiation condition (ii) Climatic conditions i.e. the power generated by the solar array will be greatly affected due to the different seasons. Apart from the two major issues specified above, shading is a serious issue to be concentrated which greatly affects the total performance of the system. Large-scale PV panels are usually installed in the area where there is an adequate solar resources and vast land [4]. In additional as previously mentioned the performance will be greatly affected due to the shadows caused by wire poles, the trees, nearby buildings or even the shadows of front row PV arrays on the modules due to the improper design or the limitations of natural conditions. Due to this shading impact on PV modules hot-spots will be created [6, 7]. Usually Hot-spot is defined as the localized region in a solar cell whose operating temperature is obviously higher than its surrounding area, which provides a very low current and becomes a reverse diode to the rest of parts of solar cells/PV modules which are connected in series [5, 9]. This paper completely focuses on the output power deviations caused by different percent of shading. Two different set of readings were taken with loads in series and parallel connections, to observe how the output power various with loads.

II. MATERIALS AND METHODS

The experiment was conducted on the solar panel, in which the panel was made up of Polycrystalline silicon material. The dimensions of the solar panels were 660 × 460 mm of two insight solar panels, which uses halogen lamp as light source. The logger plotter is connected to the solar module output for the result analysis. The logger plotter is further connected to the computer for accurate data of PV and IV characteristics.

Table 1: Specification of PV panel

Company	Ecosense Insight Solar
Model No.	ELDORA 40P
Cell material	Polycrystalline silicon
Artificial Source of Radiation	Halogen - with regulator
VOC	21.90V
ISC	2.45A
Rated voltage	17.40V
Pmax	40W

Fig. 1. Ecosence INSIGHT Solar system.

Fig. 2. Logger plotter

The experiment was done with load conditions in the solar panel along the different shading percentage. The angle and the temperature of the solar panel were kept constant at 15° and 33.8 °C during the experiments. The percentage of shading was varied with a specific load and the corresponding values of Current and Voltage were noted. The power was calculated from the observed values of Current and Voltage.

The formula used to calculate power was

$$P = I \times V$$

Where,

P is Power in Watts, I is Current in Ampere and V is Voltage in Volts.

Solar panel can be connected in two ways series and parallel to get desirable output. The radiation was varied in steps to observe the voltage and current in the series and parallel connection of the solar panel. Solar panel was subjected to the shading effect in both series and parallel connections. The performance of the solar panel was detected by the output voltage and current in the series and parallel connections. The output power of the PV panel was determined by the obtained values of voltage and current in the effect of shading.

III. RESULTS AND DISCUSSIONS

The investigation on solar panel was started with different percentage of shading. The angle was adjusted to 15° and the temperature was maintained at 33.8 °C. The pot meter was set to 50 Ω and the corresponding readings were taken for various percentage of shading. In table 2, the current and voltage of the PV panels are noted when the panels are subjected to different percentage of shading. Power is calculated by simple formula of multiplying current and voltage. The voltage and current output of the solar panel was found to be decreasing with the increasing effect of shading.

Table 2: Effect of PV panel for different percentage of shading in load condition

Sl. No	Percentage Of Shading (%)	Voltage (V)	Current (A)	Power (W)
1.	0	11.7	0.140	1.638
2.	25	10.3	0.120	1.236
3.	50	9.8	0.093	0.911
4.	75	8.8	0.072	0.634
5.	100	8.5	0.065	0.552

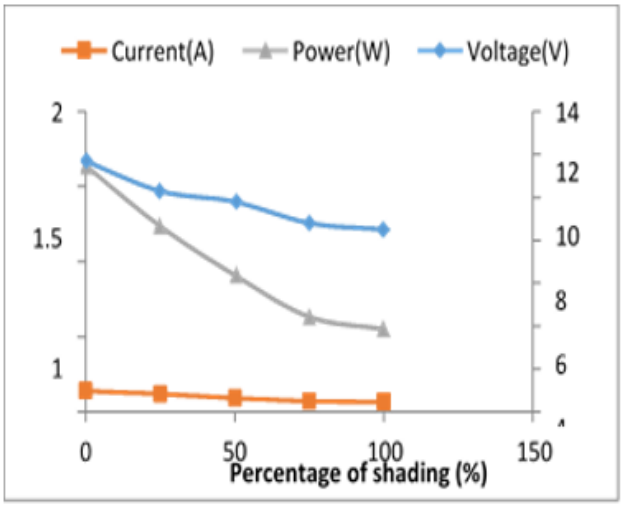

Fig. 3 Effect of PV panel for different percentage of shading in load condition

The effect of shading on the solar panel was plotted in the Fig. 3. and it was observed that the voltage and current is decreasing as the percentage of shading is increasing. The power is also decreasing with the increase in shading percentage, as power is the function of voltage and current.

