REVIEW ARTICLE

Influence of Mine Environmental Parameters on the Performance of Solar Energy System - A Review

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ABSTRACT

Owing to the rise in the price of fossil fuels and natural gases, there is an increase in cost of power generation. In order to generate eco-friendly electric power without polluting the nature or leading to emission of greenhouse gases, this paper focuses on energy production via solar power systems. It is feasible due to the availability of solar panels at reasonably lower cost. The influence of environmental parameters like dust, temperature, humidity and wind speed, along with the mining site factors in generation of solar energy is reviewed. It is finalised that by maintaining clean environment and cooling operations, these adverse impacts could be reduced.

Keywords: Solar power system, Solar panels, Fossil fuel, Mining factors, Cooling operation.

1. INTRODUCTION

There is an acute power crisis at industrial sectors due to the depletion of fossil fuels. Analysing the rate consumption of various energy sources is essential and it is also required to indicate the available resources. Figure 1 shows the ratio of energy utilization in India. It illustrates that power saving and balancing the electricity need and production could be achieved only by maximum utilization of renewable energy resources.

![Figure 1. Ratio of energy utilization](image)

In this attempt, solar energy is considered as the best alternative. This system consists of a solar photovoltaic panel to convert solar energy into electric energy, where the panel is usually made of silicon. Direct conversion of solar energy to electricity is technically a simple process, since it is available naturally, which is renewable too. All that one requires is good sunshine as a source. Two or more semiconductor layers are combined to form a PV panel, where the characteristics develop a stable electric field across their junctions [1]. Since it is cost effective and can be available even at remote areas, this mode of energy is widely being adopted. Solar systems are employed in mining sectors too to light both inside and outside the pit, apart from its other industrial applications. With respect to the fact that its performance is effective if only maintained in clean environment, solar panels might not be durable due to the polluting nature of mining sites and so it gets degraded over time. [2] Recently, many mining factories have realised the value of adopting renewable energy resources and have chosen solar panel system. Due to certain topological characteristics in open pit mines, installation of floating solar panels is preferred to other PV types. [3] On the other side, even the expansion of solar panel construction influence environmental parameters indirectly.
in correspondence with carbon dioxide release. Installation of more PV modules deliberately accounts for higher deviation in global warming. It is also important to note that energy consumption by means of solar panels is much greater. [4] A set of solar panels were demonstrated, each made of different material. Among them, the panels made of amorphous silicon were proved to be comparatively better in terms of life cycle assessment, performance, energy conversion and global warming effect. Concerning these as factors, the thing that is forced to be given priority is, maintaining dust free environment. This is the sole aim of this article, where it reviews the influence of environmental factors that affect the working performance of solar panel.

2. EFFECT OF ENVIRONMENTAL PARAMETERS ON PV PANEL PERFORMANCE

2.1. Effect of dust
Solid particles that can be graded below 500μm in diameter are said to be dust. Its sources are soil, volcanic eruptions, etc., where it is also caused due to Aeolian process, that pollutes the surrounding atmosphere to a greater extent. It might contain plant pollen, fibres, fallen hairs, skin cells, minerals and meteorite substances, microorganisms, tiny shreds and related items. Dust evolves out of industrial and vehicular activities as well, that scatters in the environment to degrade the natural conditions further. [5] When considering the mining operations, the tasks including drilling, digging, excavating, cracking and transporting lead to increase in dust. The parameters of dust such as size, mass, chemical properties and environmental factors like weather, humidity, surface finish and tilt angle also relate to dust settlement. Due to the collection of dust over the solar panels, the absorption of sunrays by the surface of the panel gets reduced resulting in lower transmittance in turn to performance degradation. Here the incident light over the photo voltaic device is scattered to lower its efficiency. [6] Normally, as dust cumulates more at the surface, the panel performance deviates more, where the affecting parameters like rainfall, varying temperature and wind speed vary from region to region and so the dust settlement is not even at all areas. Owing to the variation in open and short circuit voltage, the former one is negligible, where in case of short circuit (SC) type, there occurs deep power shortage. This reduction of current and output power terms to 28.6% and 30.6% accordingly when the PV module is kept under the exposure of sun for about 12 days [7].

[8] When subjected to dust sand accumulation over the module, it was noticed that the SC current and power were lowered by 40% and 34% correspondingly. [9] With these, even the cell temperature and humidity would have the impact over the formation of dust at the contact area. [10, 11] analysed that the energy conversion efficiency degradation was found to be 10%, 16% and 20% for 12.5 g/m², 25 g/m² and 37.5 g/m² considering accumulation of dust. Reduction in efficiency in accordance with dust accumulation is shown in figure 2.

