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Performance of PV Panel Mounting Structure for Flat Surface and Roof-Top in UAE Climatic Conditions

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Abstract

PV Panel mounting structure for ground, flat surface and rooftops are getting common and gaining their popularity for several reasons, with availability of vast land that can easily be turned into flat surfaces and flat roof tops of buildings, there is a high probability of such products getting common in short span of time in this region. Conventional mounting structures require ample amount of time for them to be ready for installation, such flat surface mounting structures reduces or eliminates a huge chunk of expense. The efficiency is effected due to the tilt which is obvious, but the effect on performance of the rooftop PV system due to temperature and less air flow is discussed in this paper.

Keywords: *Photovoltaics, Renewable, Rooftop, Flat Surface, Ground Mounted PV, Mounting Structure, Performance*

1. Introduction

The electricity consumption in UAE is increasing every year from 69,914. GWh in 2007 to 105,363. GWh in 2013 a 51% increase in six years [1]. Out of which less than 1% is coming from Renewable sources [2] resulting in second highest Ecological footprint per capita in the world as per 2011 data [3]. However the UAE government is committed to increase the share of renewable sources in its generation capacity. Dubai has announced a target of generating 5% of its total energy through renewables by 2030 and Abu Dhabi has announced a target of total 7% of its total energy production through Renewable sources by 2020. In this race towards a greener and healthier future there is a high demand for cost effective and time saving solutions. Photovoltaic tops the list for alternative energy resources in this region due to its current available efficiency and cost. It is clear that the flat surface PV mounting structures will gain their popularity as they saves ample amount of money as well as time when compared to conventional PV mounting structures, but how much is it effecting the performance of the PV system, is the question that we have tried to investigate by setting up a flat surface PV mounting system in UAE climatic conditions and monitored its performance in comparison with another conventional PV mounting structure.

The experiment was conducted in Ras-Al-Khaimah Research and Innovation Center (RAKRIC) associated with American University of Ras-Al-Khaimah (AURAK). RAK Research and Innovation center is a state of art R&D center specializing in sustainable system solution development related to solar technologies. This center is the succession of research platform developed by the CSEM-UAE in 2007 when the Government of Ras Al Khaimah allocated to CSEM-UAE 87000 m² of land in the industrial zone to build a world unique Solar R&D facilities open to co-operation with world leading academic, technology and industrial development centers.

2. Preparation

The experiment consisted of two sets of panels at different mounting structures, as shown in fig.1 the conventional structure was reasonable above the ground as standard system would be 1 meter from south and 1.8 meter from north side and at 25° (local latitude) tilt which is the optimum tilt angle specific to Ras-Al-Khaimah for whole year considering the fixed angle mounting system, the other set of panels were mounted on flat surface mounting structures provided by Flamco (FALX) at 15° tilt 10 cm above the ground from south and 30 cm above the ground from north, this mounting system

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holds the panel from fourteen different points if using landscape model which is flexible as per your design but the design of FALX is giving increasing strength to the support of the panels which eventually reduces the amount of air flow underneath the panels which will be discussed later in this paper.

Fig 1.

The solar panels selected for this project were p-Si 240Wp panel provided by Solon one pair on standard mounting structure and one pair on flat surface mounting structure surrounded from all sides by similar panels on same mounting structure, so as to simulate real conditions for the two panels that we planned to test on this flat surface mounting structure.
The major instrument used in this test is a Daystar Raydec Photovoltaics Multi-tracer RD-3200, This instrument is an integrated measurement system for testing multiple photovoltaics modules under natural or simulated conditions. It is controlled with a MTRACE software controlled with a computer. It has 16 separate isolated inputs of PV modules of different sizes along with separate temperature readings for each input, a total of 6 different pyranometers can be connected along with 8 different temperature sensors that are isolated from the temperature sensors of the channels. It is calibrated from time to time at RAKRIC, along with different temperatures and radiations. It measures Peak-power at fixed voltage and user set voltage, periodic I-V Curve measurements of the attached modules along with PV module voltage, current and temperature thru out the test.
The other major advantage of testing at RAKRIC was it solar radiation weather station, equipped with global, diffused and beam radiation sensors SMP11, SMP11 and EPPLEY NIP mounted on SMT tracker respectively along with unshaded and ambient temperature sensors.

