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Impact of Partial Shading on Monocrystalline and Polycrystalline PV Technologies

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ABSTRACT: Different renewable energy sources are getting preferences in comparison with thermal and nuclear energy sources due to the abundant availability and almost no harmful emission. Solar energy is one of the best and easily available renewable energy and can be converted into electrical energy with the help of solar photovoltaic on the principle of photovoltaic effect. However, the performance of PV module is affected by the environmental conditions like humidity, temperature, dust, shading etc. Shading of a panel causes non-uniform distribution of the irradiance over the surface of the panel, leading to significant energy losses. Characteristic parameters of a solar PV module are affected by the loss in irradiance over its surface. Different types of shading have different impacts on the performance of solar PV modules. In this paper, the effect of different types of shading on the characteristic parameters were studied.

KEYWORDS: Photovoltaic module, Shading, Dusting, Characteristic parameters, Efficiency, Renewable energy

I. INTRODUCTION

Increase in the demand of energy leads to the exploitation of the conventional sources of energy such as fossil fuel. Over-exploitation of the conventional sources of energy causes harmful emissions and leads to global warming issues. Therefore, a clean and sustainable energy source is required to meet the current demand and balance the gap between the energy demands. Renewable energy sources are clean and environment-friendly resources and have potentials to meet the energy demands. One of the best and easily available renewable sources of energy is solar energy. Solar energy can be used for different applications like meeting the heating demands and providing the electrical power with the help of solar photovoltaic modules. Solar PV modules convert the solar energy into electrical power with the help of the photovoltaic effect. There are different types of technologies available such as mono-crystalline, polycrystalline, thin film etc. to convert the available sun's energy into useful power. However, the performance of the PV module is affected by the environmental conditions.

Environmental conditions like humidity, temperature, dust, shading and wind velocity greatly affect the performance parameters of the module and result in the reduction in the power output and efficiency. Out of which, shading and dust have the greatest impact on the reduction in the performance of a module.

a) Shading

Shading of a module is caused by the shadow of different objects such as due to nearby buildings, branches of trees etc. There are three types of shading which can be categorized as dark shading, light shading, and partial shading. Dark shading is caused by the deep shadow of an opaque object blocking 100% useful irradiance over the surface of the panel. Light shading is caused by the nearby refracting surfaces of the PV module blocking nearly 45% radiation passed through it and partial shading by blocking only irradiance of 25% of the total radiation.

b) Dusting

Dusting of a panel is caused by the nearby soil and other emissions accumulated on the panel from the nearby industries, power plants etc. Different types of dust which are usually found on the panel are carbon dust, transport dust, soiling, charcoal dust, etc. Dust accumulation on a PV module also leads to significant losses of power and loss in conversion efficiency.

II. LITERATURE REVIEW

Swapna Roy, 2014; investigates the impact of partial shading on the PV module and finds that there is percentage loss of voltage in a string was 21.04% and percentage loss of 28.67% voltage in the array when one third of the area was shaded.[1]

R.Ramaprabha, 2007; investigated the performance of series and parallel connected solar PV cells and also analyse the harmful effects of partial shading. The performance of parallel connected solar cells in an array were most suitable configuration for the partial shading but for the series connected solar cells in an array the effect of shading was harmful and leads to loss in power[2].

Valeriu Bostan, Ana Ruxandra Toma, 2017; investigates an experimental analysis of comparison between two different technologies, polycrystalline and thin film and found that thin film has the higher response to the light shading conditions and better performance at higher temperatures than polycrystalline. In diffuse conditions the generated power by polycrystalline was half of the thin film. Also the shading tolerance for thin film is greater than the polycrystalline and response to the vertical shading was less effective.[3]

