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Full Length Research Article

THE EFFECT OF SOLAR IRRADIATION ON SOLAR CELLS

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ABSTRACT
Photovoltaic systems have been increasingly used in the generation of electrical energy, either as a means of providing electricity in areas where there is no grid connection (stand-alone systems), or by providing electricity to the grid (grid connected systems). In a deregulated energy market, the cost of energy produced from fossil fuels is rising and the photovoltaic energy becomes a promising alternative source. Yet it still suffers from problems that need to be resolved in order to be widely accepted as an equivalent alternative to fossil fuels. Firstly the more direct problem of efficiency and cost needs to be overcome and secondly the indirect problem of the quality of power provided by photovoltaic technology has to be addressed. In this work, the effect of irradiation of solar cell is studied, data were collected experimentally, a total of 28 data were collected in 14 days, and Microsoft Excel software was used to analyse the data. The effect of solar irradiation on solar cells was studied, and the irradiance pattern through the specific color spectrum was determined.

INTRODUCTION
Irradiation is the measure of energy density of sunlight and is measured in kWh/m^{2}and is the integral of irradiance since the energy is integrated over time. It is often expressed as peak sun hours (psh). The psh is simply the length of time in hours at an irradiance level of (1kW/m^2) needed to produce the daily irradiation obtained from the integration of irradiance over all daylight hours. The irradiation data is important to estimate how much solar energy is available. Most solar energy technologies rely on it to provide energy, as well as used it for modelling ad design related device or system like photovoltaic (PV) system (Al Riza *et al.,*2011). Spectrum analysis is amongst the most useful techniques in modern science used in many disciplines like astronomy, geology, medicine and solar system (Turpin, 1981). The modeling of the clear sky irradiance components of solar radiation is necessary in many applications of solar energy like systems design and simulation, control process of the accuracy of radiometers, data quality control, gaps filling process, as well as in routine engineering practice like the peak cooling load of buildings is determined for a hot, cloudless, summer day.

Furthermore, the effects of the cloud generally induce most of the variability and uncertainty in radiation calculations, years of hourly data are necessary to constitute a valid reference data set whenever a general assessment covering all types of sky conditions is needed.
Irradiation solar spectrum is a method to recognize the pattern of the solar irradiation throughout the day. The instrument used measured the spectral irradiance in units of watts per meter squared over the wavelength range in nanometers. This has helped a lot of researchers to monitor the irradiation level. However due to so many data of irradiance in a day, the specific analysis of the irradiance pattern is time consuming (Karim *et al.,* 2010). Furthermore, in order to obtain energy at certain level, manual calculation is needed. It leads an increase of the time taken to analyse. Moreover, problem may occur on how to read the irradiance level on the system due to the same color for all data. Therefore, for the better understanding of the irradiation pattern, a method of solar irradiance labeling using color contour approach is developed.

The aim of this research is to study the effect of solar irradiation on solar cells through experimental measurement. Its measurable objectives is to study the effect of solar irradiation on solar cells, as well as to determine the irradiance pattern through the specific color spectrum. If the current and the voltage of a solar cell can be obtained, then the Power of the solar cell at any point can be calculated using:

$$P = IV \quad (1)$$

Where; P = power in watt (W), I = current in Ampere (A), V = voltage in volt (V)

Solar Irradiance
The design of a photovoltaic system relies on solar radiation at a particular site. Irradiance is the measure of the power density of sunlight or the total power from a radiant source falling on a unit area. The solar constant for Earth is the irradiance received by Earth from the sun through the atmosphere (Karim *et al.,* 2011).

$$S = E/(4\pi R^2) = 1370 \text{ W/m}^2 \quad (2)$$

Where: E=is the Sun total power = 3.9×10^{26}W, R= is the average earth/sun distance = 1.5×10^{11}m.

