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Investigation of the Effect of Solar Panel Temperature on Power Output Efficiency in Brass, Nigeria.

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Abstract

Background: Luminous efficacy is a property of light sources, which indicates what portion of the emitted electromagnetic radiation is usable for human vision relative to the overall efficiency of a light source for illumination. This also applies to solar panels.

Purpose: To confirm the possibility of using solar panel as an alternative source of generating electricity and to highlight hindrances to the maximization of solar panel efficiency in the Niger Delta region of Nigeria using Brass as a case study.

Materials and Methods: A Modern digital instrument, BK precision model 615 digital light meter and Alda AVD890C digital multimeter, were use for measurement of solar radiation, current and voltage respectively, under varying conditions of temperature.

Result: An average Solar panel temperature of 26.2 ^{o}C was recorded in the morning hours. Towards noon, solar panel temperature increased up to 45 ^{0}C. Output current also increased from 0.0 to 20.0 x 10^{-1}A. Solar panel temperatures between 26^{o}C and 45^{o}C appeared to favour increase in output current. Above 45^{o}C, output current began to drop despite further increase in solar panel temperature. The best solar panel operating temperature in Brass is 45^{o}C. Between the solar panel temperatures of 26^{o}C and 32^{o}C, output voltage remained relatively stable varying between 8.0V and 8.10V.

Conclusion: Within limits, solar panel efficiency appears to be temperature dependent up to a maximum temperature, increasing up to 87.0% at 43.8^{o}C. Higher temperatures appear to be counterproductive on solar panel efficiency.

Introduction

Luminous efficacy is a property of light sources, which indicates what portion of the emitted electromagnetic radiation is optimally suited for different human requirements. This also applies to solar panels. Luminous efficacy also measures the fraction of electromagnetic power, which is useful for lighting [7]

Although daylight data are in great demand, the number of locations where they are regularly measured is grossly insufficient compared with other parameters, such as temperature, rainfall [3,5,6]. This may be due to the high cost of equipment, and death of skilled personal and so they are frequently estimated from global, beam and diffuse radiation.

Hence, there has been a need for adequate information on the characteristic distribution of photometric luminance and efficacy in every region especially for areas where solar panels are used. Some of the works reported for some part of the world on sky luminance measurements and distribution and luminous efficacy models [4,7], reviewed luminous efficacy measurements made in the previous 50 years, for both the beam and diffuse radiation in Southern England.

In Nigeria, few studies have reported the measurement and analysis of solar radiation and its components. This is in spite of the increased demand for alternative sources of power supply in the nation with deep interest in renewable energy sources. Such studies have found that performance was not strongly correlated with wind speed. At an irradiance of 900 W/m^2 and a module temperature of 45^0C the maximum power output was less than 40W at least 26% short of its rated power of 55 Watt [1]. It is for this reason that solar panel output dependence on environmental factors needs to be understood to aid in the design of panels for optimized performance.

Solar cells are encapsulated in black materials which makes them good heat absorbers. The gap between the solar cells and glass casing of the panel encourages green house effect which equally adds to the temperature remains relatively uniform throughout the day.

The solar cell is a PN junction divide which can be modeled as a diode with a photo generated current source in parallel, when this is done ,the current I, flowing through the PN junction is given by equation

$$I = I_0(\exp\frac{qv}{\eta KT \ -1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where I_o is reverse saturation current that is dependent on temperature, K is the Bozeman’s constant, q , the electron charge , a diode dependent ideality factor. Equation (1) shows the inverse relationship of current and temperature .

Brass is an island in Bayelsa state made up of; Twon, Okpoama Ewoma Diema Kala- Orubo and Imbi-Kiri communities. It lies between latitude 4^0.19N and longitude 6^0.14E. Brass is boarded to west by Brass and to the east by St. Nicholas River and the south by the Atlantic Ocean respectively. It lies at the lowest point of Nigeria with many streams flowing through it. The climatic conditions are similar to those of other location in the Niger delta region. It has uniform ambient temperature throughout the year with little variations of 27 ± 2^0C; this temperature is lower than other locations because of its closeness to the ocean.

The aim of this paper was investigate the effects of solar panel temperature on the power output efficiency of solar panels in Brass , Nigeria.

Materials & Methods

The Solar panels were designed with a glazed front and back. Glazing was done with a 4 mm thick long Iron glass. The cell used in this study was a mono crystalline silicon type with an area of 1.9m^2, a solar temperature coefficient of 0.005/K and maximum output current and voltage of 2A and 8V, respectively.