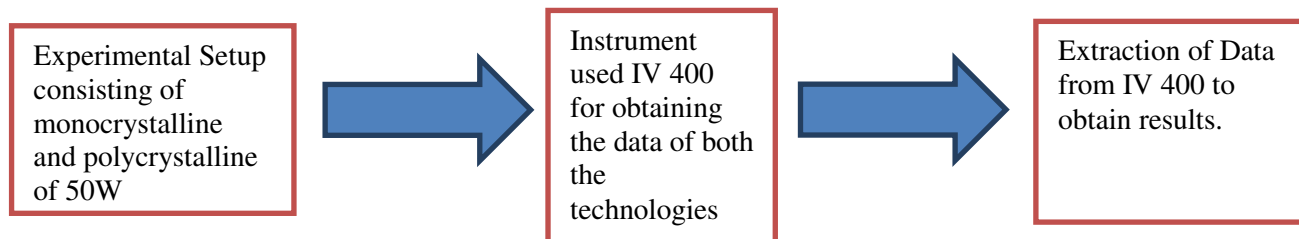
Fawzan Salem, Mohamed A. Awadallah, 2016; works on the methodology based on the ANN detection and assessment of the partial shading in the photovoltaic array and investigates that whenever there is reduction in the power output of an array takes place ANN distinguishes that the new operating condition is partial shaded or not.[4]

S.Silvestre, 2017; analysed the reduction in power output on shading of the single solar cell out of 36 solar cells of a PV module and investigates that 32.5% power output is decreased. Also the amount of series resistance increases with increasing shadow rate and shunt resistance decreases which cause the hot spot problems in a module and hence durability of module is decreased due to increased shading rate. [5]

Idriss Hadj Mohammed et al., 2018, did an investigation study carrying out by taking two different technologies, mono-crystalline and polycrystalline under different shading rates and found that the distortion in I-V curve is caused by shading and the notch that appears at the corresponding current is a result of mismatch caused by non-uniform irradiance over the surface of panel. Also the notches in the I-V curve highlight that the bypass diodes form a direct conduction of current, without passing through the shaded PV cell. [6]

III. METHODOLOGY

In this experiment we have taken two solar PV technologies viz monocrystalline solar panel and polycrystalline solar panel both of same rating having 50W. We have created the condition of partial condition by blocking the 25% of incidence radiation on inclined solar panels facing south. We have used IV400 instrument for extracting the solar PV parameters like open circuit voltage, short circuit current, power output at incidence radiation, irradiance falling on inclined solar PV technologies etc. and all of the data was extracted and simulated by using top-view software which is one of the best software connected to IV400 and to extract the useful data.



Flow chart for Methodology to obtain result

IV. RESULTS AND DISCUSSIONS

From the above discussion it is estimated that there is great influence of the dust and shading of a PV module on the characteristic parameters which leads to the reduction the Power output and conversion efficiency. Therefore, cleaning of dust is very necessary at a regular interval so as to avoid the negative impact of the dusting and also devising of new

technologies for cleaning may lead to the increase in the power output of a solar PV module. Also avoid the shading of panels as shading at different rates has negative influence on the generation of the module and it can completely block the radiation on the panel and reduces the efficiency and leads to the hot-spot problems within the modules. Impact of Partial shading were studied on two different solar PV technologies, Mono-crystalline and Polycrystalline of same rating.

From Fig. 1 and Fig. 2 it is observed that partial shading affects output power and efficiency of both technologies adversely as percentage of shading increases from zero to hundred portion wise. At 25% horizontal and vertical shading power output of a polycrystalline 50W solar panel reduces to 14.88 W and 12.21 W whereas percentage reduction in power output can be seen as 31.31% and 25.69% respectively. For 50% horizontal and vertical partial shading reduction in power can be seen as 17.79W and 15.8W and percentage reduction in power output can be observed to be affected more than 25% shading portion and is 37.44% and 33.25% respectively. As we moved to obtain the results of 75% horizontal and vertical partial shading, we have 22.44 W and 16.74W power output for polycrystalline which is very less than 25% and 50% partial shading. When we partially shaded the whole of the exposed area of 50W Polycrystalline panel we obtained power output of 18.98W and thus percentage reduction is 39.94% which is highest of all the shading patterns.

