FACULTY OF ELECTRICAL ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FINAL YEAR REPORT

EFFECTS OF DUST AND TEMPERATURE TO THE PERFORMANCE OF SOLAR PV SYSTEM

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Bachelor of Electrical Engineering (Industrial Power)

May 2014

"I hereby declare that I have read through this report entitle "Effects of Dust and Temperature to the Performance of Solar System" and found that it has comply the partially fulfilment for awarding the degree of *Bachelor of Electrical Engineering (Industrial Power).*

Signature : ____________________________

Supervisor's Name : ____________________________

Date : ____________________________

EFFECTS OF DUST AND TEMPERATURE TO THE PERFORMANCE OF SOLAR SYSTEM

TIONG LEE UNG

A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle "Effects of Dust and Temperature to the Performance of Solar PV System" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________

Name : ______________________

Date : ______________________

To my beloved mother and father

ACKNOWLEDGEMENT

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ABSTRACT

There are dust and temperature have influencing the energy performance of the photovoltaic system (PV). The outcome of this experiment is based on the mono-crystalline PV panel of Sunmodule SW185, manufactured by Solar World with nominal output power 185 W and dimension 1610 x 810x 34mm. Electrical parameter likes open circuit voltage, short circuit current, temperature and irradiation have been recorded to the various situation. The experiment have been carry on clean solar PV panel, PV panel with present of dust and wind velocity effect on temperature of module. The calculated output power and percentage of power loss have been calculated among the clean module and the present of dust. 35g of dust have a highest percentage of power loss compared to the 25g and 30g dust. The wind velocity have been measured by using wind sensor. The efficiency of mono-crystalline module for combine of two climatic parameters (temperature and wind velocity) had be defined. The increase of wind velocity have increases the efficiency while increases of temperature have decreases the efficiency of the PV system.

ABSTRAK

Habuk dan suhu telah mempengaruhi prestasi tenaga sistem photovoltaic (PV). Hasil daripada kajian ini adalah berdasarkan kepada panel PV mono-kristal daripada *Sunmodule* SW185, yang dibuat daripada *Solar World* dengan keluaran nominal kuasa 185 W dan dimensi 1610 x 810x 34 mm . Parameter elektrik seperti voltan litar terbuka , litar pintas semasa, suhu dan penyinaran telah direkodkan dalam pelbagai keadaan. Eksperimen telah dijalankan dengan solar PV panel yang bersih, solar PV panel yang berhabuk dan kesan halaju angin pada suhu modul. Kuasa keluaran dikira dan peratusan kuasa kehilangan telah dikira antara modul yang bersih dan berhabuk. 35g debu mempunyai peratusan kuasa kehilangan yang paling tinggi berbanding dengan 25g dan 30g habuk. Halaju angin telah diukur dengan menggunakan sensor angin. Kecekapan modul mono-kristal untuk menggabungkan dua parameter iklim (suhu dan halaju angin) telah ditakrifkan. Peningkatan halaju angin telah meningkatkan kecekapan manakala peningkatan suhu telah mengurangkan kecekapan sistem PV.

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LIST OF ABBREVIATIONS

A	-Cross sectional area of PV module
a-Si	-Amorphous silicon
a-SiSJ	-Single junction amorphous silicon
c-Si	-Crystalline silicon
CdTe	-Cadmium telluride
CIGS	-Copper indium/ gallium disulfide/ diselenide
G	–Irradiation
MPP	-Maximum
Isc	-Short circuit current
P	-Output power
PV	-Photovotaic
SEM	-Scanning Electron Microscope
TCO	- Relative temperature coefficients
Voc	-Open circuit voltage
μc-Si	-Microcrystalline silicon
Θ	-Angle
η	-Efficiency
V	-Wind velocity
T	-Temperature
η_2	-Calculation efficiency

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, the non-renewable resource have been nearly used out and it is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human timeframes. When humans burn diesel, gasoline and other photo-organic materials it releases energy which can be used to power vehicles, homes and businesses but it also releases pollutants that harm the environment and our health [1]. Therefore, renewable energy has been created which are continually replenished on a human timescale such as solar, hydro, geothermal, biofuels, biomass and wind. These all renewable resources have replaced non-renewable energy for generated energy at certain condition to avoid the huge pollutant that produces by non-renewable energy [2].

