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Performance Analysis of Monocrystalline and Polycrystalline Solar Panels in a Semi-Arid Region

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ABSTRACT: *The nexus of this research is to analyze the performance of solar panels in a Semi-Arid region. This research was carried out in Okuku, in Yala, Cross River State. A TES 1333 model solar power meter was used to measure solar radiation while an auto range multimeter model 8236 was used to measure current and voltage from the solar panel, respectively. Data collected from the measuring instruments were computed and analyzed. This was done in order to maximize the abundant potential of solar radiation from the sun for the generation of electricity. Results show that polycrystalline solar panels are more efficient than monocrystalline solar panels in a semi-arid region.*

KEYWORDS - *Efficiency, Electricity, Polycrystalline, Monocrystalline, Solar Panels.*

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I. INTRODUCTION

The central factor in the creation of wealth and a significant factor in economic development is energy. It determines the stability and economic development of a country [1][2][3]. However, the epileptic nature of electricity supply in Nigeria is frustrating and worrisome. The alternative avenue to grid electricity is the generator which makes use of fossil fuel and this is used by 80% of the world's population [4]. Fossil fuels have environmental and political drawbacks. In addition, they are expensive. This has inspired many researchers to look into a clean, free and abundant source of energy, which is solar energy. This form of energy is the most favourable form of renewable energy [5].

The performance of a solar system using a PV SYST software was investigated by [6]. In this work, a 10KW grid-connected PV system was simulated. The effect of solar irradiation, energy output of the PV array, performance ratio and PV array losses was considered. Effective energy output was observed to be 20.14KWh/day, performance ratio was 77.9% and array output was directly proportional to irradiation. However, increase in temperature above 300C led to a decrease in energy output.

The effects of solar radiation on energy conversion efficiency of solar panel in Uyo and Port-Harcourt were investigated and the analysis compared by [7]. Solar radiation measurements as well as formal meteorological data were utilized in this study. Data were also recorded from digital instruments used. Graphical analyses were made between solar radiation and current, voltage and efficiency. Results obtained show that solar radiation is directly proportional to current and efficiency but fairly stable with voltage. A comparative analysis show that an average of 87.8 Klux of solar radiation 22.4 x 10^{-1}A of current, 8.2 V of voltage recorded 96.5% of power efficiency in Uyo. While 67.9 Klux of solar radiation, 15.1 x10^{-1} A of current and 7.5 V of voltage recorded 65.9% of power efficiency in Port–Harcourt. This result shows that solar panel power efficiency is better in Uyo compared to Port-Harcourt.

An investigation to study the influence of solar flux and solar power on the performance parameters of Photovoltaic (Polycrystalline) was investigated by [8]. The data used in the research was obtained by in-situ measurement approach using a digital solar flux meter, a SM206 precision digital solar power meter and an M890C+ digital Multimeter. Otained result shows a correlation for current, efficiency and solar power as well as for solar flux which indicates that high solar power and solar flux positively enhances the performance of the photovoltaic. It further revealed that once the solar power or solar flux reaching the panel exceeds 200W/m^2, the voltage from the panel approaches maximum and remains fairly stable irrespective of the amount of solar power or solar flux reaching the panel. The data collected for three months, July, August and September shows prediction efficiency of 87%, 63% and 71% at 11: 30am, 12: 30 pm and 10: 30 am respectively.

To determine the effects of solar panel temperature on its efficiency in Calabar, Nigeria, by determining the output current and voltage changes due to solar panel temperature, [9] used a model 220k type digital thermometer and Alda ADV 890C digital multimeter to obtain measurements of solar panel temperatures, current and voltage, respectively. Comparisons were made of the values of current and voltage obtained with solar panel temperature changes and efficiency of the output of the solar panels. Results indicate that a maximum output current of 18.4x10^{-1}A was recorded at 42.8^{o}C. Beyond this temperature the output

current dropped down to $12x10^{-1}$A at 54.8°C. The voltage output remained relatively stable as solar panel temperature increased. Power output efficiency dropped from 82.3% at 42.8°C to 52.4% at 54.8°C. High solar panel temperatures was observed to have adverse effects on solar panel efficiency. The result obtained in this study suggest a maximum operating temperature of solar panel in Calabar, Nigeria.

[10] investigated the relationship between solar radiation (flux) and current, voltage, solar radiation and efficiency of solar panel, in Port Harcourt Nigeria. Solar Radiation (flux) measurements as well as meteorological data were utilized. Data were recorded from the digital instruments used. Analyses were made between solar radiation (flux) and current, voltage and efficiency. Results obtained shows a direct proportionality between solar flux and output current as well as solar flux and efficiency of solar panel. This implies that an increase in solar flux leads to increase in output current which enhances efficiency (performance) of a solar panel.

