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Effects of climate change on the Efficiency of Solar cells

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***Abstract*—**Electric power generation around the nation is mainly generated by non-renewable energy sources .These resources will be gone at some time in near future .Photovoltaic systems have shown great success. But performance of these solar cells depend on many factors, temperature, wind, humidity, pollution, dust and rain. Accumulation of dust from the outdoor environment on the panels of solar photovoltaic (PV) system is natural. There were studies that showed that the accumulated dust can reduce the performance of solar panels, but the results were not clearly quantified. The objective of this research was to study the effects of dust accumulation on the performance of solar PV panels. Experiments were conducted using dust particles on solar panels with a constant-power light source, to determine the resulting electrical power generated and efficiency. It was found from the study that the accumulated dust on the surface of photovoltaic solar panel can reduce the system's efficiency .

Introduction

Among all solar energy technologies, the photovoltaic system offer an option because the absorbed solar radiation is converted in electrical energy. Stand alone PV modules are the most common devices that produce electrical generation in present energy scenario. In order to evaluate these types of panels ,a performance analysis must be taken in accordance with the standard test methods available. This can provide information, valuable for designers and manufacturers in the frame of solar PV design and system performance optimization for a particular application. Moreover consumers can also compare the performance and cost effectiveness ratio of a competing product. This field not been investigated extensively in the literature ,only a few references refer to PV module that can be applied to transient weather conditions. Most of them are studies about electrical and thermal performances under steady-state conditions [1–3]. Nevertheless, steady-state outdoor testing includes several difficulties associated with the weather conditions. In many places in the world and over many periods throughout the year, the weather conditions do not fulfill the requirements for the steady-state method and long testing periods may be needed to acquire steady-state values. Dynamic or quasi dynamic characterization methods can offer an effective alternative to overcome these problems. Some representative references regarding quasi-dynamic and dynamic procedures are described below.

Bernardo et al. [4] proposed an empirical model which approaches well the specific electrical power under unstable conditions. However, the specific electrical power predicted by the model showed wider divergences in comparison with the results shown in the thermal part. This system works under concentrated radiation delivered by a parabolic trough reflector. Concentrating PV collector using lenses are also characterized, i.e. the Fresnel concentering system presented by Chemisana et al. [5]. Jie et al. [6] developed a transient method for a hybrid PV collector wall (Building Integrated Photovoltaic–Thermal – BIPVT-type). The system was modeled and simulated with a special program, HYBRIDPV-1.0, written in FORTRAN. A performance analysis of a PV collector by means of an explicit dynamic model was proposed by Chow [7]. The model is suitable for dynamic system simulation applications. The electrical characterization was conducted by using the electric power generated under similar terms as the traditional linear expression for the thermal dependence of the PV electrical efficiency [8]. Using the lineal expression for PV efficiency dependence, Solanki et al. [9] conducted an indoor characterization and modeling of a PV air collector concluding that the results obtained were similar with those obtained outdoors. In addition, the nature of the characteristic curve found out was similar to the one performed by Hottel–Whiller–Bliss for flat plate collector. A deep review about PV collectors was presented by Kumar and Rosen [10]. Zondag et al. [11] developed a simulation procedure for the thermal and electrical yield of a PV/T collector using a 3D dynamical model and three steady state models (3D, 2D and 1D). It was observed that the time-dependent model is required for an accurate prediction of the collector yield if the collector temperature at the end of a measurement differs from its starting temperature. The model proposed requires extensive knowledge of the Runge–Kutta numerical process. The traditional linear expression for PV electrical efficiency was included in the model as well. Concerning the thermal performance, PV collectors have similar behavior with the conventional thermal modules.Since no specific standards exist, the official methodologies available for referring are the same than those for thermal collectors. In this way, discussion regarding steady-state, quasi-dynamic state and dynamic procedures is based on the one stated in a previous study of the authors [12]. This research analyses and proposes a simple dynamic linear model based on the piston flow concept. The main conclusions were that the time period for measurements should be at least one order of magnitude lower than the response time of the linear model. On the other hand, the outlet temperature and the corresponding power delivered by the collector can be calculated from a linear expression involving the average temporary integral of the weather variables. The averaging time must be equal to the linear model response time. In terms of the electrical characterization, a derivation from the classical single diode model expression has been used instead of the basic and wide spread linear method to evaluate the maximum power output in operating conditions. The proposed method offers a much more detailed description of the module behavior under different working conditions, producing results for the characterization, independent of the maximum power point tracker used in the calibration. In the proposed methodology, the characteristic values of the different standards can be analytically obtained. Considering the different aspects pointed out previously, the present research defines a PV/T characterization method based on the quasi-dynamic method [13] and the derived single diode model presented in [14–16]. In addition, the quasi-dynamic procedure is complemented taking into consideration the results obtained in Ref. [13]. The paper aims at obtaining a suitable PV model which better reflects the thermal and electrical behavior of the collector under stationary and transient conditions. The results are presented in two parts: (i) theoretical, (ii) experimental.