![Figure 2.1-Characteristics of solar panel](image)

2.2. Effect of temperature
Solar cells respond more to temperature variations alike to other semiconductors. The band gap of such materials get reduces due to temperature increase which further has the effect upon their characteristics. This band gap reduction is in relation with the energy increase of the electrons of the semiconductors. In order to discontinue the bond, minimum energy is thus required and to minimize the band gap, bond energy has to be reduced. [12] In the PV cell, there is a vast difference in the open circuit during extreme temperature rise. Beyond this, fill factor and conversion efficiency also go on decreasing as temperature increases. In this regard, the short circuit current can be negligible. Altogether, it is determined that the PV panel performance gets degraded with respect to increase in surface temperature. In
[13], it is given that, as PV cell temperature minimizes by 22°C, there is 10.3% rise in energy. [14] also insisted that due to the formation of dust from the environment, SC current and the ambient temperature of the solar module are reduced so that the overall efficiency of the panel automatically gets degraded over time. Analysis on temperature versus current and voltage confirm the fall of 0.45% open circuit voltage and 0.09% rise in short circuit current when surface temperature is enhanced by 1K. Figure 3 illustrates that increase in Isc is considerably lower and Voc reduction is higher [15].

2.3. Effect of humidity

In relation with humidity, both the positive and adverse effects have been resulted in common. It plays a better role to upgrade the system efficiency. At the same time, it might affect its productivity. [16] On discussing about the drawback in connection with efficiency, two causes can be drawn,

- Since dust adheres to the panel surface because of the influence of humidity, it paves way for the collection of more dust particles over its surface which in turn leads to the reduction of energy conversion efficiency.
- The surface transmittance is reduced due to which the effect of humidity retracts the sunrays contacting the surface, thereby, affecting the system.

In contrast, when heavy wind comes in contact with the surface, along with the humidity effect, it behaves as a cooling agent in reducing the panel temperature, thus upgrading the efficiency. Light beam gets reflected, refracted or diffracted when it reaches the humid panel surface. Non-linear deviations of irradiance occur as a result of moisture effect leading to variable open circuit voltage (Voc) and short circuit current (Isc) in a non-linear and linear fashion respectively, where the linear variation in Isc is too large compared to the changes in Voc. It means that short circuit current is affected more corresponding to panel performance degradation and the effect over open circuit voltage is insignificant [17].

2.4. Effect of wind

It is the known fact that the cell temperature influences the photovoltaic module to an unlimited extent. As a whole, ambient temperature and the wind speed accounts for cell temperature. As wind velocity is inversely proportional to cell temperature, cell temperature is reduced in respect of wind speed increase, thereby improving the panel performance. Hence the role of wind velocity is significant in solar panel operations. Sedimentology and aerodynamics are the two effects that occur due to wind velocity [18, 19].

2.4.1. Sedimentology effect

Non-dusty environment is applicable for sedimentology effect, where the wind speed provides positive impact over the system productivity. By varying the ripple height and spacing of the collected dust at the surface, heavy wind lowers its deposition. Figure 4 shows the sedimentary effect, where the direction of wind speed is noted.

2.4.2. Aerodynamic effect

In contrast to sedimentology effect, aerodynamic effect is considered for dusty environment. According to this, as the velocity
of wind increases, dust accumulation also increases, thus degrading the system efficiency, which is related by the equation shown in (2.1),

\[ F_s = V_d \times C \]  

(2.1)

where, \( F_s \) refers to sedimentation flux, \( V_d \) denotes wind velocity and \( C \), airborne dust concentration. From figure 5 and equation (2.1), it is understood that sedimentation flux increases with the velocity of the wind resulting in higher deposition of dust which in turn lessen the efficiency.

![Figure 5. Aerodynamic effect of wind speed](image)

**3. CONCLUSION**

Solar energy is opted as a better choice of power generation world-wide, especially in remote areas, where mining and mineral industries are rarely accessed, because in these areas, continuation deposition of dust particles might damage the solar panel. This paper is focused on how mining factors bring undesirable results over PV panel operation. The environmental parameters that have negative impact including dust, moisture, temperature and wind velocity over the system performance in terms of short circuit and open circuit system and fill factors are reviewed. As these factors degrade the system performance, it is essential to keep the panel from dusty environment by ensuring cleaning and cooling at regular intervals.

**REFERENCES**