First the two PV panels are connected in series connection with 15% tilt angle, 100ohms resistance. The voltage and current are measured while changing the radiation. Then the panels are connected in parallel and voltage, current is again measured by changing the radiation of the halogen lamps.

Table 3. shows that the solar panel on series connection is capable of producing voltage and current in different solar radiation. The output power of the solar panel in this specific connection was calculated through the obtained voltage and current.

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Table 3: Effect of PV panel on series

Sl. No.	Radiation (W/m2)	Voltage (V)	Current (A)	ower (W)
1.	110	14	0.146	2.044
2.	120	14.5	0.150	2.175
3.	130	15.3	0.155	2.372
4.	145	16.7	0.161	2.689
5.	160	17.1	0.166	2.839
6.	185	17.9	0.169	3.025
7.	195	18.1	0.175	3.168

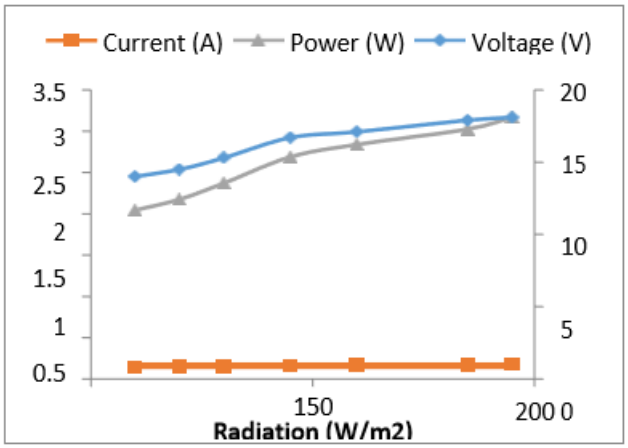

Fig. 4. Characteristics of PV panel on series connection

Fig. 4. shows the characteristics of solar panel connected in series with different radiation. The voltage increase more when the radiation increased but the current doesn't shows much difference. Table 4. shows that the solar panel on parallel connection is capable of producing voltage and current in different solar radiation. The output power of the solar panel in this specific connection was calculated through the obtained voltage and current.

Table 4: Effect of PV panel on parallel connection

Sl. No.	Radiation (W/m2)	Voltage (V)	Current (A)	Power (W)
1.	110	11.8	0.167	1.971
2.	120	12	0.169	2.028
3.	130	12.3	0.173	2.128
4.	140	12.9	0.179	2.310
5.	150	13.4	0.185	2.479
6.	160	13.6	0.188	2.557
7.	170	14.1	0.194	2.795
8.	183	14.5	0.197	2.857
9.	190	14.7	0.199	2.925
10.	199	14.9	0.205	3.054

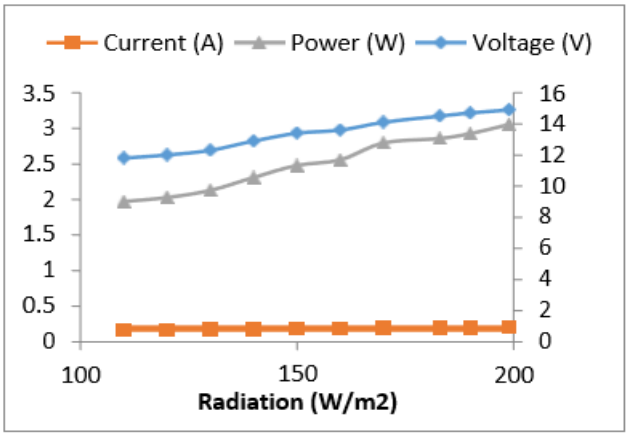

Fig. 5. Characteristics of PV panel on parallel connection

Fig. 5. shows the characteristics of solar panel connected in parallel with different radiation. From the above two graph it is clear that in series voltage is more than in parallel and current is more in parallel than in series.