Figure 1.1 shows the solar PV module. Solar photovoltaic modules or panels are used because it have many advantages to human. Firstly, it produce DC electricity and can be charge storage batteries with environment friendly, no pollutants and free noise. It is light weight and can be easily transported and installed. It is a flexible sources if small amounts of electrical power and can be produced from milliwatts to megawatts at the place of demand while avoiding transmission. Besides that, PV requires low maintenance by checking the electrical wiring, cleaning the module surface, topping up the batteries and others [3].

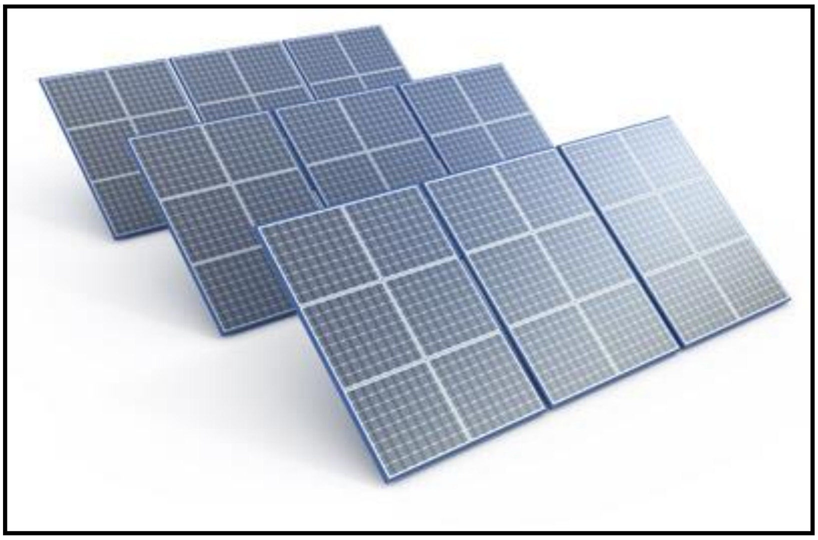

Figure1.1: Solar PV module.

Even PV system can generate energy but there also have several factors will decreases the output energy. The temperature on the PV module also decreases the output energy and efficiency. The voltage will significantly decreases with an increase in module temperature while the current increase with increasing temperature [4]. Besides that, the dust on the PV module also will decrease the irradiant pass through the module. The dust that covered on the PV module will cause the decreases of the output power [5].

Photovoltaic bring many benefits to human which is environment friendly, no pollution and free noise energy. Therefore, this project is carrying out to investigate the effect of the dust and temperature on the PV module. So that, the ways to solve the effect of dust and temperature can be carry out to improve the energy of PV panel. With the higher efficiency produced by the PV system, these renewable resources can replaced non-renewable energy for generated energy to avoid the huge pollutant that produces by non-renewable energy.

1.2 Problem Statement

The development and research on efficiency in photovoltaic (PV) systems has usually been concentrated on design the sizing of the panel, radiation availability and the operating strategies that influence the efficiency of PV panel. There does not have analysis of the dust and wind velocity effect the temperature on the solar PV system. In this work, the influence of dust and temperature coefficient are studied experimentally on the energy efficiency of the PV installation in the UTeM. The experiment data are used for the calculation are energy efficiency among the wind velocity and temperature, percentage of power loss due to the layer of dust and output power of the PV system. With improvement energy due to dust and temperature, the payback period of PV system in UTeM will decrease and the PV panel will not break down easily by cracking through overheat and dust. UTeM also can save fund from the electricity and used for other beneficial areas.

1.3 Objective

- To investigate the issue of the dust on the efficiency UTeM PV system.
- To investigate the issue of the temperature on the efficiency UTeM PV system.
- To obtain calculated efficiency among wind velocity and temperature for UTeM PV solar system.