A general purpose digital thermometer Model 220K, used with type K temperature probe was used to obtain solar panel temperatures. Before use, the probe and instrument were calibrated to zero ^{0}C following the manufacturer's guidelines. The temperature probe was placed in an ice bath to stabilize the reading, and then the mode keys pressed to 0^{o}C. To obtain solar panel temperature readings the probe was placed the on the surface of the solar panel take temperature.

Voltage and current output readings were taken with an Alda Model AV 890 digital Multimeter. This is an easy to use 3.5 digital liquid crystal display (LCD) meter , designed to read resistance (R) , Voltage (V), current (I) and capacitance (C).

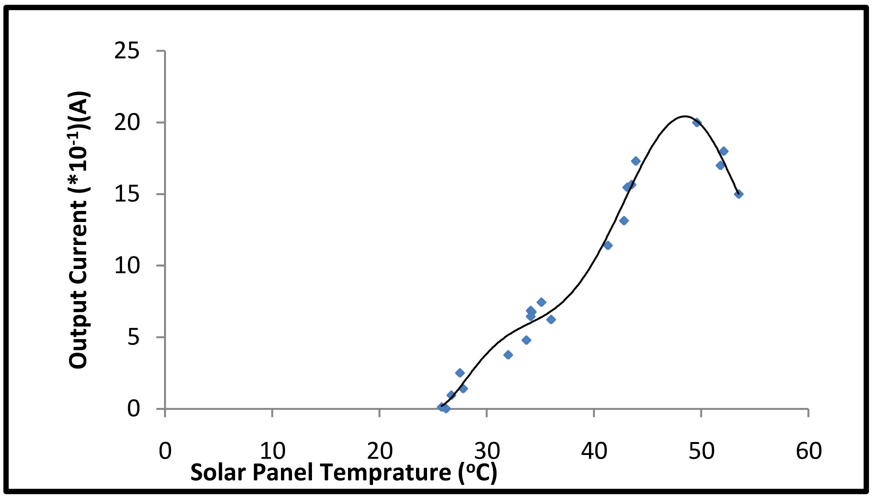
The method of study involved the initial collection of current and voltage output data from the solar panel, using the digital multimeter (Alda Modle AV 0890C). Solar panel temperatures were then measured at the surface of the panel with the digital thermometer. The solar panel and the thermometer were placed on the same horizontal test plain at the height of one meter facing the sun. Instantaneous measurements were made at both stages and at intervals of 5 minutes averaged over 30 minutes. This was done between the hours of 6.00am to 5.00pm for fourteen days to ensure effective and accurate data collection. Results collated were input into equation (2), from Kachhava(2003), to calculate solar panel power efficiency output.

$$\text{Efficiency} = \frac{power\ \ of\ Solar\ \ panel}{Area\ \ of\ Solar\ \ panel\ \ X\ 1000W/m2}\ \text{X}100\% \qquad (2)$$

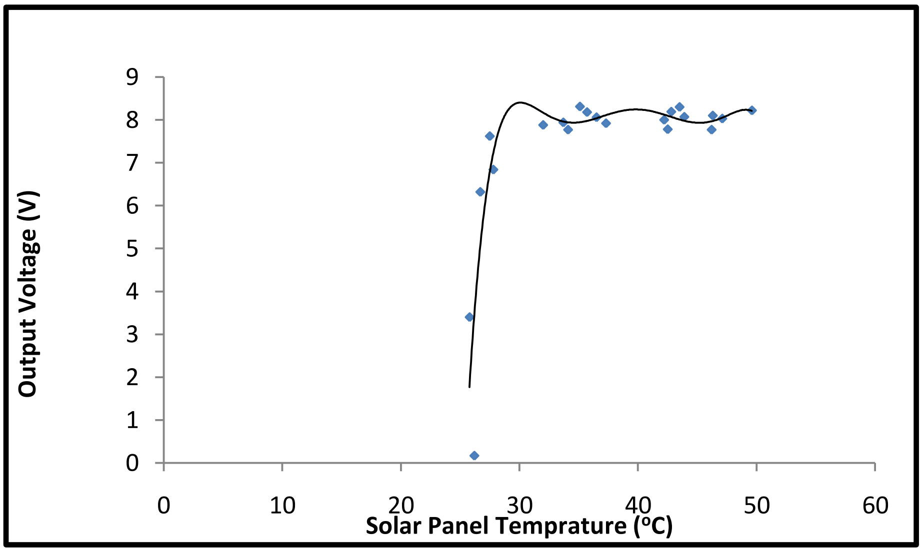
The resulting output current, voltage and efficiency were plotted against solar panel temperature, respectively.

