PV Soiling Rate Variation over Long Periods

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ABSTRACT

Soiling of PV modules can significantly decrease their power output, especially in desert environments where there is much dust and little rain[1]. It is desirable to clean PV modules as infrequently as possible, because doing so uses manpower and scarce water. Therefore it is useful to study the soiling loss over long periods, to determine whether the soiling rate eventually slows down or even stabilizes (ie. a maximum dust layer thickness is reached).

BACKGROUND

A 35,000 m^2 Solar Test Facility was established at Qatar Foundation, Doha, in 2012 in order to identify solar energy technologies suitable for the local climate, and study the effects of dust and heat. The research supports the deployment of PV in the country; current plans include 200 MW of PV and a carbon-neutral 2022 World Cup football tournament[2]. Of particular concern is soiling of PV panels, causing them to lose performance. This study aims to understand long-term soiling behavior in the absence of cleaning or rain.

METHODOLOGY

Four PV arrays were set up at the Solar Test Facility. Each comprised eight polycrystalline PV modules, connected to identical grid-tied inverters, and operated at maximum power point conditions. The only difference between the arrays was the cleaning interval: (i) one week (“high”), (ii) two months (“medium”), (iii) six months (“low”), and (iv) not cleaned (“never”). Of course, all arrays were subject to rain. The test period was two years commenced February 2013.

Each array’s daily DC electricity production, module back-surface temperatures, and plane-of-array irradiance were recorded every minute. Daily Performance Ratios (PR) were calculated based on DC energy production, normalized by the installed array capacity (kWp) and irradiance, and adjusted to Standard Test Condition of 25 ℃[3].

Additionally, meteorological data and aerosols concentration were recorded.

FINDINGS

Energy losses of each array due to soiling are shown in Figure 1. The results are expressed as the arrays’ PR relative to the long-term average PR of the weekly-washed array, ie. the weekly-washed array is treated as the “100%” benchmark. It is seen that:

- The soiling rates generally appear to be higher in winter than in summer, ie. The lines are steepest in the months around January-February, and relatively flat around June-July.
- The greatest power loss occurred on the never-washed array, which after 234 days produced only 32.4% of the DC power of the weekly-washed array
- The soiling rate tends to decrease the longer the time since last cleaning, as seen by comparing the slopes of the medium, low and never-washed arrays approaching November 2014
- However dust continued to accumulate on the never-washed array even after 234 days, ie. The line was still going down when it rained in November 2014.

The latter two observations are illustrated more clearly in Figure 2, which presents the average daily soiling rate versus time since last cleaning or rain. It is seen that for PV modules cleaned within the past month, the average energy loss was roughly 0.5 %/day, while after six months the rate fell to around 0.2 %/day.

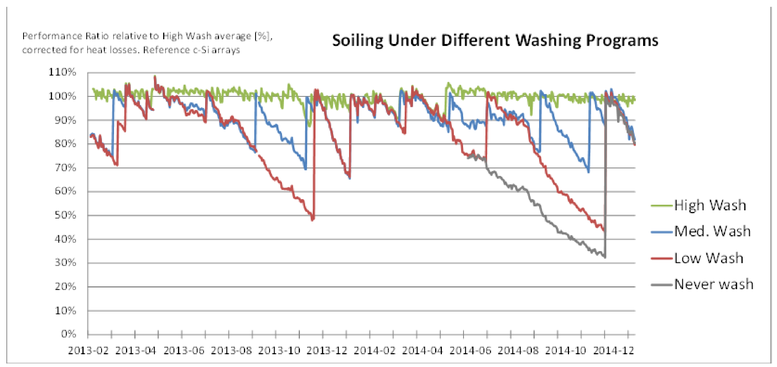

Figure 1. PV energy production decrease due to soiling.

Dust continued to accumulate at a substantial rate even after 234 days without cleaning.

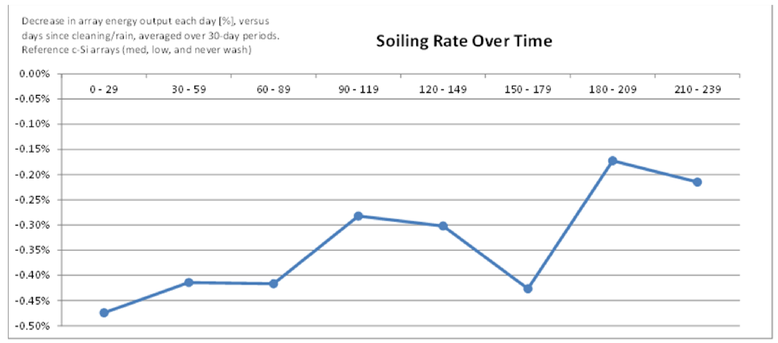

Figure 2. PV soiling rate versus days since last cleaned.

The daily soiling rate after 6 months was around half that of when recently cleaned.

Figure 3. Test stands at Solar Test Facility in Qatar.

Four cleaning schedules were tested: weekly, every 2 months, every 6 months, and never.

CONCLUSIONS/ SUMMARY

The results indicate that even after very long periods, dust continues to accumulate at a significant rate on PV modules in the desert. This suggests that the dust forms a mechanically-stable structure even at appreciable thicknesses, rather than becoming weak and blown off by wind, as might have been expected (and desired).

The daily soiling rate was generally greater in winter than in summer. It is speculated that this was because condensation formed on the modules in the early morning, causing dust to stick, rather than there being a greater concentration of airborne dust. Further work is required to understand this effect.

REFERENCES

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FURTHER INFORMATION

Qatar Environment & Energy Research Institute, ww.qeeri.org.qa

This presentation contains no confidential information.