Dust and Soling Accumulation Effect on PV Systems in MENA Region

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ABSTRACT

Photovoltaic efficiency is highly affected by dust accumulation; the dust particles prevent direct solar radiation from reaching the panel surface, therefore a reduction in output power will occur. A study of dust and soiling accumulation effect on the output power of PV panels was conducted for different periods of time from May to October in three countries of the MENA region, Jordan, Egypt and Algeria, under local weather conditions. This study leads to build a more realistic equation to estimate the power reduction as a function of time. This logarithmic function shows the high reduction in power in the first days with 10% reduction in output power compared to the reference system, where it reaches a steady state value after 60 days to reach a maximum value of 30%.

1. INTRODUCTION

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect[1], a phenomenon commonly studied in physics, photochemistry and electrochemistry.

A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power.

In general, the PV insulation are expected to be designed for optimum yield, Researchers studied the factors that determine the optimum or maximum yield.

The accumulation of dust on the surface of a photovoltaic module decreases the radiation levels reaching the solar cell leading to losses in the generated power [2] . Dust not only reduces the radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation [3].

Soiling studies were conducted to determine dust accumulation rate and Power reduction as a function of soiling parameters such as location, wind speed, atmospheric dust concentration and exposure time between cleanings [4-5].

The major function of Dust accumulation research is to study the loss of energy-yield of PV plants as a function of : (1) angle of inclination, (2) particle size distribution, (3) environmental parameters such as relative humidity, wind velocity, and frequency of dust episodes, and (4) Panels cleaning.[6]

The main objective of this work is to study the dust accumulation effect on power output under local weather conditions in the dusty period (spring/summer).

This work represents the first complete dust analysis study for (spring summer period) under these weather conditions, which lead to know exact dust accumulation effect on power output of solar panels.

2. LITERATURE REVIEW

Studies related to dust accumulation are critical as a further decrease in the (practical) system efficiency will tend to make PV systems an unattractive alternative for energy source.

El-Shobokshy and Hussein are credited as pioneers on a comprehensive study into the impact of dust on the performance of PV cells as they started studying the dust effect since 1993, The study included investigations into the physical properties of the dust accumulation and deposition density on their impact on parameters degrading PV efficiency.[7]

In additional to the properties of dust, the researcher studies also the effect of the geographical location on the dust accumulation in many regions.

Summary of different studies for dust accumulation for 1 day see (Figure 1) in Libya (latitude: 27°N) [8] , Kuwait, Kuwait (latitude: 29°N) [9] , Limassol, Cyprus (latitude: 34.6°N) [5] , Abu Dhabi, UAE (latitude: 24.5°N) [11] , Riyadth, Saudi Arabia (latitude: 24.6°N) [11].

