SSRG International Journal of Recent Engineering Science
ISSN: 2349 – 7157 /doi:10.14445/23497157/IJRES-V7I5P106
Volume 7 Issue 5, 29-32, Sep-Oct, 2020

Estimating the Performance of Different Photovoltaic Module Under the Niger Delta Climatic Conditions.

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Abstract — *The paper reports the performance of different solar PV modules under the Niger-Delta Climatic Conditions. 20W monocrystalline and polycrystalline PV modules were consecutively monitored outdoors and indoors against varying temperature, illumination, and loads. Both modules' performances were analyzed and compared, using LM35 as a temperature sensor, 150kΩ varying resistor as load, and Arduino-Uno as the microcontroller. Results obtained showed that the increase in temperature negatively affects the efficiency of both photovoltaic modules. However, the monocrystalline photovoltaic modules perform better even under higher temperatures. In an average daily illumination, monocrystalline PV also performs better. The polycrystalline PV can still serve efficiently as it gives almost the same energy as the monocrystalline, and combined with its cost-effectiveness, it is preferable on a large scale.*

Index Terms*-Monocrystalline, Polycrystalline, Solar Photovoltaic*

I. BACKGROUND

The Niger delta is the Niger River's delta sitting directly on the Gulf of Guinea on the Atlantic Ocean in Nigeria. It is typically considered to be located within nine coastal southern Nigeria states, which includes all six states from the south-south geopolitical zone, one state (Ondo) from the southwest geopolitical zone, and two states (Abia and Imo) from southeast geopolitical zones [1].

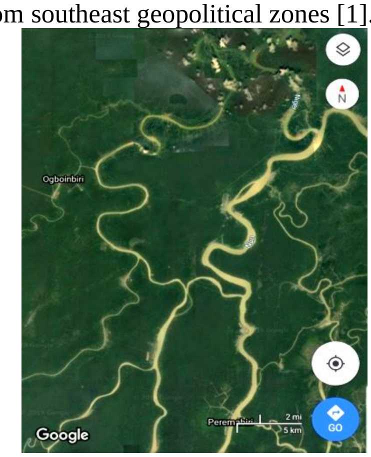

Fig 1. Map of Gbaran-Ubie (*source: Google maps, 2019*) [2]

Fig 1 shows the map of Gbaran-Ubie in Bayelsa state, which for this study is used as a base for all practical data collation and analyses. Its geographical coordinates are 4° 48′ 0″ North, 5° 54′ 0″ East (Retrieved November 20th, 2019, from https//:www.maplandia.com/Nigeria/rivers/southernijaw/gbara)

The Niger delta society is changing, the economy is developing quickly, and the energy demand increases. Fossil fuels, like oil, gas, and coal, are still the main source of energy. However, these energy sources are not only limited but are also adversely affecting our environment, causing greenhouse and pollutions. Hence, the viabilities for power generation in Nigeria through the utilization of the sun's energy has been considered [6]

Although the capacity of photovoltaic (PV) power is on the increase, there is still not much efficiency achieved in this, the market share is still quite small, and there is no formal awareness of the particular type of PV suitable for a given climatic condition. For this reason, the research to estimate the performance of different Photovoltaic modules under the Niger Delta Climate is encouraged for proper selection of the correct PV module for better performance. Moreover, many climatic factors affect PV modules' performance, but the effects of illumination and temperature are monitored and measured for this study. Computations and graphs are plotted using Microsoft Excel and Microsoft word. The comparisons are conducted for the monocrystalline and polycrystalline photovoltaic modules, which are the two types of solar panel predominant in Nigeria. The practical that generated these results was conducted over two (2) weeks because of changing weather conditions and the determination to get accurate data. This study's significance is that it will ascertain the performances of the two types of PV modules studied under the Niger delta climatic conditions.