The performance of a solar photovoltaic system for two soil natures, white and grey, and for two inclination angles 0^0 and 30^0 was examined by [11]. Results show that photovoltaic panels perform better when placed on a white soil and when inclined. [12] studied the operating temperature of solar cells, presenting various correlations concerning its effect on the electrical performance of PV systems. [13][14][15] examined solar cell materials and the progresses made in different PV technologies. Moreover, the effect of some parameters affecting PV systems performance like the heat transfer mode, angle of inclination and Thompson's effect has been evaluated for optimum configuration of PV systems [16][17][18][19].

In this work, the performance evaluation of PV systems is investigated, with focus on the solar radiation efficiency and output power of a monocrystalline and polycrystalline solar module in a semi-arid region.

II. MATERIALS AND METHOD

Materials used in this research are a TES 1333 digital solar power meter, MS 8236 digital multimeter, a digital stop watch for time checking, a Yingli solar YS310 monocrystalline solar panel and a Yingli solar YS310 polycrystalline solar panel. Both panels have the same technical specifications as follows: peak power output - 130 watts, voltage at peak power - 22.05V, short circuit current - 8.31A, module efficiency - 18.5% and surface area of panel - 0.98m^2. These technical specifications were given by the manufacturer at a standard test condition of solar radiation, 1000w/m^2 and temperature of 25^0C.

The digital multimeter was used in measuring the open-circuit voltage and short circuit current from both solar panels. Simultaneously, the digital solar power meter was used in taking readings of solar radiation from both panels. The above procedure was done for every 15 minutes, between the hours of 6am to 6pm, for 6 months, to obtain a justifiable inference.

Collected data was computed and analyzed to obtain output power and efficiency of solar panel as eqn (1) and eqn (2) according to [20].

$$\text{Output power (watts)} = \text{Voltage} \times \text{Current} \quad (1)$$

$$\text{Efficiency of solar panel (\%)} = \frac{\text{Output power of solar panel (watts)} \times 100}{\text{Area of solar panel } (m^2) \times \text{solar radiation } (w/m^2)} \quad (2)$$

III. RESULTS AND DISCUSSION

Performance analysis of two PV systems (monocrystalline and polycrystalline) in a semi-arid region was x-rayed. Data was collected, computed and analyzed. Average data measured and computed in this study is given below in Table 1. An average efficiency of 12% and 13% for monocrystalline and polycrystalline solar modules was observed, respectively. This translates to an average output power of 51% for monocrystalline panel and 55 watts for polycrystalline panel. An average solar radiation of 409 w/m^2 was observed.

Table 1: measured and Computed Parameters

Measured and Computed Parameters in Units	Amount
Mean solar radiation (w/m^2)	409
Maximum solar radiation (w/m^2)	992
Mean monocrystalline output power (w)	51
Maximum monocrystalline output power (w)	128
Mean polycrystalline output power (w)	55
Maximum polycrystalline output power (w)	152
Mean monocrystalline efficiency (%)	12
Maximum monocrystalline efficiency (%)	17
Mean polycrystalline efficiency (%)	13
Maximum polycrystalline efficiency (%)	20