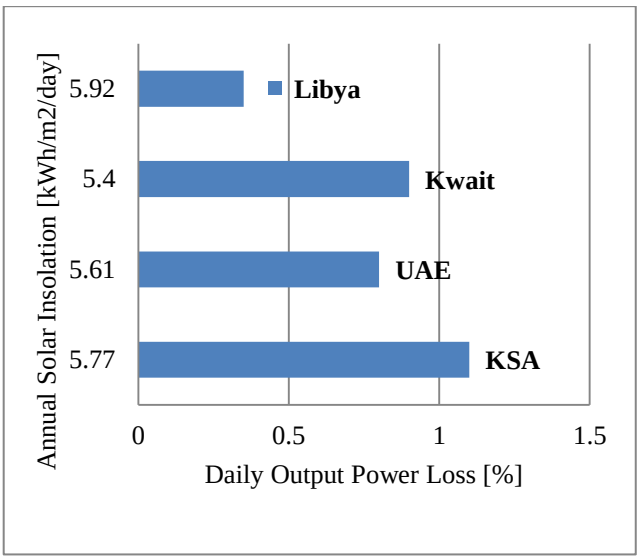

Figure 1: Daily output power loss due to dust accumulation

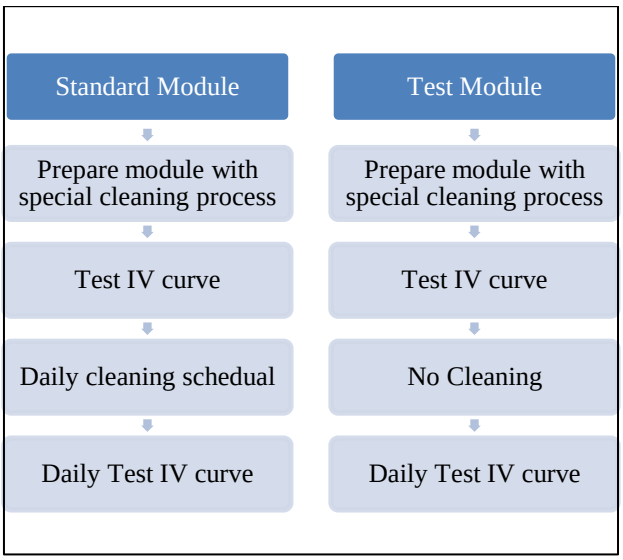

Figure 2: PV panels testing methodology

3. METHODOLOGY

One of the main challenges for solar applications in MENA region is the dusty weather conditions that will cause a serious problem in the energy yield.

In order to find a proper solution for the dust accumulation [12] we need first to study the dust accumulation itself throw: (1) Define dust types and expected accumulation patterns. (2) Study of dust effect on PV modules.

Dust accumulation is found to have a measurable effect over the degradation in the yield output; this problem required an immediate-efficient solution.

For each chosen country, a comparative study was conducting using two PV panels under the same weather conditions, see (Figure 2), where the first PV panel had been regularly cleaned and the second panel was left without cleaning.

This Experiment conducted in Amman/Jordan, in Almansorah/Egypt and in Mascara/Algeria. Two identical PV modules Polly Crystalline 250W each were used in this research. The modules, which are mounted south oriented and tilted of 25°. A measurement tool were used (1) Current Measurement Tool (Clamp meter) (2) Digital Multi-meter (Fluke 15B, Germany) and a resistive load.

Methods commonly applied by researchers to monitor and assess a module's electrical performance are current voltage (I–V) and power voltage (P-V) curve scanning.

These curves represent the values of electrical parameters of a module such as maximum power output (Pmax), maximum output current (Imax), maximum output voltage (Vmax), open circuit voltage (Voc) and short circuit current (Isc).

4. RESULTS AND ANALYSIS

This study started from 21st May 2016 to 8th October 2015, a continuous data measurement was collected for studying the performance of PV panels (DC side) to build IV curve.

4.1. IV Curve Analysis

IV curve readings for multi days were taken for the clean and dusty panels, based on the readings power reduction was calculated depend on two methods:

1. Panel Peak Power reduction (max. power point)
2. IV Curve working window reduction (area under IV curve)

The peak power which measured as a comparison method represent the real working point for the inverter, this value is a single value and varied from panel to the other due to dust effect on the IV curve so the reduction appears high.

The working window is defined based on the working window for micro inverter it is between (16 – 36) V for full load situation and started from 10 volt in no load operation, in this study the selection of area reduction because it show the overall effect of dust accumulation on the IV curve shape, this method shows conservative reduction in compare with the reduction of max. power point.

4.2. IV Curve Readings

The average power reduction readings due to dust accumulation on PV panel for three locations, see (Figure 3) . Three peaks appeared in the figure; one in the first days of experiment and two in the last period which represent completely dusty days.

These peaks had high power reductions which reached more than 80%, this is a sign of the huge effect of dust

storm on the power of PV panel. And after few days from the storm the power reduction back to its normal ranges because of natural air movement and its effect on dust distribution.

The other readings between (10-30) % over the period of the studying period.

