Experiment on PV Panels Tilt Angle and Dust

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***Abstract*— The performance of PV solar panels depend on dust accumulated on them and tilt angle. For every location in the world there is an optimum tilt angle of dust free PV panels for best performance. However, in some areas of the world dust is an obstacle for PV panels operation. Examples of such areas are the middle east and the Arabian gulf countries. Accumulation rate of dust depends on the location as well as the tilt angle of the PV panel. In this project, the dependence of PV panels performance on dust accumulation in addition to tilt angle will be studied for a given location. Relevant data are collected and analyzed towards enhancing the efficiency of PV panels in the presence of dust.**

Keywords—PV panels; solar energy; tilt angle; dust; data

I. INTRODUCTION

Some of the solar energy rich spots in the globe such as the middleeast and Arabian gulf suffer from climate obstacles such as dust. On one hand, solar systems such as PV panels are attractive for these areas due to the available solar radiation. On the other hand, dust can be a main obstacle for the operation of solar panels in two ways: accumulation on the solar system with time and presence in the environment surrounding the solar system. In both cases of dust presence, good part of the available solar radiation will be scattered and absorbed by dust particles which is a drawback for solar systems. The dust in atmosphere is difficult to avoid. However, the problem of dust accumulation on solar systems (mainly solar panels) can be alleviated by using technology advances such as scheduled cleaning methods and special panel covers. In [1] cleaning needs and advise on cleaning frequencies of PV panels in Doha, Qatar were suggested. PV panels protective covers against some environmental factors including dust was discussed in [2].

The effect of accumulated dust particles created by epoxy powder in the laboratory on the performance of PV module has been performed in [3] where it has been observed that dust accumulation on the PV module surface not only depends on the tilt angle. In the study PV module has been tilted vertically at 90^o. This very recent research motivates the idea of exploring the effect of dust on PV panels performance at various tilt angles. Furthermore, testing the results with real dust in the environment will bring in more practical benefits. Towards this end, the dependence of PV panels performance on dust accumulation in addition to tilt angle will be explored. Relevant available data will be collected and analyzed. Available data will include parameters related to the PV module performance such as electric current and voltage, namely, I-V data for a given location. It is worthwhile to mention that for dust free panels the optimum tilt angle depends on the location in the world.

This research of [4] investigated the contribution of dust to the long-term performance degradation of various photovoltaic (PV) modules in Australia. The study found that the degradation of the PV modules' power output, ranged from 19% to 33%. The degradation was mostly due to non-dust related factors such as corrosion, delamination, and discoloration. The effect of pollutant type which depends on the geographical site has been investigated indoors and few outdoors in [5] where the effects of pollutant types on the PV performance have been revised and experimented. A critical review and challenging questions have been developed for the researchers working in this field.

A lot of research have been devoted in recent years towards studying and improving the performance of solar systems due to the great importance of the field. An adaptive control system was developed in [6] to adjust the tilt angle of solar trackers in order to achieve best efficiency. A feasibility study was conducted in [7] for a PV solar system to be installed at a location in Jordan. The research analyzed solar data in Jordan and the appropriate components for the system were selected and bought. The overall system was constructed and its performance was analyzed by collection of experimental data. The research in [8] explored an existing solar system in Jordan which includes water heating solar collectors and a PV module to operate a pump for water circulation. The overall efficiency of the system was studied using available experimental data. The parameters for optimum efficiency were found with aid of neural networks.

II. SYSTEM DESCRIPTION

Three identical 50 W panels were used in this research and they have different tilt angles, namely 15^o, 20^o, and 25^o as shown in Fig.1. At the beginning of the test the three panels were cleaned very well and after that at each following day the reading were taken instantaneously at 12:15 PM using an IV Multi-tracer from daystar, Inc. This multi tracer has multiple channels that can be used to test multiple PV modules at the same time, the software being used to control the multi-tracer is called MTRACE. It collects, averages and saves the data. The

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connection of the multi-tracer with the PVs and the computer is shown in Fig. 2. The test was conducted for two weeks only. More detailed research is planned to be carried out later for a longer period of time where the data will be collected and analyzed for a complete season to see how the dust affect the efficiency of the PV panels in Ras Al Khaimah. This will help understand the optimum cleaning frequency, and at which tilt angle the panel is less affected by the dust.

Figure 1. Experimental PV panels with different tilt angles.

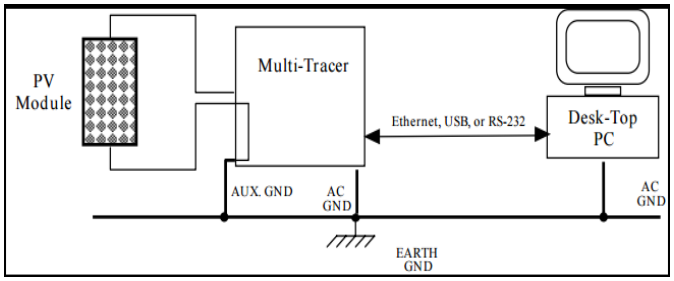

Figure 2. Connection of the multi-tracer.

Figure 3. Dedicated solar weather station.