II. METHODOLOGY

The outdoor experiment was conducted on the rooftop of a Medical building in Gbaran, Bayelsa state. The solar panel was placed horizontally, facing the sun directly. Arduino Uno was used as the microcontroller. A 150kΩ variable resistor was used as the load varied between 0-150kΩ, while the current and voltage given is recorded at a given time. LM35 was the temperature sensor used. Readings were taken between 9 am to 4 pm. The indoor monitoring was done indoors so that the temperature and illumination can be controlled. A system using a wooden box connected with eight lamp holders with 60 W each was improvised. The box was padded with foam and wrapped in aluminum foil. Readings were taken from 25°C to 80°C with a fan and an Air conditioning unit's aid. The reading had to be taken repeatedly to obtain accurate readings. The effect of fan cooling on the temperature of photovoltaic modules has also been adopted in the literature [4]

The 150-ohm variable resistor is varied from 0 to 150 for each temperature change. The V_m and the I_m reading of the panel were taking, for the I-V curves. During this test, the ammeter was connected in series with the variable load resistor, while the voltmeter was connected in parallel with the variable load. With the help of a microcontroller (Arduino), the temperature was recorded while the illumination was kept constant

III. RESULTS AND DISCUSSION

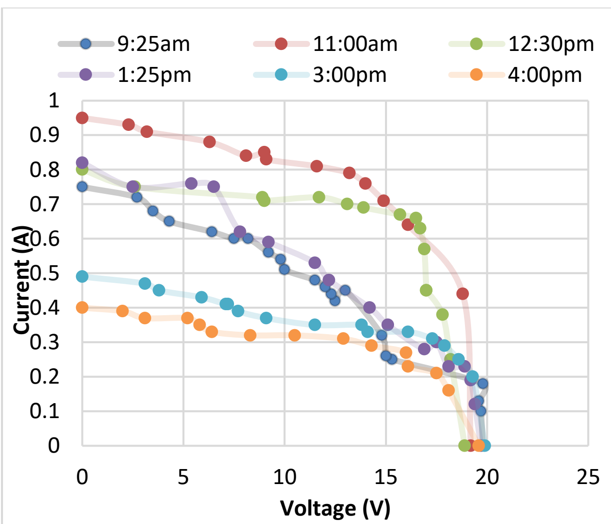

Fig2 Outdoor I-V curve of monocrystalline PV -illumination

Figure 2 shows the I-V curve of the monocrystalline PV module obtained from outdoor monitoring. The exact curve of the I-V characteristics of the panel is not clearly shown. This is because there are so many climatic factors beyond control that affects the performance of the PV. However, with the data collated and plotted, it is shown that the monocrystalline PV module performed better than the polycrystalline PV module during the outdoor monitoring. The current here increased from 0.78A to 0.97A between 9-11 am, then dropped continuously till it got to 0.4A at 4 pm. This is because there is adequate illumination with a considerably lower temperature between 9-11 am than 11-4 pm.

Figure 3 shows the I-V curve of the polycrystalline PV module obtained from outdoor monitoring. The current here did not increase immediately as in the monocrystalline PV. It dropped from 0.57A – 0.51A before increasing to 0.8A between 9 am - 1 pm and then dropped to 0.25A at 4 pm. Comparing it with the monocrystalline PV on the outdoor monitoring, polycrystalline PV modules perform less; there is no immediate increase in current rather, a drop occurred first before an increase.