Whilst, the irradiation is the measure of energy density of sunlight and is measured in kWh/m^2. Irradiation is the integral of irradiance since energy is integrated over time.
The total irradiance of typical solar spectrum on the earth surface on a clear day is 1 kW/m^2 (Zaharim *et al*., 2009). However, the availability of the irradiance usually considerably less than 1 kW/m^2 due to the rotation of the earth and due to the weather condition. On a sunny day, the irradiance is higher than the rainy day. The condition for higher irradiance is when the direct solar radiation is not blocked by clouds, which is the combination of the bright light and radiant heat The term ‘sunshine duration’ has been used to indicate the cumulative time during which an area receives direct irradiance from the Sun of at least 120 watts per square meter by World Meteorological Organization (Al Riza, *et al.,* 2011). Cloudy is the condition that happens when sun is blocked by the clouds or reflects off part of it, which is

experienced as diffused light. On a rainy day the amount of solar radiation available during a rainy day is drastically reduced compared to the sunny day.

Solar Irradiation Modelling

A research about the potential of wind and solar energy in Malaysia East Coast have been done to monitor solar radiation and solar energy over a year period (Wang *et al.,* 2010). I this research work, the measuring equipment was installed on the tallest building at Pekan, University Malaysia Pahang.

In order to calculate global solar irradiance, a research paper solar energy prediction method using Artificial Neural Networks (ANNs) has presented used to predict a clearness index (Karim, et al. 2011). The ANN model is based on the feed forward multilayer perception model with four inputs and one output. The inputs are latitude, longitude, day number and sunshine ratio while the output is the clearness index.

Solar Cell Operation

The photovoltaic (PV) effect is the direct conversion of light into electricity in solar cells. When solar cells are exposed to sunlight, electrons excite from the valence band to the conduction band leaving behind holes. In one PV cell, the upper or n-type layer is crystalline silicon doped with phosphorus with 5 valence electrons while the lower or p-type layer is doped with boron, which has 3 valence electrons. By bringing n and p type silicon (semiconductors) together, a p-n junction serves for creating an electric field within the solar cells, which is able to separate electrons and holes and if the incident photon is energetic enough to dislodge a valance electron, the electron will jump to the conduction band and initiate a current coming out from the solar cells through the contacts (Shuanghua, 2010). Figure 1 shows this process.

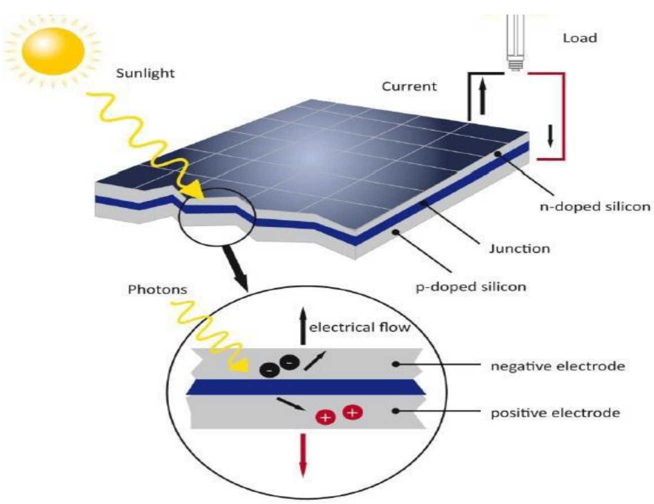

Figure 1. Solar cells working principle (Source: Renewables in Africa).

Effect of Installation Location, Orientation, and Tilt of Solar Cells

The orientation and tilt of the photovoltaic panels determine the amount of light intensity that the panel surface receives. If the panels are installed in northern hemisphere, they must be oriented facing south, also facing north in the southern hemisphere. In regions near the equator, the orientation is not considerable but a minimum of 10 degree tilt is necessary for that evacuate water in rain condition. The optimum tilt angle of panels depends on installation location. As a general rule, Tilt of panels should be equal to the latitude minus 10 degrees (Wang, *et al.,* 2010). Figure 2 shows different direction and tilt angle and the proportional amount of light intensity received on each surface panel in comparison to an optimum of 30° and facing south.