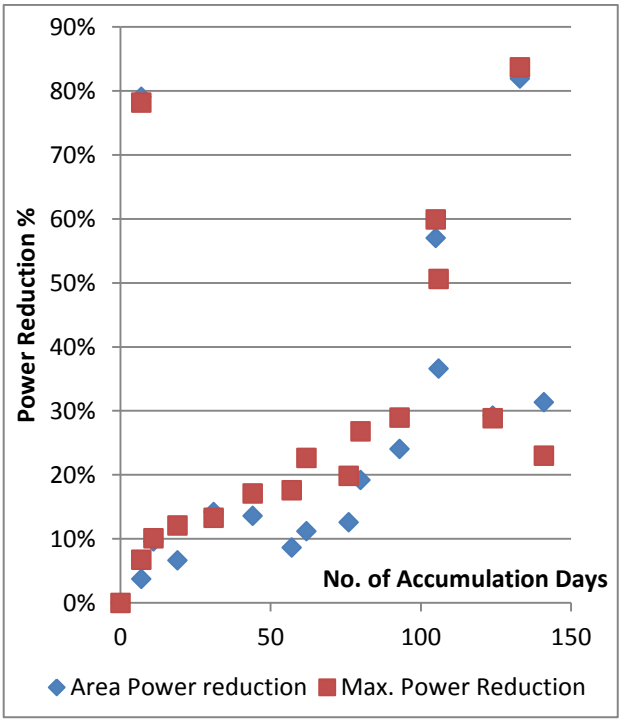

Figure 3: Power reduction due to dust accumulation

Dust storm sample readings at noon time see (Figure 4) shows the power reduction which reached 80% from the standard clean panel.

In Algeria, June 2016, was a full sunny month with average of 920 W/m^2 direct solar radiation. The readings show a high power output for the clean panel which reached its designed value and a power reduction of 14% from the power output, see (Figure 5) the IV curve for the dusty panel show irregularity in the current values which near to short circuit point.

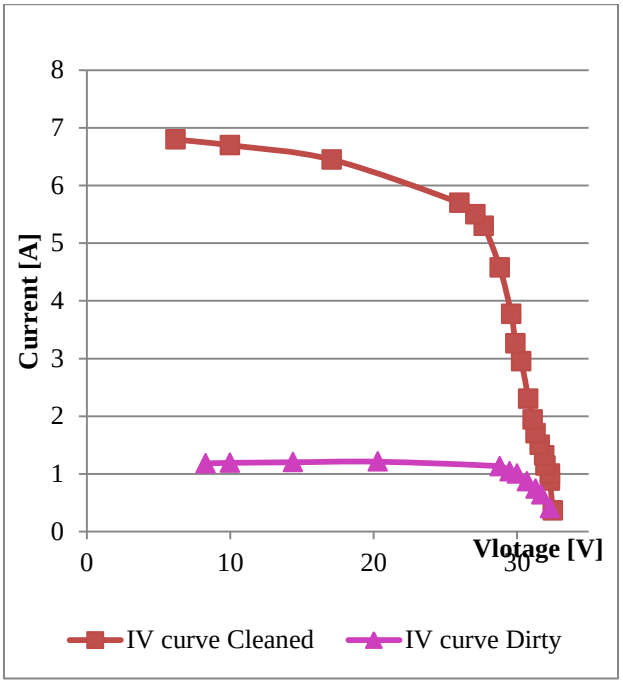

Figure 4: Dust storm reading , Egypt

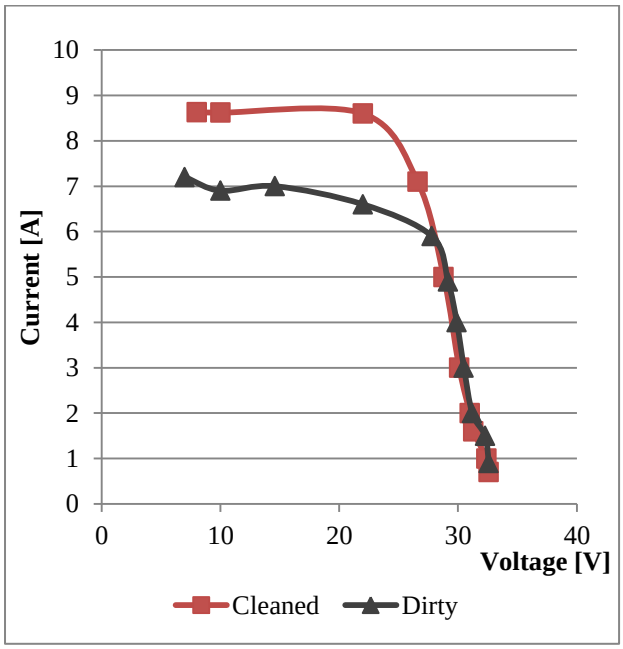

Figure 5: June 2016 IV curve, Maskara

Reduction on working current due to dust accumulation reach (2.5 A) after 4 months of experiments which represent a power reduction of 29% for the dusty panel.