Experimental setup

The photograph of the solar PV solar cell is shown in Fig. 1. The orientation of solar PV module was kept in the due south during the experimentation to harness the maximum incident solar radiation. The PV module is inclined with25^{o}

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Fig 1: Photograph of the Experimental set up

Instrumentation

The solar radiation measured on the inclined surface of the PV module with the help of HTC LX 107 model solar power meter having experimenting accuracy ±10 W/m^2 and measuring range of 0–2,000 W/m^2. Calibrated digital hygrometer is used to measure the temperature and relative humidity and ambient tempreture. The measuring accuracy and range for measurement of relative humidity are ±5 and 30–79 %;

±1o and 0–70 ^{0}C are the measuring. Ground temperature was recorded with the help of infrared thermometer non-contact gun type having accuracy and precision ±2 % and

0.2 ^{0}C respectively. Air speed is measured with the help of anemometer probe having resolution and range are 0.1 and 0.2–60 m/s respectively.

Experimentation

The experiments were conducted in no-load condition on 14-15 June 2022 on the site of Bhilwara located at 23.33 ^{0}N latitude and 74.60 ^{0}E longitude . Experiments were conducted only during the day time hours from 10 a.m. to 5 p.m.

Result and Discussion

After construction of the solar module, it was tested. The analysis was carried out such as solar radiation intensity, relative humidity, wind velocity, ambient temperature and cell temperature. First day (Day 1) of experimentation was found to be the clear sky conditions and on second day (Day 2), the weather was hazy and partly cloudy condition. The variation of these five parameters were observed hourly basis during experimentation and it is presented in Fig 2-8 Fig. 2.3 depicts the variation of solar radiation with respect to time. It shows that the maximum solar intensity was 920 W/m^2 and 650 W/m^2 for day 1 and day 2 of experimentation.

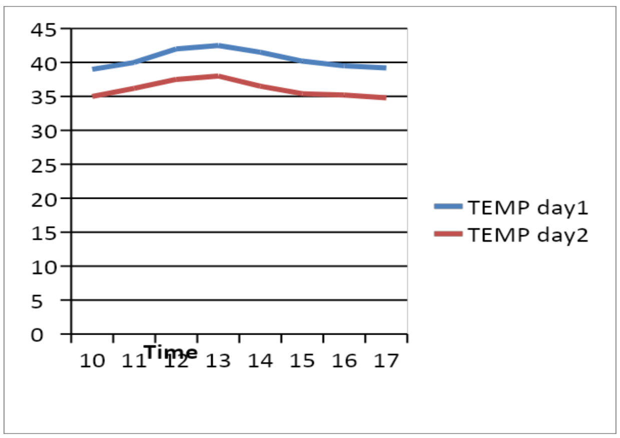

Fig 2.2: Variation of Ambient Temperature

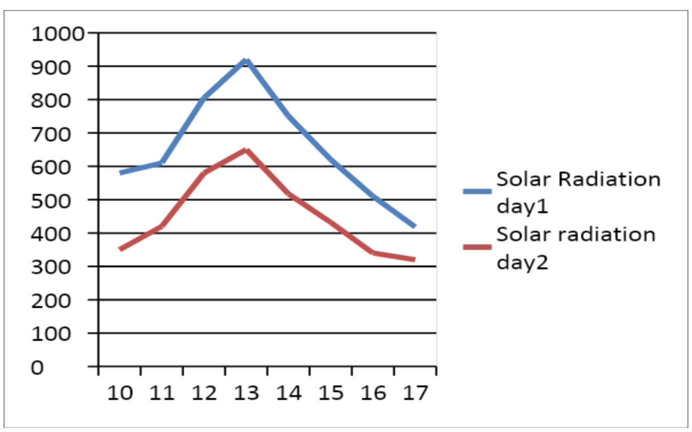

Fig 2.3: Variation of Solar radiation

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Fig 2.2 shows the variation of ambient temperature on the both day of experimentation. On the day of clear sky, which is day 1 is found to be always greater temperature than cloudy and hazy weather conditions. The average ambient temperature on day 1 is 43.65 ^{0}C and 35.25 ^{0}C for day 2 respectively.