1.4 Scope

The outcome of this experiment is based on the mono-crystalline PV panel of model Sunmodule SW 185, manufactured by Solar World with nominal output power 185 W and dimension 1610 x 810x 34mm. This experiment will include the issue of dust and wind velocity to the temperature but not cover the incident angle of the panel, shadow, and etc. The electrical parameters which recorded is open circuit voltage(V_{oc}), irradiation (E), short circuit current (I_{sc}), wind velocity(V) and temperature (T). The output power, percentage of power loss and efficiency will calculated.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and basic principles

In 1839 with Alexandre Edmond Becquerel, a 19 years old French scientist submerged two brass plates in a conductive liquid. Then he shined a light on the plates and discovered that it generated an electrical current. This process is called as photovoltaic effect. By the 1970s, leading energy scientist and business professionals began to realize the many uses of PV in earth. Every day the sun delivers energy to the earth free of charge and is a renewable energy. Photovoltaic (PV) panels are familiar now and it is a method of generating electrical power by convert the solar irradiant into direct current electricity [6].

Figure 2.1 shows the solar energy flow from sunlight into electricity. From the Figure 2.1, solar power is generated by using the sunlight converted into the electricity. There are two main types of solar energy technologies which are solar thermal and solar photovoltaic (PV). Solar thermal is the conversion of the irradiation and heat energy that can carrier by the air, water or fluid to generate electricity using steam and turbines while solar photovoltaic converts sunlight directly into electricity through photovoltaic cells. Photovoltaic system can be installed on rooftops, ground mounting, tracker, and can integrated into building design and vehicles [7].

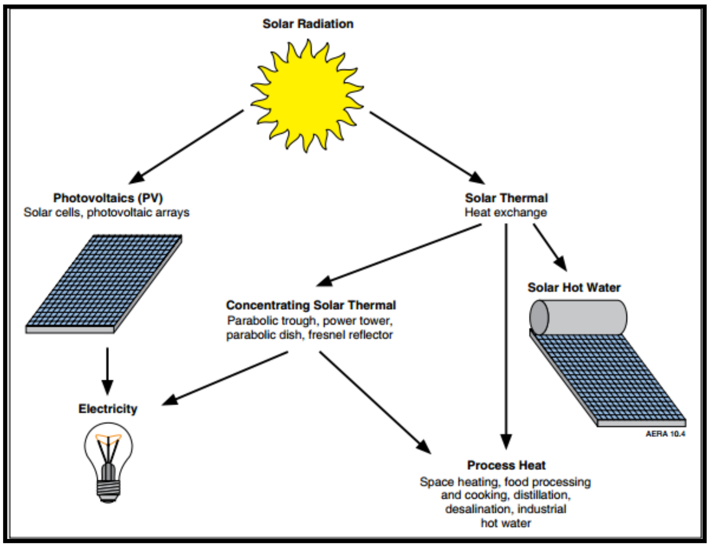

Figure 2.1: Solar energy flow [7].

Table 2.1 shows the cells made from different materials have different efficiencies. From the Table 2.1, there are few types of solar PV such as single crystalline silicon, poly-crystalline silicon cell, amorphous silicon cells and thin film. Thin film cells made from cadmium telluride (CdTe), copper indium/ gallium disulfide/ diselenide (CIGS), amorphous silicon (a-Si) and amorphous/ microcrystalline silicon (a-Si/ μc-Si). Thin film have been investigated with the aim of producing cost-effective and efficient solar cells [8]. There are few factors that will influencing the energy production of PV system such as dust, temperature coefficient, angle of incident, cumulative solar irradiance, humidity and others [9].

Table 2.1: Cells made from different materials have different efficiencies [8].

Cell material	Module efficiency	Surface area need for 1 kWp
Monocrystalline silicon	13–19%	5–8 m²
Polycrystalline silicon	11–15%	7–9 m²
Micromorphous tandem cell (a-Si/μc-Si)	8–10%	10–12 m²
Thin film copper-indium/gallium-sulfur/ diselenide (CI/GS/Se)	10–12%	8–10 m²
Thin-film cadmium telluride (CdTe)	9–11%	9–11 m²
Amorphous silicon (a-Si)	5–8%	13–20 m²

Figure 2.2 shows the temperature coefficient of the output power in MPP. Temperature coefficient is to determine the corrected outputs values of the modules when operating at the different climate condition. From the Figure 2.2, the output drops steadily when increasing of the temperature. Coefficient of current is small positive number which the current output increases marginally with increasing temperature. For the coefficient of voltage is bigger negative number which the voltage output decreases significantly with increasing temperature. Crystalline module (cSi) showed the highest dropping of the output power compared to the others. Thin film modules have a high proportion of diffuse insolation due to temporary cloudy weather or shading [8].