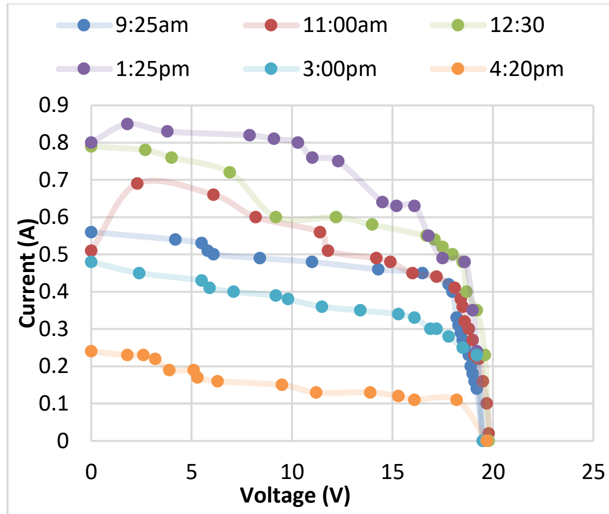

Fig 3. Outdoor I-V curve of Polycrystalline PV- illumination

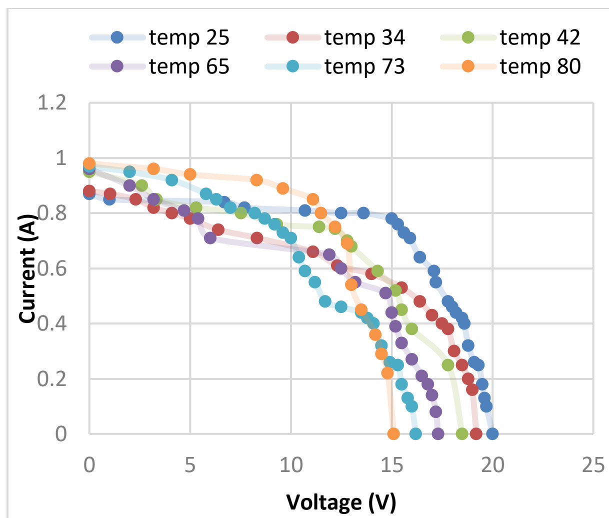

Fig 4: Indoor I-V curve for the monocrystalline panel - Temperature

Figure 4 shows the indoor I-V characteristic curve for the monocrystalline PV module. This curve is obtained by plotting the current against voltage for varying temperature ranges.

The voltage change is more outstanding than the current. Voltage dropped from 20V-15V, while current increased from 0.87-0.98A between 25°C and 80°C.

This proves the theory that states that the maximum power of a PV module decreases with each degree rise in temperature.

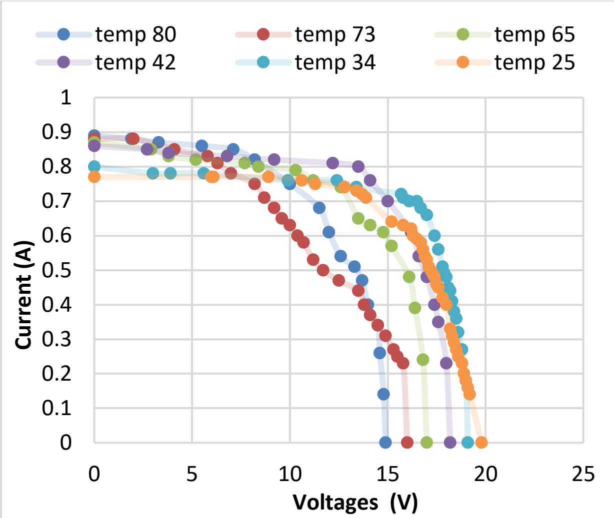

Fig 5: Indoor I-V curve for the polycrystalline panel –temperature

Figure 5 shows the indoor I-V characteristic curve for the polycrystalline PV module. Voltage dropped from 19.8V-14.9V, while current increased from 0.77-0.88A between 25°C and 80°C.

A. Comparison of the indoor and outdoor monitoring of both PV modules.

The maximum power output for monocrystalline tends to be higher than that of polycrystalline by just some fractions. On the indoor I-V curve with varying temperatures, the PV modules' maximum power decreased with each degree rise in temperature but was evidently higher in the polycrystalline PV module.

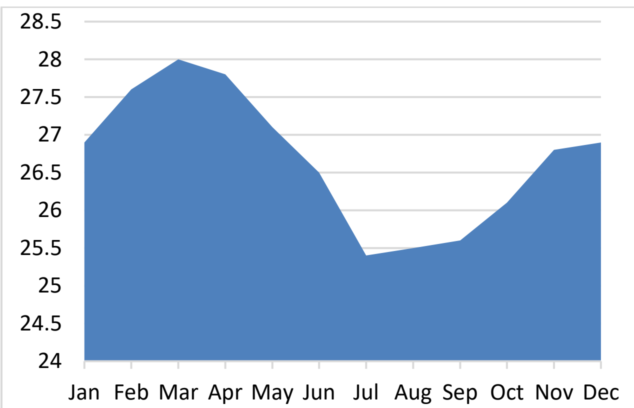

Fig 6: Variation of monthly average temperature over 2018 in Bayelsa. (Retrieved July 2018, from http://www.accuweather.com/en/ng/beyelsa/252198)