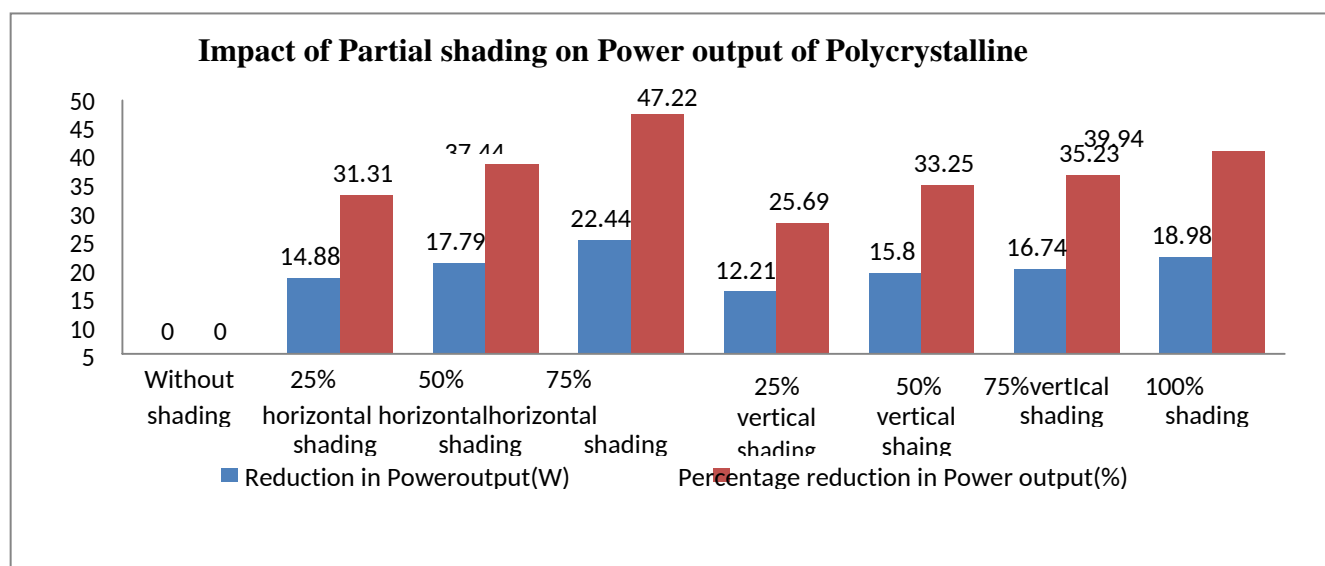


Figure 1: Impact of light shading on the Power output of Polycrystalline

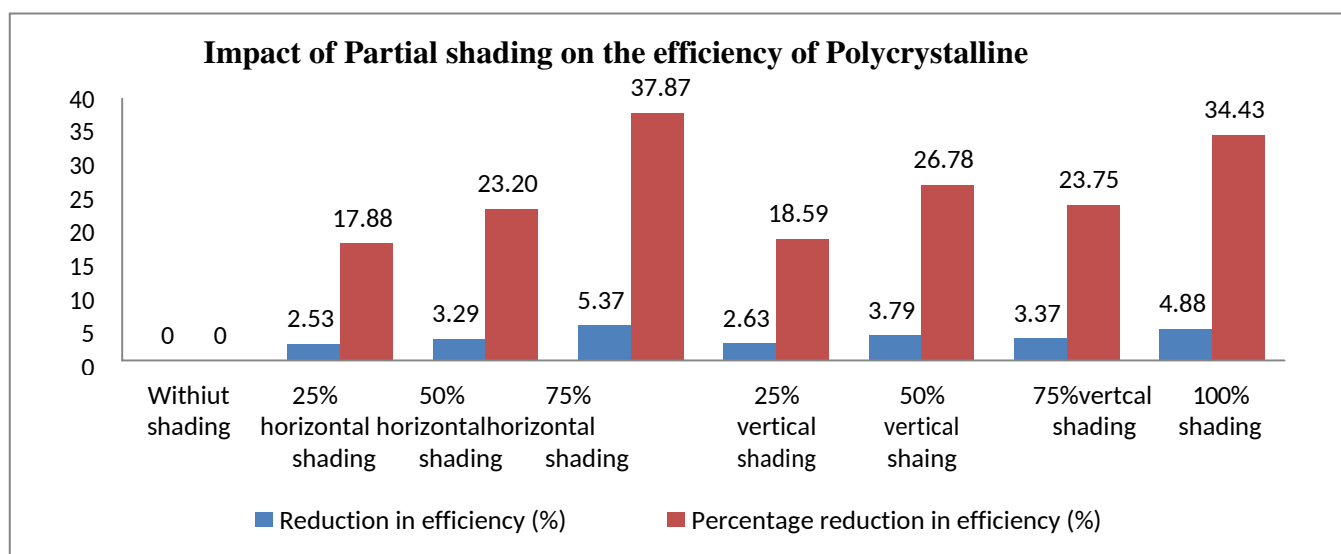


Figure 2: Impact of light shading on the efficiency of Polycrystalline.