Fig 3.1 shows the variation of ambient relative humidity of day 1 and day 2 respectively. The average ambient relative humidity is 20.95 % for day 1 and 35.58 % for day 2 respectively. It is found that day 2 have higher ambient relative humidity as compared to day 1 of the experimentation. Fig 3.2 demonstrates the variation of ambient wind velocity. It is observed that day 2 of experimentation having higher wind velocity as compared to day 1. The range of wind velocity on day 1 is 0.5-2.1 m/s for day 1 and 1.8-2.5 m/s for day 2 respectively

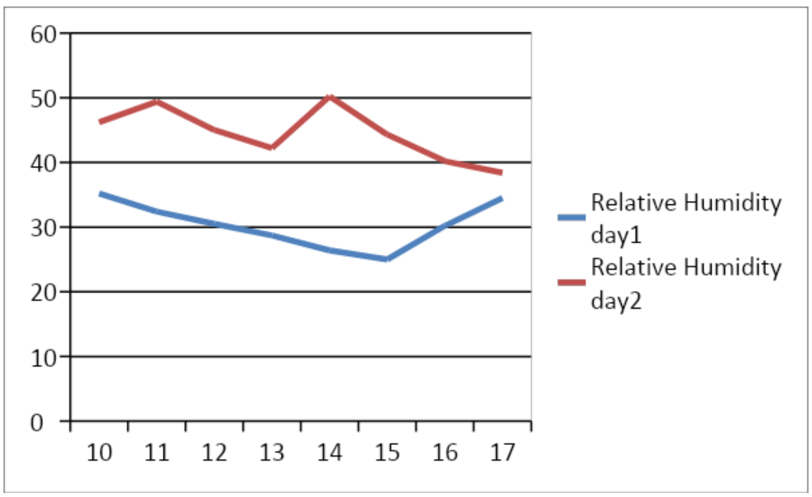

Fig 3.1: Variation of Solar relative humidity

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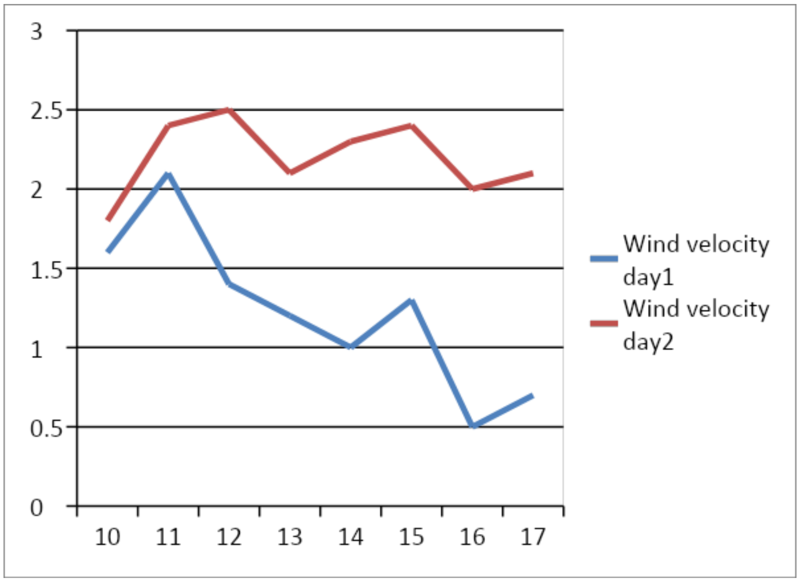


Fig 3.2: Variation of Solar wind velocity

Fig 4.1 shows the variation of the cell temperature of the solar module. Due to clear sky conditions on day 1, cell temperature is always found to be the higher than the day2. The higher cell temperature decreases the efficiency of the solar panel. The variation of cell temperature on day 1 is 40.4-61.4 ^{0}C for day 1 and 36.5-55.5 ^{0}C for day 2 respectively