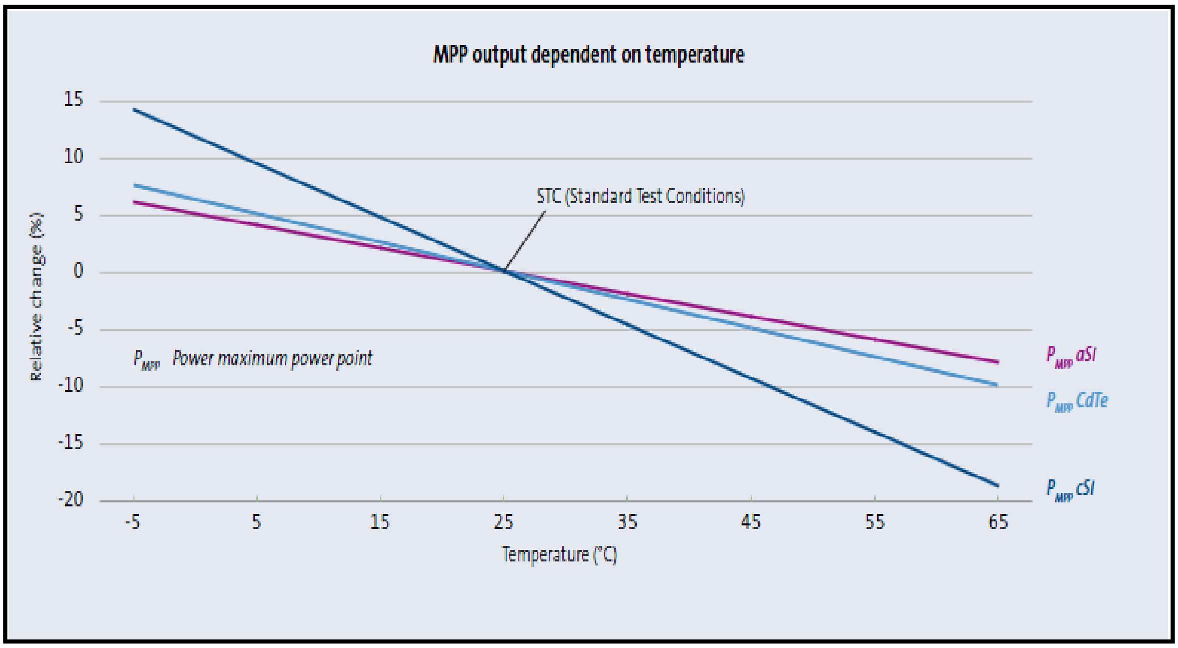

Figure 2.2: Temperature coefficient of the output power in maximum power point (MPP) [8].

Figure 2.3 shows the I-V curve of crystalline silicon solar cell. From the Figure 2.3, the open circuit voltage (Voc) is around 0.5V and the short circuit current (Isc) is 3 A. The voltage is about 80% of the open circuit voltage and the current is about 95% of the short circuit current at the maximum point (MPP) [8].