The solar panel connected in series connection was subjected to shading effect. Table 5. gives the voltage, current and power values of solar panel in the shading conditions with load. The voltage and current seemed to be decreasing as the shading area increasing in the solar panel. Fig. 6. gives the plot for the table 4.4, the voltage and power of the solar panel is decreased highly compared to the current in the shading effect.

Table 5: Effect of PV panel for different percentage of shading in series condition

Sl. No	Percentage Of Shading (%)	Voltage (V)	Current (A)	Power (W)
1.	0	14.5	0.150	2.175
2.	25	14	0.135	1.89
3.	50	13.3	0.126	1.676
4.	75	13	0.100	1.3
5.	100	12.9	0.08	1.032

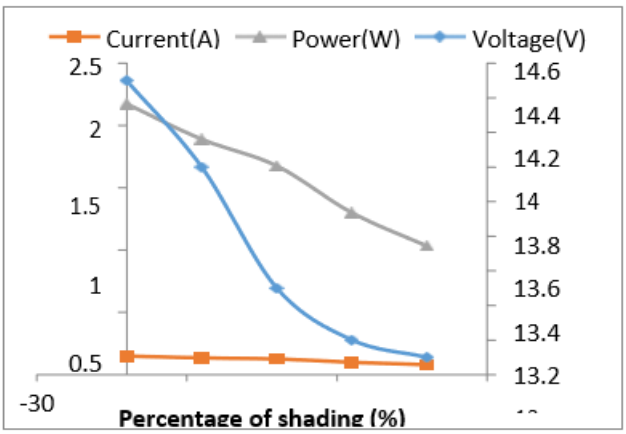

Fig. 6. Effect of PV panel for different percentage of shading in series condition

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The solar panel connected in parallel connection was subjected to shading effect. Table 6. gives the voltage, current and power values of solar panel in the shading conditions with load. The voltage and current seemed to be decreasing as the shading area increasing in the solar panel. Fig. 7. gives the plot for the table 4.4, the voltage of the solar panel is decreased highly compared to the current in the shading effect. The power of the solar panel output in the shading region was found decrease but not high as voltage due to the current constant decreasing.

Table 6. Effect of PV panel for different percentage of shading in parallel condition

Sl. No	Percentage Of Shading (%)	Voltage (V)	Current (A)	Power (W)
1.	0	12	0.167	2.004
2.	25	11.7	0.146	1.708
3.	50	11.2	0.129	1.445
4.	75	10.9	0.103	1.123
5.	100	10.4	0.09	0.936

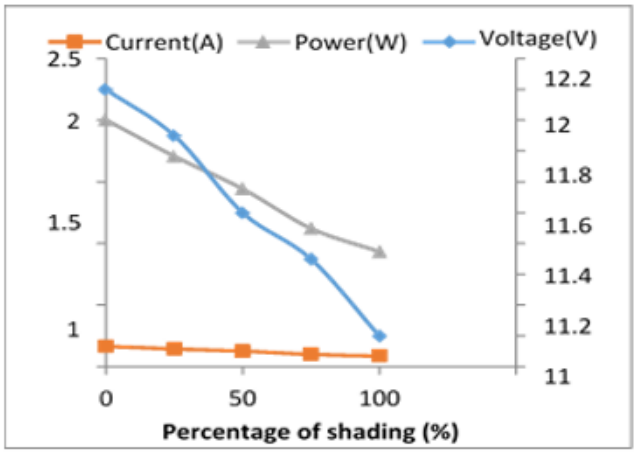

Fig. 7. Effect of PV panel for different percentage of shading in parallel condition

IV. CONCLUSION

Currently the non-renewable energy resources are the major energy source of our country. Due to this scenario, there is a constant depletion of the non-renewable energy. In order to find the alternative form of energy, the renewable energy plays a vital role in satisfying the demand that arises in the future. The solar energy is one of the key renewable energy and there are many research advances in order to improve the outcome of solar panels.

The solar panel output is severely affected by shading. When the shading region increases, the panel output decreases. The solar panel was subjected to the shading region in the load condition, voltage and current decreases with the increasing effect of shading. Due to the decrease in voltage and current, the power output from the solar panel also decreases.

When PV panels are connected in series the voltage is more than in parallel connection. Similarly, when PV panels are connected in parallel the current is more than in series while increasing the radiation. In the series and parallel connection, the effect of shading affects the output voltage and current in the load condition. The output power of the solar panel decreases with the increasing effect of shading.

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