Also, in terms of efficiency partial shading, a drastic change in efficiency reduction can be obtained for a 50W polycrystalline solar panel which is shown in Fig. 2. It can be seen that with 25% horizontal and vertical shading power output of 50W polycrystalline panel reduces to 2.53% and 2.63% whereas percentage reduction in efficiency was 17.88% and 18.59%. for 50% horizontal and vertical shading reduction in efficiency was observed as 3.29% and 3.79% whereas, percentage reduction in efficiency was about to be 23.20% and 26.78%. For 75% horizontal and vertical partial shading reduction in efficiency can be seen as 5.37% and 3.37%. and percentage reduction in efficiency was obtained 37.87% and 23.75% respectively. When we exposed fully active area of 50 W panel to 100% partial shading, we observed that reduction in efficiency was 40.88% and percentage reduction in efficiency was 34.43%. however, for 75% horizontal partial shading more loss in efficiency was seen.

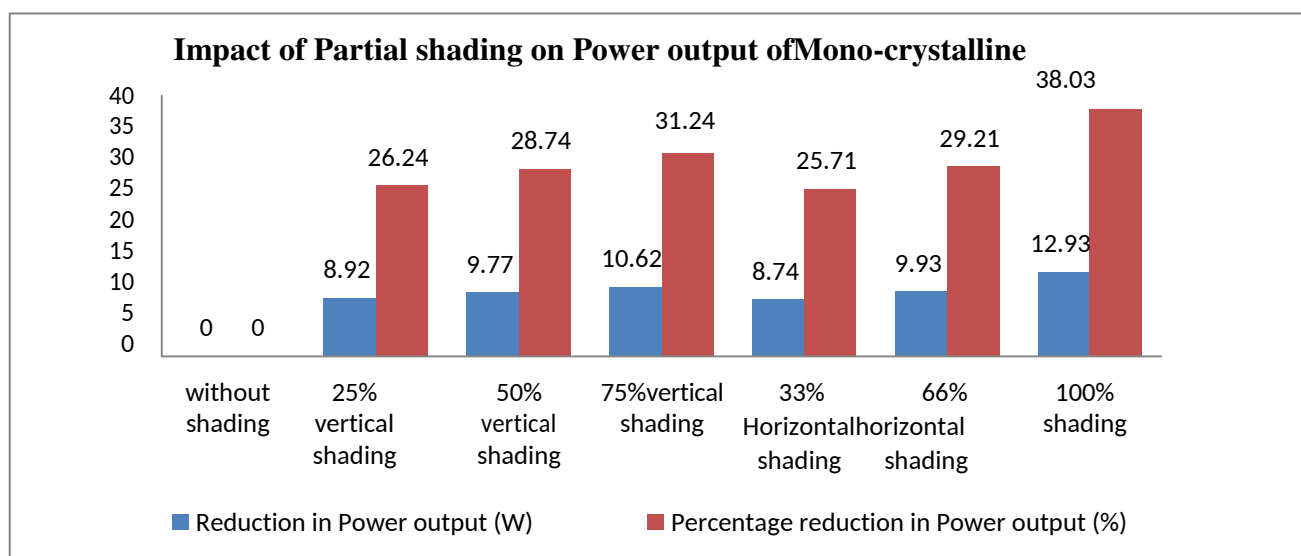


Figure3: Impact of light shading on Power output of Mono-crystalline

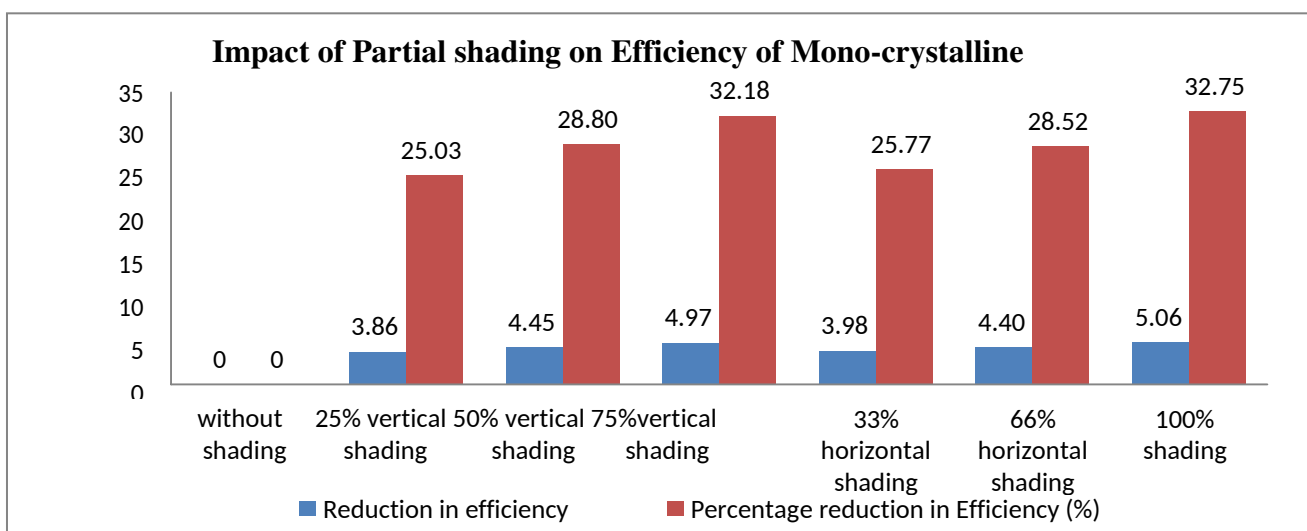


Figure4: Impact of light shading on Efficiency of Mono-crystalline

From Fig.3 and Fig.4 the effect of partial shading on monocrystalline solar panel of rating 50 W can be seen and we observed that both power output and efficiency were affected adversely by partial shading of the active areas of panel percentage wise.

Firstly, we will discuss about 25% horizontal and 33% vertical partial shading of monocrystalline we observed that



power output reduces to 8.92W and 8.74 W and percentage reduction in power output can be seen as 26.24% and 25.71%. Secondly, we will take 50% vertical partial shading and 66% horizontal shading we obtained reduction in power output as 9.77W and 9.93 W which is almost same. When we take 75% vertical shading, we observed that reduction in power output was about 10.62 W and percentage reduction was 31.24%. At last, we fully shaded the active area of 50W monocrystalline panel with partial shading and we observed a