



Impact of Dust Soiling on Photovoltaic (PV) Module Performance at the Different Heights

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Abstract: A regular accumulation of tiny dust particles on the transparent glass cover of solar PV modules is a critical challenge for harnessing solar energy. This research paper is designed to focus on the impact of dust settlement over the flat glass cover of photovoltaic (PV) modules at different heights. Consequently, a peak level of power loss (21.5%) has been detected at the ground level (0 ft), meanwhile less power loss (9.5%) at the height of 20ft. This is explained by the level of dust settlement with the height because dust density directly affects the PV output. As a result, a mass level of dust deposition (11.7 gm) was observed at the ground surface and low dust density (2.8 gm) at the height of 20 ft.

Keywords: Dust soiling; Small particles; module heights; Shadow effect; Dust pollen.

I. INTRODUCTION

Nowadays, the settlement of small dust particles onto a smooth flat glass surface of a photovoltaic (PV) module is the major concern with dc power generation. Tiny dust grains disturb the photovoltaic output at a great level. Especially, Western Rajasthan faces the problem of dust deposition at the critical level as shown in Fig.1. Besides this, some other minute particles emerged from surrounding sources like soot, industrial pollen, vehicular activities, passing clouds, and bird droppings are the main challenge for the solar power production. Moreover, in real outside conditions, several types of tiny dust grains are to be deposited over the PV glass surface due to the burning of traditional (i.e., wood, charcoal, etc.) fuels, brick plants, mining activities, and cement factories in the local area. By definition, the word dust is a combination of a small particle of diameter less than $62.5\ \mu\text{m}$ (Blott and Pye, 2012).



Fig. 1 Dust soiling on the solar photovoltaic plate at the height of 15 feet in an open environment.

These small dust particles are to be lifted by air and accumulated on the PV surface in an open environment. Accumulated dust grains block the sun's radiation from falling on smooth glass surfaces. As a result, a significant reduction in the level of power production capacity and performance of device (Said 1990; Adinoyi and Said 2013). It is observed closely that PV technology is very sensitive to non-uniform illumination (i.e., partial shading). Because only a single spot of dirt can greatly affect the overall performance of the PV module (Al-Hasan, 1998). The status of dust soiling after a different period can easily be seen as shown in Figure 2 below.

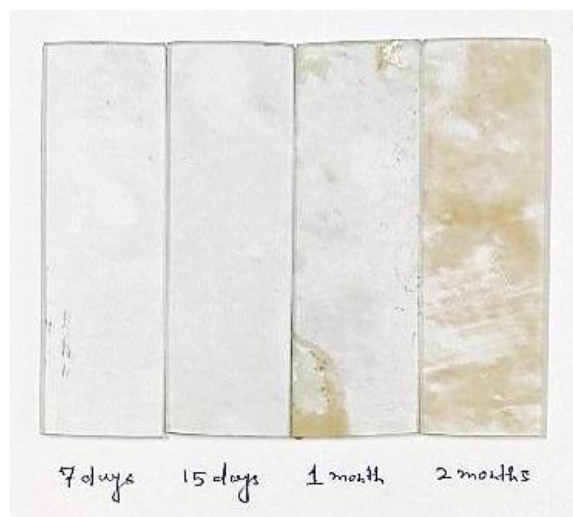


Fig. 2 A level of dust soiling on glass covers after a different time period.

2. Methodology

In this research study, the effect of naturally deposited small dust particles on PV glass cover has been estimated at different heights. For this purpose, the performance (output power) of the PV device is measured at four different heights (ground, 5ft, 10ft, 20ft) from ground level. Moreover, glass plates were mounted with an inclination of 26° south facing which is the tilt angle for solar panels in Western Rajasthan. Solar output was measured using Solar Module Analyzer PROVA 210. Thereafter, the volume (gm) of collected dust samples was measured using a weighing scale (Phoenix, GOLD-600P weighing dust with a range of 0.2 g to 600 g). In this experiment, glass plates were placed at the farmhouse which was located outside of the urban area. Data were taken during the critical dust-soiling period from January to February (winter season) for the two months. Because prevailing moisture (humidity) in air promotes the dust accumulation on the smooth glass cover due to mud formation which is more adhered to the flat glass surface. Usually, no rain event happens in this period. Moreover, the effect of bird-dropping deposition is neglected.

After deposition to dust soiling material onto the glass collector, the average power loss (%) has been determined in clear shiny days. The effect of dust settlement can be evaluated in terms of power losses by comparing maximum output power P_{max} (i.e., P_{mpp}) (clean) and after (with dust-exposed glass covers) by using solar Module Analyzer PROVA 210 stated as follows (Sulaiman 2014):

$$\Delta P(\%) = \frac{P_{max,out}(clean) - P_{max,out}(dust)}{P_{max,out}(clean)} \times 100 \quad (1)$$

3. Results and discussion

As considered experimental outcomes, the impact of small dust particles settlement over the smooth flat glass plates has been shown at different heights. In this regard, it is clearly observed that the maximum level of dust deposition is found at the ground level whereas the minimum is at the height of 20ft from the ground level as shown in Table 1 i.e., the level of dust accumulation decreases with increasing the height of plates.

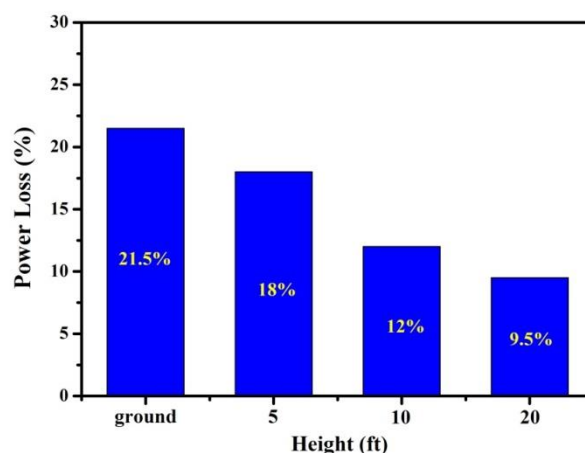


Fig. 3 Impact of dust soiling at the different heights.

Because, a maximum level of dust accumulation (11.7 gm) is to be deposited at the ground surface by the surrounding activities like human and cattle movement, vehicle transportation, etc. Meanwhile, a minimum dust accumulation (2.8 gm) at the height of 20 ft is observed. As a result, it can be easily seen that a great level of power cut (i.e., power loss, 21.5%) is obtained at the ground

level (0 ft) due to a high level of dust settlement and less effect (i.e., power loss, 9.5%) at the high altitude Fig.3. Finally one can observe, the peak level of power cut obtained at the lower height due to great dust deposition and as minimum impact at the height.

Table1 A level dust deposition at the different heights

Plate's height (ft)	ground	5	10	20
Weight (gm)	11.7	9.3	4.9	2.8

Generally, it is well noticed that dust materials can be found to have been lifted to PV glass cover by wind, and human, or animal activities surrounding the PV site (Elminir et al., 2006). This factor can be described based on gravimetric deposition of dust particles on the panel's surface. It is commonly known that air cannot lift heavy particles from ground level to high elevation. As a result, low dust density is found at the height and extreme at the ground surface.

4 Conclusions

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