This amount of reduction consider as a major reduction of power output see (Figure 6) also V_{oc} of the dusty panel show a reduction in compare with the standard one

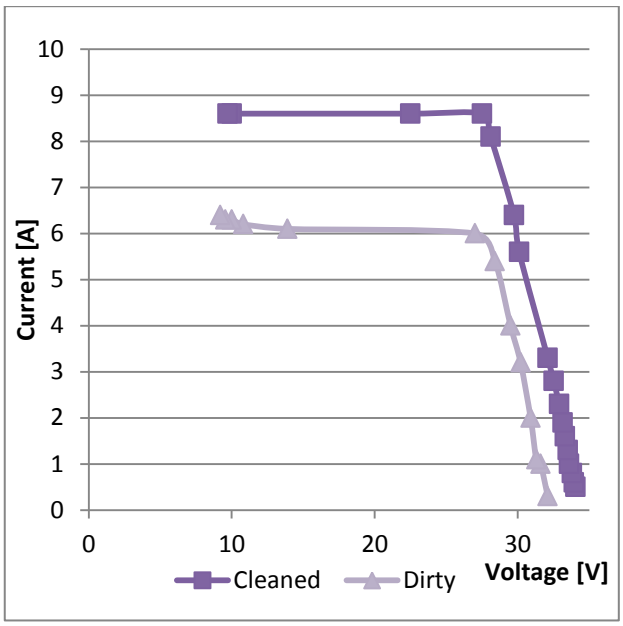

Figure 6: after four months - IV curve reading

One sample, from Jordan, shows the real dust accumulation pattern on the PV panel at the end of experiment see (Figure 7).

Figure 7: Dust accumulation pattern

4.3. Dust Accumulation Equation

Dust Accumulation cause a power reduction reach (33-35)% for 140 days of experiment, The history of power losses due to duct accumulation estimates a steady state region in the curve where the losses in power seem to be constant.

The readings after elimination the dust accumulation readings for dusty storm days match this behavior as in (Figure 8).

$$P_{loss} = 0.059 \ln(No.of\ days) - 0.326 \quad (1)$$

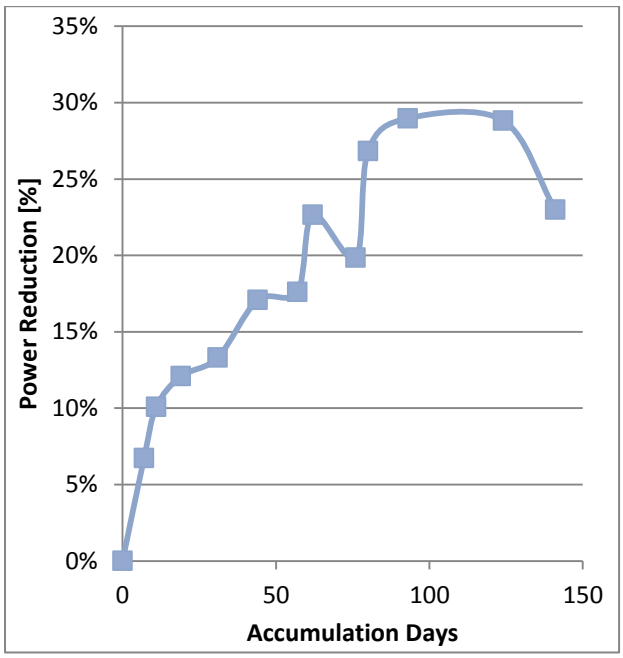

Figure 8: Power reduction

5. CONCLUSION

A study of dust accumulation effect on the output power of PV panels was conducted for 140 days in three locations under local conditions. This study leads to build an equation to describe the power reduction as a function of accumulation days. This logarithmic function shows the high reduction in power in the first days with 10% reduction, where its reaches a steady state value after 60 days of accumulation to reach around 30%.

There was a huge reduction in output power of the PV panels through the dust storm days and the power reduction reaches about 80% , and due to the weather conditions (wind, rain) the output power of the panels has increased again because the dust particles change its positions and take its normal distribution on the panels

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