reduction in power output of 12.93W and percentage reduction in power output as 38.03%. Thus, effect of partial shading on power output of 50W monocrystalline solar panel was obtained and hence we can see that there is both reduction in power output and percentage efficiency if the active area of monocrystalline is shaded in portions.

Also, in terms of efficiency we can obtained the results at different partial shading of monocrystalline of 50W rating by shading different portions. Firstly, we obtained result by partial shading of 25% vertical and 33% horizontal shading it was seen that reduction in efficiency was 3.86% and 3.98% respectively and percentage reduction in efficiency was 25.03% and 25.77% respectively. Secondly, we obtained results for 50%vertical shading and 66% horizontal shading and it was seen that reduction in efficiency was 4.45% and 4.40% and percentage reduction in efficiency so obtained was about 28.80% and 28.52%. when we shaded partially the 75% of the active are we obtained 4.97% reduction in efficiency and percentage reduction in efficiency was 32.18%. At last, when we fully shaded the whole of the active area of 50W solar panel with partial shading it was observed that reduction in efficiency was about 5.06% and percentage reduction in efficiency was about 32.75%.

V. CONCLUSION

Effect of shading cannot be neglected and reduces the Power output and efficiency of the different PV modules at different shading level. With 100%partial shading on Mono- crystalline there is reduction in 5.06% efficiency and Percentage reduction in efficiency was 32.75%, whereas on 100% partial shading on Polycrystalline there is 4.08% reduction in efficiency and percentage reduction in efficiency was 38.03%. Mono-crystalline is the best PV technology in response to partialshading. Hence the sites which are more prone to partial shading obtained due to atmospheric conditions like clouds etc. monocrystalline is the best suitable technology we can use for our site selection for installation of solar PV plant.

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