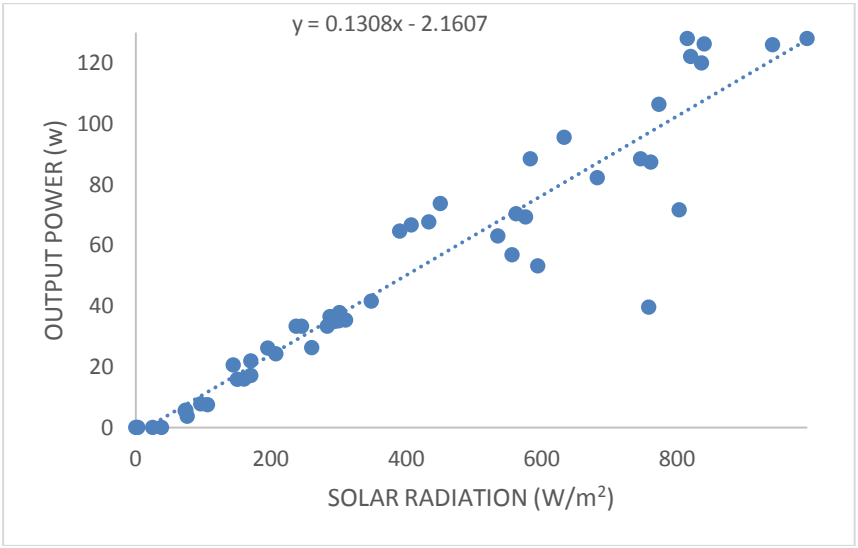

Figure 1: Graph of Monocrystalline Output Power against Solar Radiation

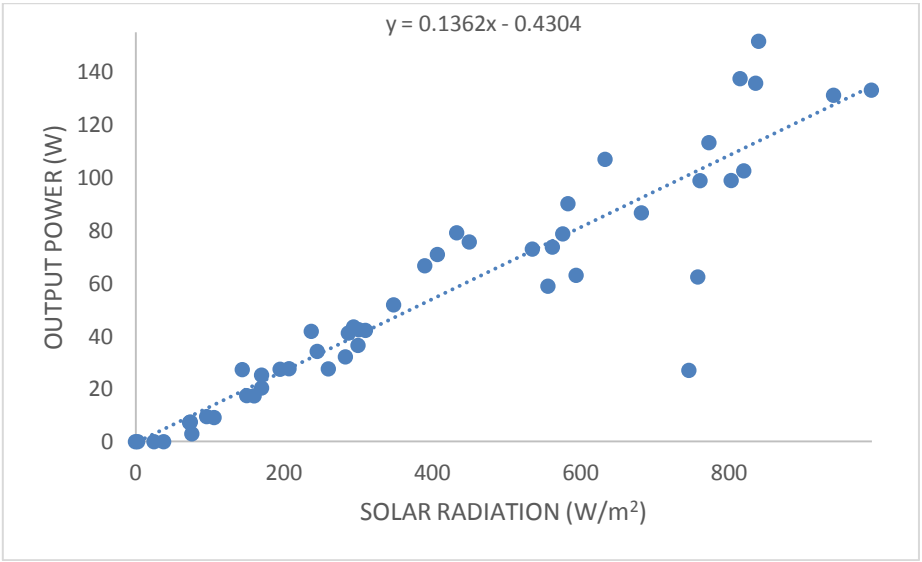

Figure 2: Graph of Polycrystalline Output Power against Solar Radiation

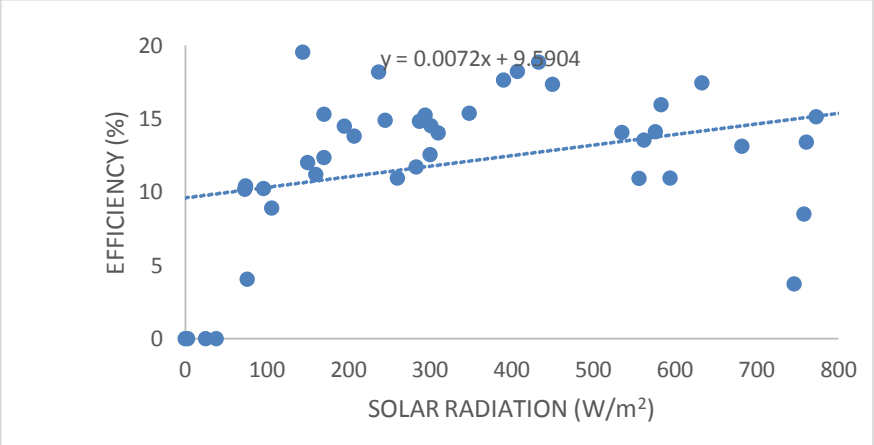

Figure 3: Graph of Monocrystalline Efficiency against Solar Radiation

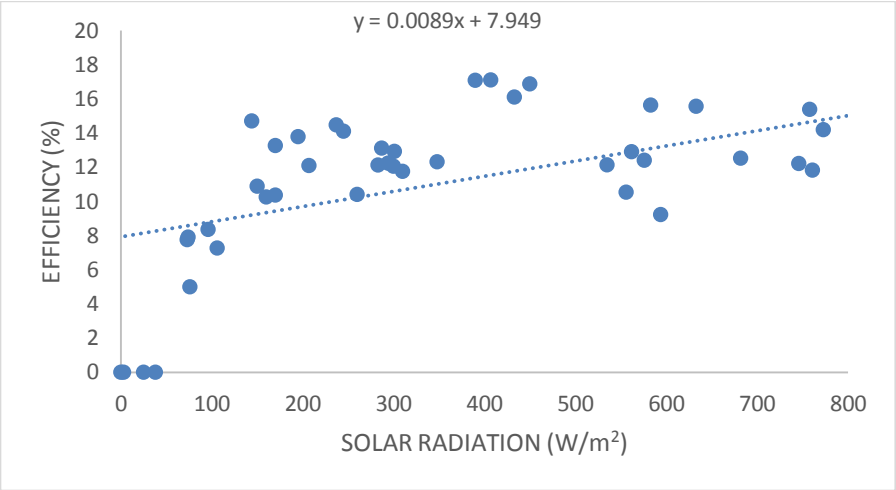

Figure 4: Graph of Polycrystalline Efficiency against Solar Radiation

From the graphs plotted in Figure 1, Figure 2, Figure 3 and Figure 4, it is observed that an increase in solar radiation leads to an increase in efficiency and output power for both solar modules. The average efficiency for both modules portrays good potentials for solar electricity generation in this study area.

IV. CONCLUSION

Performance analysis of monocrystalline and polycrystalline solar modules has been investigated. Polycrystalline solar module shows higher efficiency and higher solar output power when compared with monocrystalline module. It is concluded that polycrystalline modules has better performance than monocrystalline modules in a semi-arid region.

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