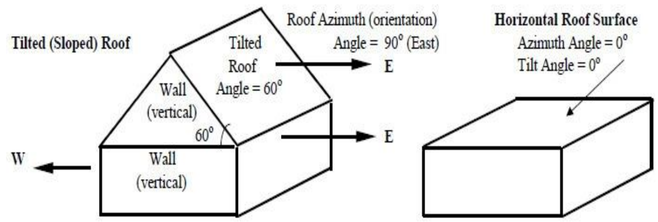

Figure 2: Orientation (Azimuth) and direction (http://energy-models.com/azimuth-angles-building-surfaces).

Data Collection Procedure

The materials used for data collections are; Digital thermometer, Digital volt meter, Solar panel, and Stop watch. A total of 28 Data were collected experimentally in 14 days, and the field procedure for the data collected is as follows.

1- Place the solar panel in the sun for at least one hour to determine the voltage and current.

2- A digital voltmeter is used to measure the parameters of the solar panel by connecting the positive and negative terminals of the voltmeter to the solar panel.

3- Select the range of the volt meter to 20V range to get the accurate voltage.

4- Place a digital thermometer in sun light for 1min to determine the actual/accurate temperature.

5- All the result collected from the entire experiment is tabulated in table 1.

RESULTS AND DISCUSSION

In this research, results from power quality observations obtained at a grid connected PV site with latitude 10° 30' 58.93" N, and longitude 7° 27' 03.98" E, measurements from the PV systems are carried out for 14 days. Data collected from the grid connected PV site under test have been analyzed, and evaluated to observe the overall effect of solar irradiance on the operation of the grid connected systems under test. Results for two different scenarios have been considered, namely, "average" and "low" irradiance and the effect of the solar irradiance on the power quality measurements have been investigated. It has been found that low solar irradiance has a significant impact on the power quality of the output of the PV system. The goal achieved via this study is the investigation of the influence of the ambient temperature and solar radiation changing effects on the system performances. Normal day, for normal functioning mode, all figures show a good concordance and similarity between the experimental and the simulated system. From the result obtained and analysis of data obtained experimentally, solar irradiation has effect on solar cells, the irradiance pattern through the specific color spectrum was determined.

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Table1: Data collected in week one and week two.

Date	Time	Temperature	Voltage(V)	Current(I)	Power (W)
Week One					
02/11/2016	9:00am	33.5ºc	6.91 v	500MA	3.455 w
Wednesday	4:00pm	38.4ºc	6.74 v	500MA	3.37 w
03/11/2016	9:00am	33.9ºc	6.95 v	500MA	3.475 w
Thursday	4:00pm	38.9ºc	6.82 v	500MA	3.41 w
04/11/2016	9:00am	34.0ºc	7.06 v	500MA	3.53 w
Friday	4:00pm	38.2ºc	6.88 v	500MA	3.44 w
05/11/2016	9:00am	34.4ºc	7.06 v	500MA	3.53 w
Saturday	4:00pm	38.3ºc	6.79 v	500MA	3.395 w
06/11/2016	9:00am	33.6ºc	7.09 v	500MA	3.545 w
Sunday	4:00pm	36.3ºc	6.94 v	500MA	3.47 w
07/11/2016	9:00am	33.3ºc	7.00 v	500MA	3.5 w
Monday	4:00pm	36.1ºc	6.82 v	500MA	3.41 w
08/11/2016	9:00am	34.5ºc	7.06 v	500MA	3.53 w
Tuesday	4:00pm	38.2ºc	6.77 v	500MA	3.385 w
Week Two					
09/11/2016	9:00am	36.0ºc	7.01 v	500MA	3.505 w
Wednesday	4:00pm	37.30ºc	6.94 v	500MA	3.47 w
10/11/2016	9:00am	33.7ºc	7.06 v	500MA	3.53 w
Thursday	4:00pm	38.90ºc	6.76 v	500MA	3.38 w
11/11/2016	9:00am	34.2ºc	7.04v	500MA	3.52w
Friday	4:00pm	38.3ºc	6.77v	500MA	3.385w
12/11/2016	9:00am	34.1ºc	6.93v	500MA	3.465w
Saturday	4:00pm	38.4ºc	6.78v	500MA	3.39w
13/11/2016	9:00am	33.7ºc	6.69v	500MA	3.48w
Sunday	4:00pm	36.5ºc	6.62v	500MA	3.31w
14/11/2016	9:00am	33.7ºc	7.04v	500MA	3.52w
Monday	4:00pm	36.8ºc	6.61v	500MA	3.305w
15/11/2016	9:00am	33.8ºc	7.05v	500MA	3.525w
Tuesday	4:00pm	36.9ºc	6.59v	500MA	3.295w