The research location have a dedicated solar weather station that can be used to validate the research results. Parameters such as radiation (global, diffuse and beam), temperature, humidity, wind and other meteorological parameters are recorded and logged continuously throughout the test period. These parameters are used to give a clearer picture of the behavior of the test and to explain the external effects on the test such as low and high radiation or low and high temperature effects. A highly accurate sensors are used in this weather station, more details on the used weather station can be found in [9].

III. COLLECTED DATA

In order to study the dependence of PV panel performance on tilt angle and dust relevant experimental data are collected from the system described in the previous section. The three PV angles with different tilt angles are first cleaned very well. Sample data is collected for 8 days over an 11 day period. Clearly the collected data is not completely enough to understand the behavior of PV angles under changing tilt angles and dust. However, it paves the road to extend the current research to fully understand the performance of the PV panels under such condition, namely, more data need to be collected in the future to better understand the behavior of the PV panels. The aim of this research is to use the collected data an indication of what is expected to happen.

The collected data is taken at 12:15 PM for every PV panel and it consists of short circuit current, open circuit voltage, current at peak power, voltage at peak power, peak power and fill factor.

The peak power of the three PV panels is plotted against the number of day in Fig. 4. Note that for the 15° and 20° tilt angle there is a slight decline in peak power with time (day number). The change is small due to the short period of the test. For the 25° tilt angle no change is noticed for the same reason. It is clear from Fig 4. that in general the peak power increases with raising the tilt angle from 15 to 25 degrees due to the fact that the system is located in Ras Al Khaimah, UAE with Latitude of 25.7°. However, the change in peak power between the three angles varies with time which gives a clear sign that there is an essential dependence of performance on the dust accumulation. Therefore, it is worthwhile to collect more data that covers longer periods of time in the future.

IV. CONCLUSION

The background for studying the dependence of PV panels performance on tilt angle and dust accumulation is set up. Towards this end, a system composed of three PV panels with different tilt angles is utilized for collecting relevant data over an 11 day period. The data gives an indication of what is expected to happen and it paves the road for future considerations to be taken into account in order to study the full dependence of PV panel performance on tilt angle and dust accumulation. The data also shows dust can modify the dependence on tilt angle.

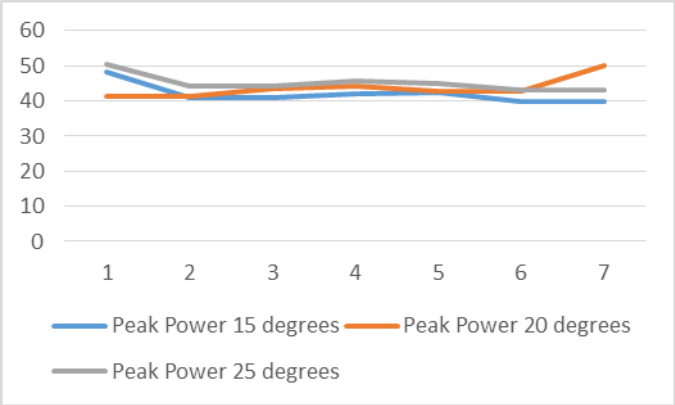

Figure 4. Peak power (Watt) with time (day index) for the three PV panels.

REFERENCES

[1] F. Touati, M. Al-Hitmi, N. A. Chowdhury, J. Abu Hamad, A. San Pedro Gonzales, "Investigation of solar PV performance under Doha weather using a customized measurement and monitoring system," Renewable Energy, vol. 89, pp. 564-577, 2016.

[2] B.S. Yilbas, H. Ali, N. Al-Aqeeli, N. Abu-Dheir, M. Khaled, "Influence of mud residues on solvent induced crystallized polycarbonate surface used as PV protective cover," Solar Energy, vol. 125, pp. 282-293, 2016.

[3] K. Dastoori, G. Al-Shabaan, M. Kolhe, D. Thompson, B. Makin, "Impact of accumulated dust particles' charge on the photovoltaic module performance," Journal of Electrostatics, vol. 79, pp. 20-24, 2016.

[4] J. Tanesab, D. Parlevliet, J. Whale, T. Urmee, T. Pryor, "The contribution of dust to performance degradation of PV modules in a temperate climate zone," Solar Energy, vol. 120, pp. 147-157, 2015.

[5] Z. A. Darwish, H. A. Kazem, K. Sopian, M. A. Al-Goul, H. Alawadhi, "Effect of dust pollutant type on photovoltaic performance," Renewable and Sustainable Energy Reviews, vol. 41, pp. 735-744, 2015.

[6] B. K. Hammad, R. H. Fouad, M. S. Ashhab, S. D. Nijmeh, M. Mohsen, A. Tamimi, "Adaptive Control of Solar Tracking System," IET Science, Measurement and Technology, vol. 8, pp. 426-431, 2014.

[7] M. S. Ashhab, H. Kaylani and A. Abdallah, "PV solar system feasibility study," Energy Conversion and Management, vol. 65, pp. 777-782, 2013.

[8] R. H. Fouad, M. S. Ashhab, A. Mukattash and S. Idwan, "Simulation and energy management of an experimental solar system through adaptive neural networks," IET Science, Measurement and Technology, vol. 6, pp. 427-431, 2012.

[9] M. Mohsen, Z. Iqbal, U. Kumar, W. Ullah, O. Akash, "Sustainable system solutions: RAK Research and Innovation Center Int. J. Sustainable Water & Environmental Systems, vol. 5, pp. 67-76, 2013.