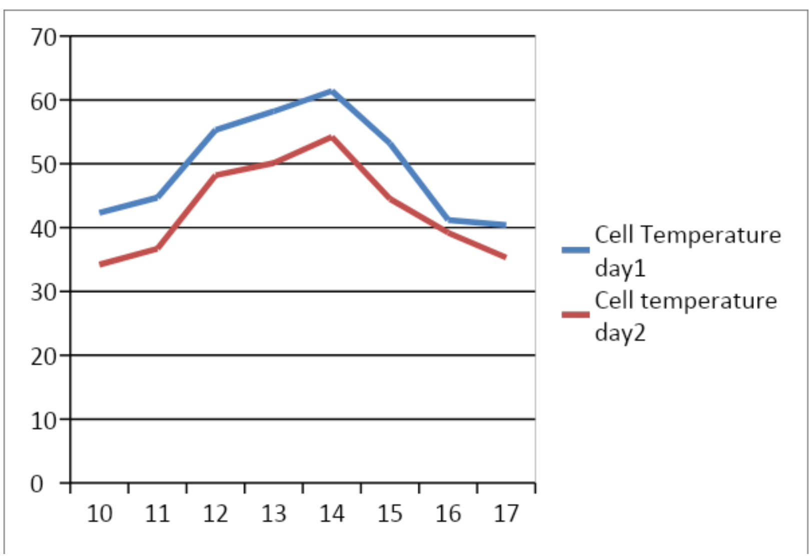


Fig 4.1 Variation of cell temperature

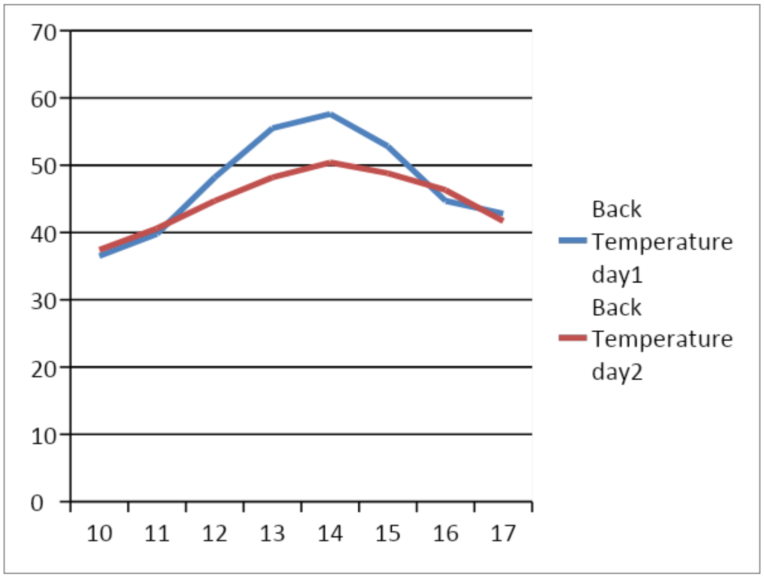
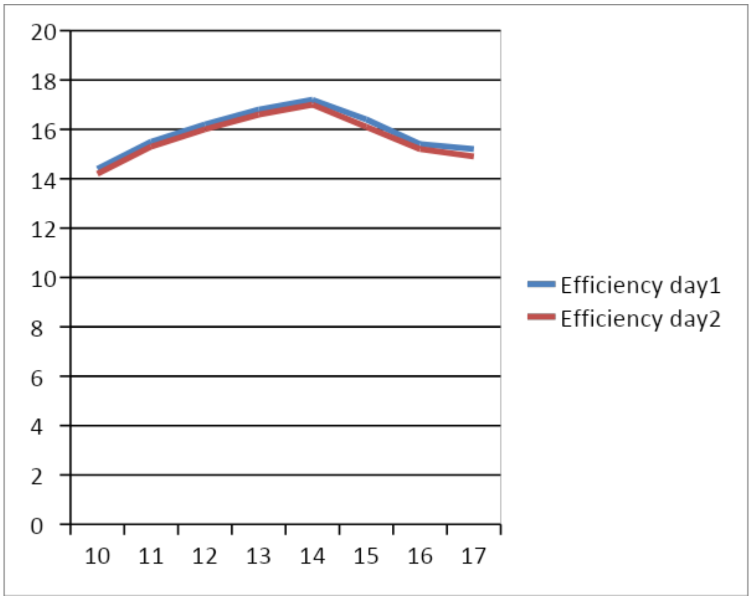


Fig 4.2 Variation of Back cell temperature

Fig 4.2 shows the variation of the back cell temperature of the solar panel . Due to clear sky conditions on day 1, back cell temperature is found to be higher than the day 2. The higher back cell temperature decreases the efficiency of the solar panel

. The variation of back cell temperature on day 1 is 36.5-57.6 ^{0}C and 37.4-51.6 ^{0}C for day 2 respectively

Fig 5 shows the variation of the Electrical efficiency(%) of the hybrid solar air collector. Due to clear sky conditions on day 1, electrical efficiency found to be higher than the day 2. The higher back cell temperature decreases the efficiency of the solar panel. The variation in electrical efficiency on day 1 is14.4 to- 17.2 and 14.2-17.0 for day 2 respectively.



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Conclusion

The study can be used to provide the design and testing data for this type of solar panal in other locations of the country. It is observed that the electrical performance of the system is higher when the design parameters such as cell temperature and back cell temperature are lower and there is a significant increase is found in the electrical efficiency in the clear sky conditions as compared to cloudy and partially hazy weather conditions. Climatic parameter like global radiation and wind velocity also affects the performance of the system. In order to increase the efficiency of the solar cell, suitable modification can be applied in the panal to provide proper cooling.

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