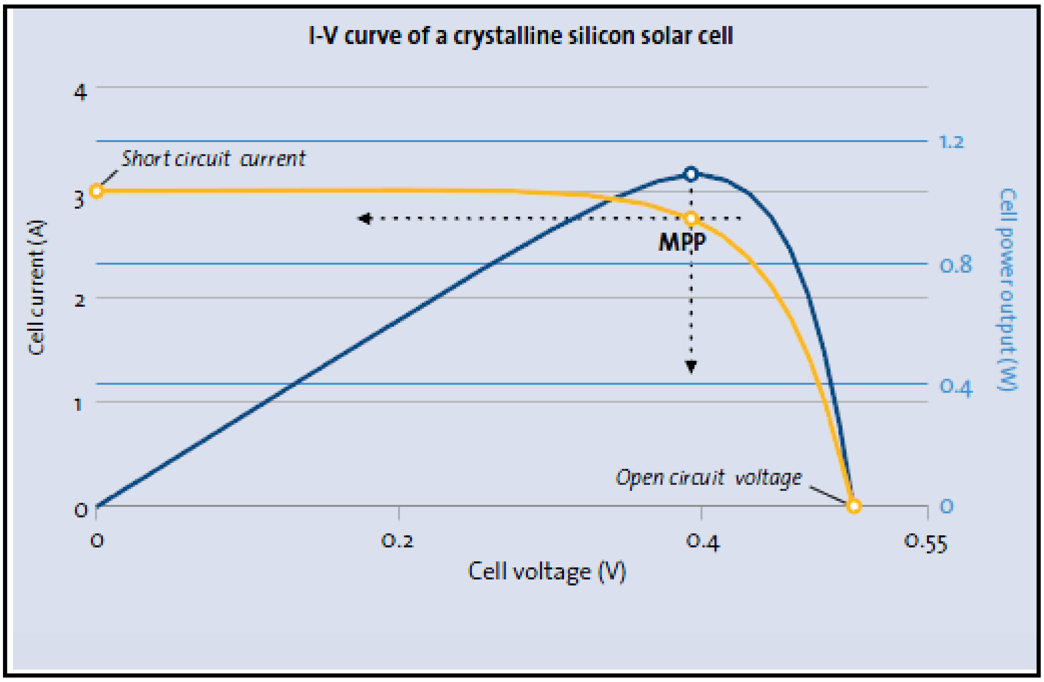

Figure 2.3: I-V curve of crystalline silicon solar cell [8].

Figure 2.4 shows the dusty solar panel while Figure 2.5 shows the clean solar panel. From the Figure 2.4, it can seem that the dust have cover the surface of the solar panel that have block the sunlight toward to the panel. From the Figure 2.5, it can seem that there are no dust on the surface PV panel which is clean and clear. Dust consists of tiny solid particles carried by air and these particles are formed by disintegration of a solid into small particle through grinding, crushing or others. Normally dust is measured by the mircometers and the dust which carry by wind that will covered on the solar panel naturally. The thickness of the dust will be increasing with the time and it will acts as a barrier between the solar panel and the sun rays. The dust will affect to the photovoltaic panels by blocking the cells from the sun's rays or the tracing sensor have been covered by dust [10]. There are few factors influencing dust settlement which are the tilt-angle and orientation of PV system, wind velocity, dust properties and others [11].

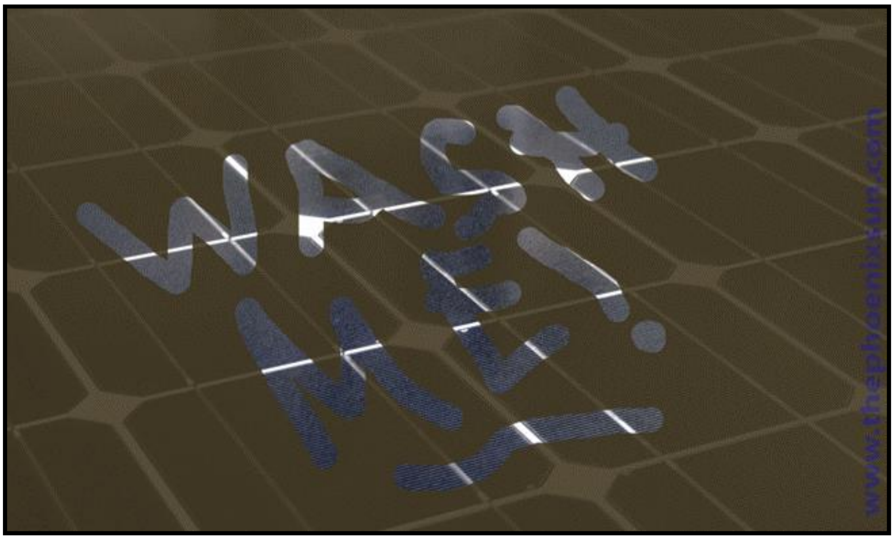

Figure 2.4: Dusty solar panel.

