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The effect of dust on solar photovoltaic systems

F. Mejia, J. Kleissl*, J. L. Bosch

Center for Renewable Resources and Integration, Department of Mechanical and Aerospace Engineering, University of California, San Diego 9500 Gilman Dr., La Jolla, CA 92093, USA

Abstract

Soiling is the accumulation of dust on solar panels that causes a decrease in optical efficiencies of CSP systems. However, geographically widespread data is only available for solar photovoltaic (PV) systems. The changes in efficiency of a large commercial site (86.4 kW_{dc}) was quantified during the summer dry period over the course of 2010 with respect to rain events observed at a nearby weather station (3.4 km away) and using satellite solar resource data. Soiling losses were found to be 0.21% per day. The site was observed to have a decrease in efficiency from 7.2% to 5.6% during a 108 day dry period in the summer at which point a rain event occurred that recovered most of the lost efficiency going back to 7.1%.

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1. Introduction

Concentrated solar power (CSP) power is quickly increasing in California with the Ivanpah power tower facilities and several concentrating photovoltaic (CPV) power plants in the Imperial Valley. Soiling significantly impacts the optical efficiency of CSP systems, but geographically dispersed, robust estimates on soiling have been elusive. The California Solar Initiative now provides photovoltaic (PV) performance data from which soiling estimates can be derived. Even for PV, soiling can be significant and influence the management and analysis of the expected performance of PV sites.

* Corresponding author. Tel.:+1 858 534 8087.
E-mail address: jkleissl@ucsd.edu (J. Kleissl)

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Fig.1 demonstrates how dust has accumulated on a PV panel. Dust accumulation can have a large effect on efficiency during long droughts [1], which unfortunately is also when the largest solar resource occurs.

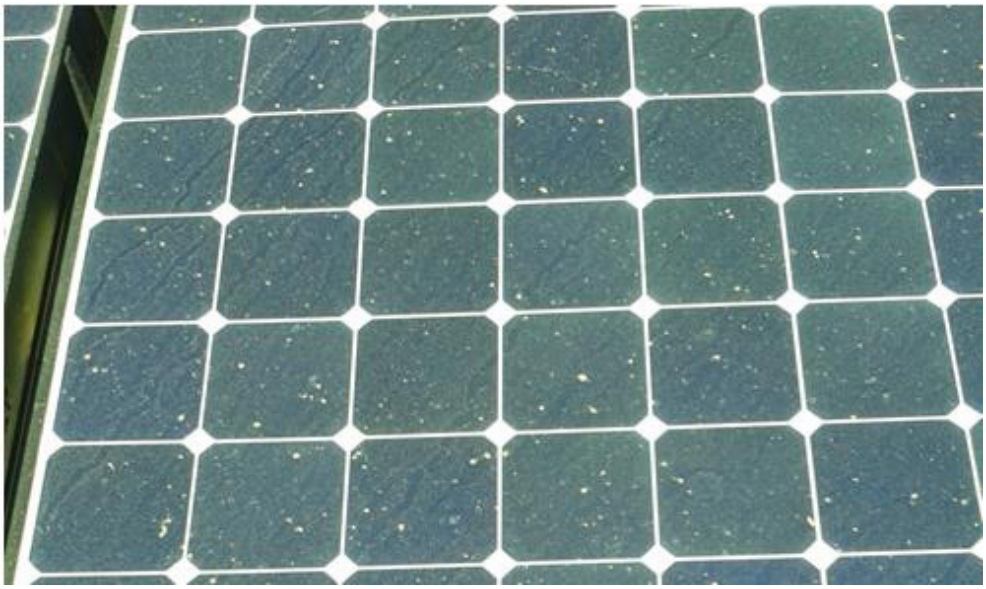

Fig. 1 Dust accumulation on PV panel in UCSD.

Some research on soiling has been conducted particularly in the middle-east [2, 3] and India [4]. Another more recent study examined the effects of soiling for 250 sites monitored by PowerLight (now SunPower) [1]. Since several of these sites are in areas with frequent rain their study focused on sites in the southwestern United States where long droughts are more common. They also excluded sites with an R^2 value between soiling energy losses and time of less than 0.7 which left a total of 46 sites. Between rain events, soiling losses were found to aggregate linearly with time with an average daily soiling loss of 0.2%. While this paper provides a methodological foundation for analysing soiling losses, the site selection criteria may have led to an overestimate of soiling losses [11].

A few studies have been conducted attempting to connect the effects of soiling in flat PV with those of CPV and have shown that CPV has greater losses due to soiling than flat PV. The main difference between these systems is that in CPV using an optical system to focus sunlight onto a smaller area either with reflectors or Fresnel lenses. For mirrors soiling can affect the system both when it enters the mirror and when it exits the mirror leading to greater losses [12]. Beyond this, CPV rely on keeping radiation reflected within a certain angle so that it can reach the solar cell. Small deviations in the trajectory of the radiation that did not affect flat panel PV, may lead the radiation away from the solar cell. One paper found a link between flat PV and CPV by comparing 5 concentrating systems of varying concentrating levels from 2X to 300X with a flat panel for 4 months [13]. They found a relationship between the concentration level and the losses observed do to soiling and also found that reflective systems were more susceptible to soiling losses than refractive systems.