SHORT REVIEW PAPER

Effect of environmental factors on the photovoltaic module performance: A short review

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ABSTRACT

In recent years, photovoltaic (PV) technologies have grown significantly as an alternative source to generate electricity via solar energy. Albeit PV technologies have grown widely, one of the major problems experienced by the PV systems during its service life is the significant drop in performance under field condition. One of the reasons that jeopardise the performance of PV system is the environmental factors. Therefore, the objective of this paper is to review the various type of environmental factors that affects the performance of the PV module and to highlight the factors that have most substantial effect on the PV systems. It was found that ambient temperature, solar irradiation, and deposition of dust particles on the module surface contributes to the major factors that causes significant drop in performance of the PV system. The effect of wind velocity and humidity might have the least impact on the PV module performance.

Keywords: Photovoltaic technologies, Environmental factor, Ambient temperature, PV module performance

1. INTRODUCTION

The demand for greener energy source has been greater in the past decade than it ever was. The expansion in the renewable energy sector in contrary to the dwindling fossil fuel reliance justifies the importance of renewable energy as a source of electrical energy to humans [1]. In correlation to this, photovoltaic (PV) modules have risen to fame in light of this scenario, to improve the implementation of renewable energy as an alternative energy source by harvesting energy from the sun and converting it to electrical energy [2]. To emphasise this context, the installation of PV modules has escalated to about 97GW in the year 2019 [3]. In addition to that, as a man-made invention, PV module have their drawbacks as well and the major contributors to these setbacks are technical and environmental factors, however, the latter has shown more pressing concerns in

reducing the PV modules performance during its operation time. This is because technical factors such as inverter, charger controller and energy storage system can be controlled to improve the performance of the PV module, but environmental factors are uncalled for and arise unexpectedly which plays a larger role in compromising the PV module's performance. Therefore, the objective of this paper reviews various type of environmental factor that affects the performance of PV systems and highlights the factor(s) that have the most substantial effect.

2. ENVIRONMENTAL FACTORS AFFECTING THE PERFORMANCE OF PV SYSTEMS

2.1. Wind velocity:

The effect of wind velocity has a positive impact on the module's performance, this is because dust deposition on the module surface can be prevented if there is sufficient amount of wind to blow away these dust particles. Besides, the effect of wind can also facilitate the cooling of the module surface naturally. In carried out an indoor experimental to the effect of wind velocity in different PV module technologies (monocrystalline & polycrystalline) [4]. The experimental setup consists of two different PV module technologies which was rested separately on a movable stand and placed inside wind tunnel in the presence of artificial solar simulator. The velocities inside wind tunnel were increased gradually from zero wind condition to monitor the performance of photovoltaic module. It was found that, at wind velocity range between 5 to 15 m/s, the average temperature of monocrystalline module and polycrystalline module decreased up to 42% and 43 % respectively. As a result, the performance for both module increases. In short, greater the wind velocity, greater the heat energy is taken away from the module surface. In strict sense, greater wind velocity is a merit to PV module performance. However, it should be noted that, the wind velocity varies with respect to different regional climate, especially the effect of wind on the performance of module may not favourable at a hotter climate such in desert regions.

2.2. Variation of solar irradiation:

Regardless of any PV module technology, the amount of power generated by the solar cells in the PV module is always dependent on the amount of the light that absorbed by the cells. In other words, the PV module generates lower power output in the early hours of the day compared to that of at midday due to the higher solar irradiation reaching the PV module front surface. In addition to that, the PV module receives the maximum amount of light when orientation of PV module perpendicular to the sunlight [5]. In other words, this depends upon the inclination angle of PV module. In carried out an outdoor experiment to study the relationship between the solar irradiation and power generated in photovoltaic system in different orientations [6]. The solar modules were installed on flat roof area at different orientation (180º from actual North, North 74º East) with the tilt angle variation of 5º each, from -25º to +25 º It was found that, the power generated by the PV module increases with increasing solar irradiation. Besides that, at peak hours the power generated for the module deployed at south 20º East generates more

power compared to other orientations. This is because the PV module surface facing South 20º East receives higher solar irradiation compared to the other positions. From this experiment, it can be seen that the tilt angle of the PV module affects the performance of PV module. Therefore, the tilt angle should be optimized according to the climate and regional requirements to maximize the power output of the PV systems.