Figure 2.5: Clean solar panel.

Figure 2.6 shows the graph of Isc versus time for dust and clean panel. Based [10] and Figure 2.6, effects of natural dust on the performance of PV panel in Bangladesh, the short circuit current of clean panel is greater than the Isc of the dusty panel. Therefore, the output power of the PV module with dust will lower than the clean module [10].

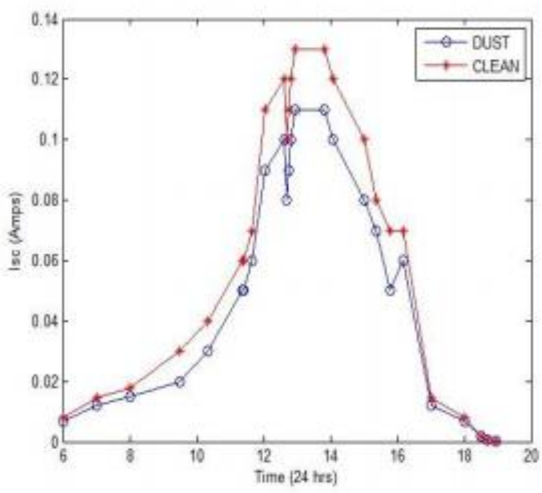

Figure 2.6: Graph of Isc versus Time for dust and clean panel [10].

2.2 Review of previous related works

Energy losses due to accumulated dust on the surface of photovoltaic modules. In a rain fall period, the rain water cleans the dirty solar PV panel and it can help the panel recover to its normal performance. Even it is a light rain, which below 1mm, it is enough to clean up the dust on the surface of the PV panel. The long period that without rain like summer the accumulation of dust can cause daily losses exceeding 20%. The dust caused irradiance losses also depend on the angle of incidence. From the result, the dust caused irradiance losses will increases with angle to a maximum angle, ϴ=75° then will decreases for larger value of ϴ. This happen because the diffuse radiation. In addition, there have a simulation ray-tracing technique have been carry out to explain the behavior of the losses in solar irradiance due to the present of the dust. In this model, diffuse radiation is taking in order to understanding the full behavior of losses to the angle of incidence. The model will produces a nice shape of the experiment data for reasonable values of the input parameters when the diffuse radiation is take into calculation. The energy losses with present of dust on the PV module need calculated in a different way for a system with a fix PV module or with the tracking. Besides that, when estimating the energy losses to the dust on module, the diffuse component in the global radiation needed to be taken into account [12].

The effects of the temperature on photovoltaic modules can be determined by using basic equation a relation between efficiency, sun radiation and the temperature. The changing of the temperature will affect the output power of a modules. The voltage will decreases when increasing of the temperature and an increases in temperature will decreases the voltage. In cloudy climate, the effect of temperature on efficiency of PV module have been determined. The result shown clearly that efficiency of the module decreases when temperature is increases [4].

In other experiment, it have showed that the important of the optimal mounting PV module to achieve an efficient cooling on the PV modules. It have concluded that freestanding and flat roof mounted system have the lowest rise in temperature. An airflow is needed on a slope roof systems between the roof and module to decreases the temperature. For the integrated façade system, a high degree of sophistication is required to get sufficient cooling of the module [13].

2.3 Summary and discussion of the review

The dust on the PV module affect the output power and efficiency of the PV module. The weather and angle of incidence also to be consider when collecting data of the solar PV module with present of dust. Raining day can clean up the dust on the surface of the PV module and recover the energy performance. When temperature increase, the voltage and current will affected. Voltage will decrease while current will decrease when increasing of the temperature on the panel. Therefore, output power and efficiency also will be affected by changing of the temperature. A freestanding and flat roof mounted system will have the lowest rise in temperature compared to other mounting structure. Electrical parameter like open circuit voltage, short circuit current, irradiation and temperature needed to measure to quantify the effect of dust and temperature on the PV module.