Results

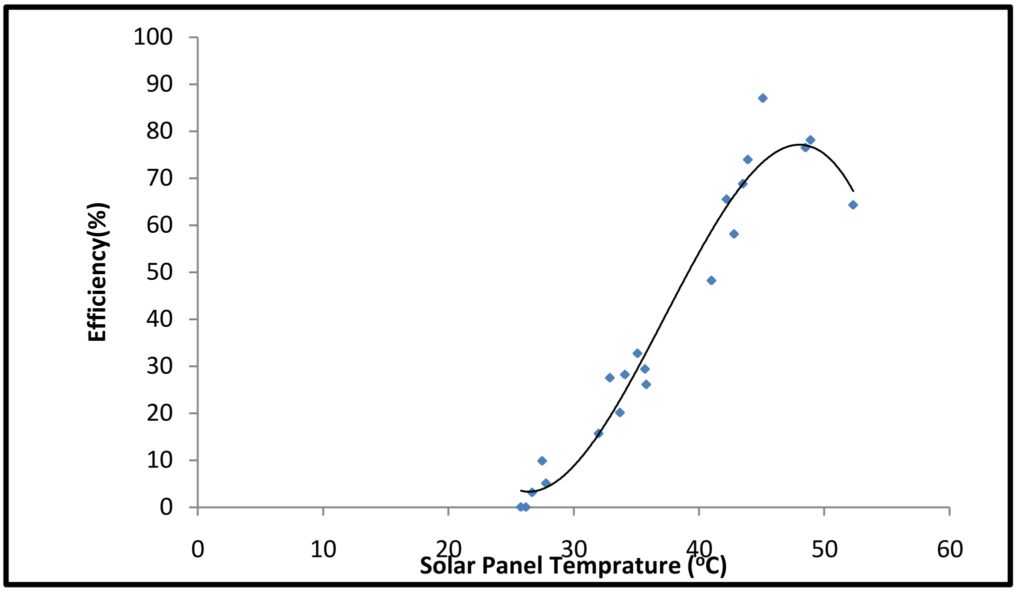
Average solar panel temperature of 26.2^{o}C was recorded in the morning hours in Brass but towards noon, solar panel temperature increased up to 45^{o}C. Output current also increased from 0 to 20.0 x 10^{-1}(A). Figure 1 shows that, as solar panel temperature increased steadily between 26^{o}C and 45^{o}C, there was a corresponding increase in output current production up to a maximum at about 49^{o}C. Above this point, output current began to drop.



Output voltage also increased in the same pattern with a peak of about 7.9V recorded at a solar panel temperature of 30^{o}C. Further increase in solar panel temperature yielded a relatively stable output in voltage between 8.0V and 8.10V (figure 2).



Solar panel efficiency was observed to increase with rise in temperature (figure 3). A maximum efficiency of about 87.0% was obtained at a solar panel temperature of 43.8^{o}C. Further increase in temperature produced a drop in efficiency. The effect of solar panel temperature on output current is similar to its effect on efficiency.



Discussion

The foregoing suggests that solar panel temperature affects the output (Figure 1 and 2) and efficiency (Figure 3) of power generated. Photons from the sun that strike the metal case of the solar panels are converted to heat energy which increases the temperature of the panel. The initial rise in temperature produces a steady increase in the conductivity of the semiconductor. This results in the increased current output. At the maximum temperature, the efficiency of solar panel decreases with increasing temperature because such high temperature and increased conductivity produces a balance in the charges within the material, reducing the magnitude of the electric field at the junction. This in turn inhibits charge separation, which lower the voltage across the solar cell.

A study by Ettah et al [8] investigated the effects of solar panel temperature on the power efficiency of solar panel in Calabar, Nigeria confirmed a maximum output current of 18.4 $\times 10^{-1}$ A at 42.8^{0}C. Voltage output remained relatively stable as solar panel temperature increased. The current results of solar panel efficiency in Brass appears to follow the same pattern.

Power output efficiency dropped from 82.3 % at 42.8^{0}C to 52.4% at 54.8^{0}C. They concluded that, high solar panel temperature may have adverse effects on solar panel efficiency. The result obtained in their study suggested a maximum operating temperature of solar panel in Calabar, Nigeria [8]. In the current study, efficiency changes due to temperature rise amounted to a drop of -

Conclusion

The efficiency, current and voltage output of solar panels in Brass has been studied. Findings are suggestive of temperature dependence of performance. These results may instructive in the design and utility of solar panels in Brass.

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