Figure 3 is a graph of voltage against power, where the blue pattern represents the reading of the voltage (V) in the solar panel for seven days, while the red pattern represents the reading of power in the solar panel obtained for seven days. Both the blue pattern and the red pattern show a point of lower and higher voltage output in different point in time, indicating that the more the irradiance the more the power that is store, satisfying the working condition of a normal working solar panel. From Table 1 in week one the value of the temperature varies from 33.3ºc to 38.4ºc, while the power varies from 3.5 w to 3.37 w indicating that the solar irradiation has effect on the solar panel as the power depends on the temperature of the day before taking a reading.

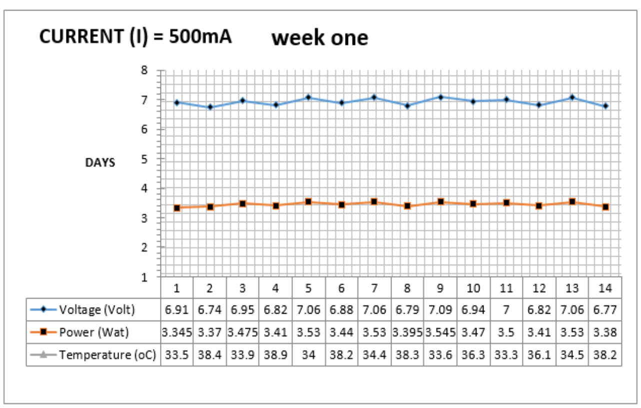

Figure 3: Graph of Voltage against Power Week One.

The graph of voltage against power is shown in Figure 4, the blue pattern represents the reading of the voltage (V) in the solar panel, and the red pattern represents the reading of power in the solar panel obtained for seven days respectively. The graph shows that both the blue and red patterns are indicating a point of lower and higher voltage output in different point in time, pointing out that the more irradiance the more the power that is store, satisfying the working condition of a normal working solar panel. From table 1 the value of the temperature varies from 33.7 ºc to 38.90 ºc, and the power varies from 3.295 w to 3.53 w indicating that the solar irradiation has effect on the solar panel as it depends on the temperature of the day before taking a reading.

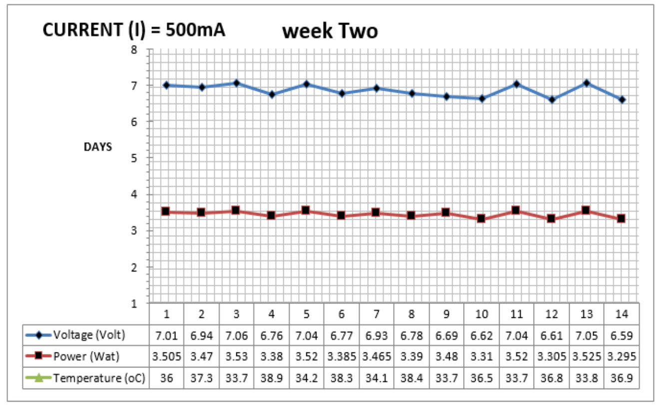

Figure 4: Graph of voltage against power week two

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