From Fig 6, March has the highest temperature, and July has the lowest. It is expected that the solar PV will give its maximum output in March, but this is proven otherwise as an increase in temperature decreases the power output of a PV module. Table 1 shows the energy calculations of both solar PV modules across the year 2018

Table 1

Energy calculations of both solar PV modules across the year 2018

Months	Daily Radiation (kWh/m^2/day)H	Monthly Radiation (kWh/m^2/month)H	Mono Energy (kWh)	Poly Energy (kWh)
Jan	4.834	149.854	0.0776	0.0635
Feb	4.923	137.844	0.0713	0.0584
Mar	4.771	147.901	0.0765	0.0627
Apr	4.557	136.71	0.0707	0.058
May	4.283	132.773	0.0687	0.0563
Jun	3.843	115.29	0.0597	0.0489
Jul	3.546	109.926	0.0569	0.0466
Aug	3.704	114.824	0.0594	0.0487
Sep	4.266	127.98	0.0662	0.0543
Oct	4.363	135.253	0.07	0.0573
Nov	4.602	138.06	0.0714	0.0585
Dec	4.808	149.048	0.0771	0.0632
	Total	**1595.46**	**0.8257**	**0.6765**

The energy output of a solar PV varies differently depending on the PV and its efficiency. The energy output of both the polycrystalline PV and the monocrystalline PV can be determined by Equation 1.

$$E = A \times r \times P_{ratio} \qquad (1)$$

'A' is the panel (0.0003744m²), 'r' is the panel's yield, 0.1843% for monocrystalline and 0.151% for polycrystalline PV modules, 'H' is the yearly irradiance for that particular location. The P_{ratio} is the performance ratio, which includes the coefficient for different losses that might affect the PV. These losses depend on the location, the type of PV, and the system sizing. The generally accepted value is 0.75. It can be more or less but between 0.9 and 0.5.

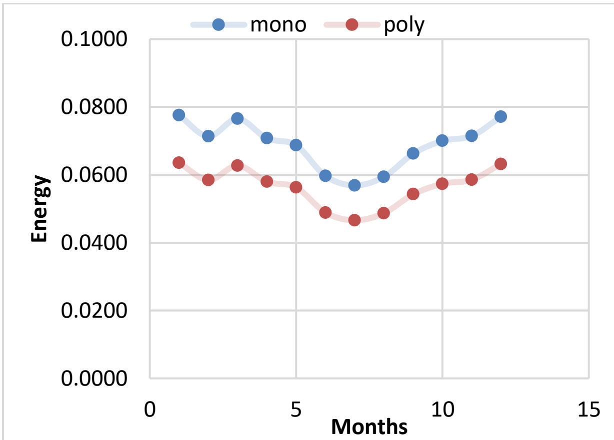

Fig 7: Energy curve for both modules in 2018

From fig 7, the monocrystalline energy curve for 2018 supersedes that of the polycrystalline solar module. This proves that the experiment conducted follows the Monocrystalline solar module's theoretical aspect being more efficient than the polycrystalline solar module.

Regarding the way each solar photovoltaic property varies with temperature, it can be concluded that an increase in temperature affects the efficiency of both PV cells. Greater efficiency for the solar panel does not come from higher temperatures. It comes from adequate illumination and a low temperature. March has the highest temperature, January and December give the highest energy because they have a reasonable amount of sunlight and a moderate degree of temperature.

IV. CONCLUSION

Theoretically and practically, the monocrystalline PV modules are more efficient than the polycrystalline under the Niger Delta Climate. However, it is more costly than polycrystalline. This is due to its manufacturing process. As a result, individuals tend to go for the polycrystalline PV modules. However, installing a polycrystalline PV module might accrue more cost in the long term due to maintenance costs.

The solar panel performs most efficiently in December and January, which have an average temperature of 26.7°C, while March, which has an average temperature of 28.9, performs less. This proves that truly high temperature negatively affects the solar panel efficiency

After conducting the experiments for both indoors and outdoors, it was deduced that other factors and variables could affect the quality or the efficiency of the solar PV modules.

ACKNOWLEDGMENT

The authors are grateful to God Almighty for his protection and grace all through the period of this work. The second author will appreciate his family members for their support through this work's various stages.

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