Fig 2.

2.1 Experimental Setup Case 1

In first setup it is a comparison between conventional mounting In the first setup it is a comparison between conventional mounting structure and flat surface mounting structures FALX installed at RAKRIC (25.669°N, 55.781°E) along with a K-type thermocouple attached to their back surface of PV panel using a thermal compound, both of them facing geographic south, Raydec RD-3200 is used to monitor and data log the performance of both these panels.
Both panels are cleaned simultaneously every time before the test starts, the test is conducted in the sunshine hours between 7 AM to 7 PM, the test was conducted over a period of two months twice every week in July and August 2014.

Results and discussion Case 1

As expected the ground mounted PV panel produced more power than the conventional one throughout the testing period as it was July and the lower tilt angel generates more power than the Altitude angle (25°) in summer. Previous study done at RAKRIC clearly shows the difference in power production at different tilt angles on different times of the year as showed in Table 1[4].

Table 1: Optimum Tilt Angle during Months for Maximizing Energy Production [4]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tilt Angle	35°		25°	15°	0°				25°	35°		

Similar behavior was observed in our test results one of the examples is in Fig 3. But the difference in power production was less than what was expected.

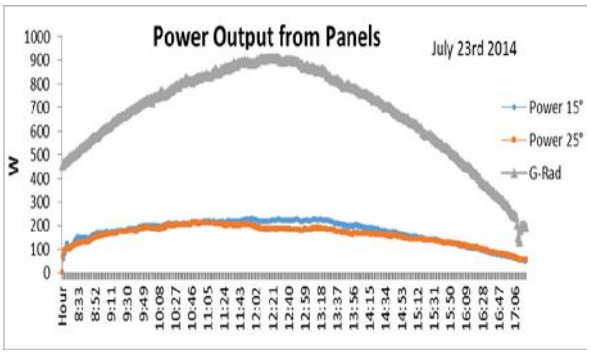

Fig 3. Power Production of Similar Panels at Different Tilts in Comparison to Global Radiation

The ambient temperature was in mid-40's at noon, the expected surface temperature of solar panel is expected to be around 60°C but it was surprising to see such higher temperature readings on the ground mounted panel Fig 4. As it is clear that the ground mounted PV panel was in mid 70's around noon time.

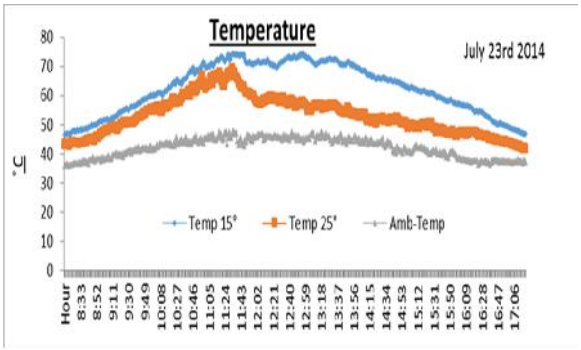

Fig 4. Surface Temperature of PV Panels in Comparison with Ambient Temperature

2.2 Experimental Setup Case 2

In this setup two PV panels were installed on the ground mounting structure along with six dummy panels around it so as to simulate real wind conditions around the tested panels, one temperature sensor was installed on back of each PV panel, Raydec RD-3200 was used in this test to measure maximum power, cell temperature and IV-Curves on different intervals.

Both panels were cleaned at the start of the test, every week the test is repeated as one panel is cleaned before every test and the other remains in its same condition as it was on day one of the test to see the dust accumulation on this panel at lower tilts and on flat ground.

Results and Discussion Case 2

In the first test both panels were cleaned on 19th of August 2014 the maximum power from both panels is given in Fig-5 results are identical.

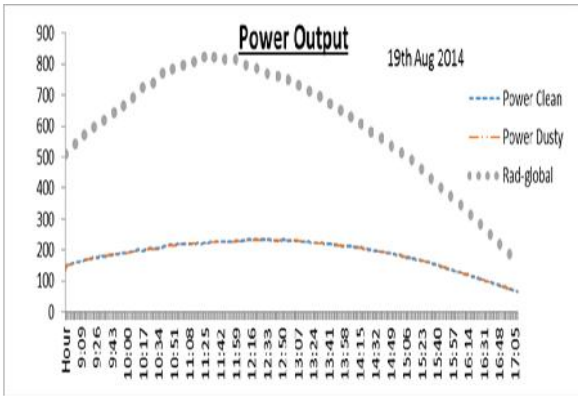

Fig 5. Maximum Power from both Panels in Watts on day one in Comparison with Global Radiation

The temperature readings were also identical on both panels as its clear in Fig 6.