2.3. Soiling:

The deposition of dust particles on the module surface compromises the conversion of solar energy to electricity energy. This is because some part some part of the incoming solar irradiation will be blocked by this dust particles consequently the PV cells receives less amount of solar irradiation. In investigated the effect of different types of industrial dust on the performance of the module [7]. The experimental outcome revealed that the loss in efficiency in the PV module was 64%, 42%, 30%, and 29% for coal, aggregate, gypsum, and organic fertilizer dust respectively compared to a clean module.

2.4. Humidity:

In investigated the effect of various humidity level on the PV module performance [8]. The humidity level in the air was varied with the aid of an air humidifier. It was found that the PV module produces maximum output power of 7.84W at lower humidity that is 65.40%, whereas the lowest power produced by the PV module was 5.00 W at humidity level of 98.20%. In other words, the drop in power output were 36.22% due to an increment in the relative humidity. This is because at high humidity the solar irradiation reaching the PV module is jeopardized compared to lower humidity. However, the surface temperature of PV module was lower at higher humidity compared to that of higher humidity. The interpretation of this experimental work indicates that at a higher humidity level, there will be dew formation on the PV module surface. Consequently, this dew formation could hinder the incoming solar irradiation reaching the PV module surface where the conversion efficiency from solar energy into electrical energy will be compromised. Despite the solar irradiation being compromised, the formation of dew facilitates the reduction of the surface temperature of PV module. This is because the specific heat capacity of dew (water droplet) is higher than that of specific heat capacity of air. In other words, the dew formation on the PV module screen could absorb more heat that is generated by the PV module surface compared to that of air and in strict sense this can be said as passive cooling.

2.5. Ambient temperature:

In developed a mathematical model to investigate the effect of ambient temperature on the power generation of a 3 MW PV power plant system under Ecuador climate [9]. It was found the performance of PV power plant decreases with increasing ambient temperature. The occurrence of this phenomena is due to the fact that, the ambient temperature increases with solar irradiation. As a result, the temperature of PV module surface will increase under field condition as well. This is because during daytime, the temperature of the PV module

surface is always higher than the ambient temperature because the heat from the metal structure or the PV module mounting is transferred to the back surface of PV module causing it to have higher temperature than the ambient temperature.

3. DISCUSSION

From the literature review in section 2.0, it can be said that the ambient temperature, solar irradiation, and dust deposition on the module surface have the most significant effect that cause extreme rise increase in module temperature. Since the PV module is a function of temperature, hence when the temperature of module increases beyond its standard test condition then the voltage across the PV module drops significantly whereas the current only slightly [10]. Ultimately, the performance of PV drops. Besides, the dust deposition on the module surface is another major problem in the PV system, especially when the PV systems are located near to industrial zone where the soiling effect is higher which will eventually comprise the energy conversion from solar energy to electrical energy. This is because dust particles are very small in diameter that is approximately less than 500 μm. Due to the light weight of dust particles, they are easily lifted by the action of wind [11]. These depositions of dust will form a layer over time in such all the heat energy will be trapped by these layers. Consequently, this will cause the temperature of module to rise. The humidity might have the least effect on the module surface. This is because the dew formation on the module surface at greater humidity can be prevented by tilting the module to certain angle to facilitate the movement of dew across the module. However, this phenomenon could be difficult to occur if the PV module is set horizontal relative to the ground, which results in diffraction, reflection and absorption where the solar radiation reaching the module is compromised, reducing the performance of PV. Moreover, a greater wind velocity is a merit to the performance of PV module, because at greater wind velocity more heat energy from the module surface could be taken away. In addition, greater wind velocity can also blow away the foreign particles that are deposited on the module surface. However, the wind velocity varies with respect of time and different climatic region and it may not favourable permanently on the PV module performance.

4. CONCLUSION

This paper reviews various type of environmental factors that affects the performance of PV systems and highlights the factor(s) that has most substantial effect.

- Increase in ambient temperature, solar irradiation and deposition of dust particles on the PV module surface are the main contributors that cause significant increase in module temperature and decrease of the system's performance.
- The humidity level might have the least effect on the PV module performance.
- Greater wind velocity has a positive impact on the PV module performance.

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6. CONFLICT OF INTEREST

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8. REFERENCE

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