Cost and Performance Comparative Model of Dust Mitigation Technologies of Solar PV in Saudi Arabia

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Abstract—Solar photovoltaics are rapidly emerging as promising technologies to tackle the world's energy challenge. Certain geographic locations with high levels of insolation, while offering vast capacities for harnessing the world's available sunshine, face certain climatic challenges. The dust problem, particularly, a prevalent issue in many of these locations, has posed a serious problem for PV deployment. Module efficiency has shown to decrease by up to 70% due to dust.

While some research has investigated potential technologies for dust mitigation, not much studied the impact of implementing them commercially, or took into account climate effects. This paper presents a dust-mitigation for solar PV model, consisting of a performance component and a financial component, to compare three main dust-mitigation technologies (electrodynamic screens or EDS; air-blowing mechanisms; and superhydrophobic nano-coatings) against each other, and against a reference based on manual cleaning. The model calculates the Levelized Cost Of Energy (LCOE) as an objective metric for comparison. Saudi Arabia is used as a case study to validate the results, given its unique combination of enormously high annual insolation and frequent dust storms.

Dust mitigation technologies show major dependence on weather patterns, and increase total power output dependence on seasonality. Different technologies increase power output disproportionally depending on the location despite the relative proximity of the test points. In some locations, the annual power production increases by up to ~17%. Overall, there is a correlation between increased energy production and decreased LCOE, showing that the increase in annual energy offsets the associated costs. The model is globally applicable, has the potential of studying additional technologies, and incorporating effects of other aerosols, making it relevant for any large-scale PV application.

Keywords— comparative model; solar photovoltaics; Saudi Arabia; dust; dust-mitigation; technologies; aerosols; module performance; levelized cost of energy