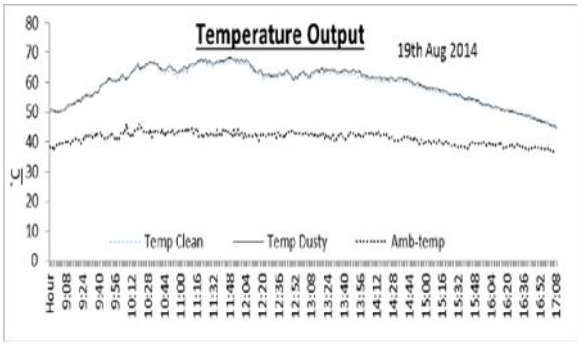

Fig 6. Temperature Output from both Panels on day one along with Ambient Temperature

As of the first test all readings were identical for both panels but as we proceeded the dust effect was reducing the efficiency of the panel faster than expected. As it was clearly observed during the test that the efficiency was dropped significantly within a short period of three weeks Fig 7.

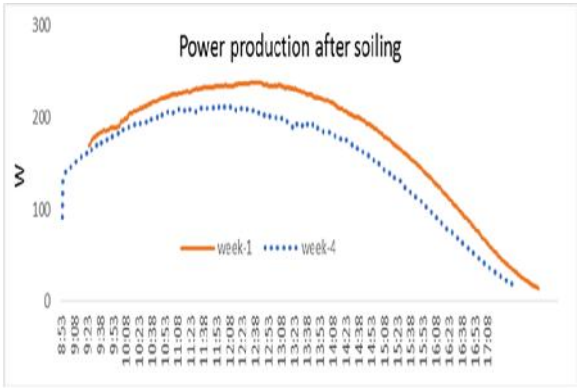

Fig 7. Power Production of Ground Mounted Panel in first week and fourth week

As can be seen in Fig 7 within 3 weeks that the ground mounting structure was reducing power production within three weeks significantly.

Conclusion

For case one it was a comparison of conventional mounting structure and ground mounted structure for similar panels the result clearly shows that the lower tilt angle was producing more power as it was summer time in UAE but the efficiency was very low when compared to former studies for the same tilt in summer time in this region. The reason was clear after visualizing the temperature graph of both the solar panels, the temperature is 10-15 degree higher on the ground mounted structure than the other panel on conventional structure, clearly due to the less air flow underneath the panel and as we know the air velocity profile in this region is not very over whelming. This was a sign of concern as such higher temperatures might damage the panel or might increase the roof temperature of the building if the insulation is not so good, thus the sizing for a system that is planned to be installed on a roof top or on ground should consider these extra losses as they cannot be accurate while calculating cell temperature using simple ambient temperature and Nominal Operating Cell Temperature in an expression Fig 7 which is widely used to estimate the cell temperature [5] the less air flow underneath

the ground mounted solar panels helps in increased panel surface temperature thus reducing the efficiency.

$$T_{Cell} = T_{Air} + \frac{NOCT - 20}{80} S \qquad \text{(Eq. 1)}$$

Eq. 1 formula to calculate cell temperature [6]

This expression Eq. 1 is widely used to estimate the cell temperature but it is only valid for open rack system [7] the use of Installed Nominal Operating Cell Temperature INOCT [8] that also takes in to account the mounting configuration of your system that is connected to the load can be more suitable in this case.

For case two it was a simple test to check if this lower tilt angle of solar panels gathers more dust than usual and specially when they are on ground, so results are very clear that within a short period of three weeks the efficiency was 20% less when compared to another identical panel on similar mounting structure, reason was low wind velocity and plenty of dust particles in the atmosphere.
If I conclude both the results it is clear that the cost of installation of ground mounting PV structure is very low and they save plenty of time but while designing a system using such structures the estimator must consider these extra losses.

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