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Comparative Study of the Effects of Relative Humidity on Solar Electricity Generation in UYO and Port- Harcourt, Nigeria

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Abstract: **A study of the effects of relative humidity on solar electricity generation was carried out in Uyo and Port –Harcourt cities. Their results were compared to ascertain which city generates more solar electricity in relation to relative humidity of the city. Relative humidity, output current, and output voltage, were measured using digital instrument. Also formal meteorological data were utilized. Analysis show that, relative humidity is higher in port-Harcourt; > 93% in the morning hours, >70% at noon hours and >80% during evening hours, this giving output current of; <10x10^{-1}A in the morning hours, ≈15x10^{-1}A at noon hours and <8x10^{-1}A in the evening hours. Also power efficiencies of; <50% in the morning hours, ≈65% at noon hours and <35% during evening hours were recorded. While in Uyo city relative humidity is lower with values of; <90% in the morning hours, <65% at noon hours and <70% during evening hours, also output current of; >15x10^{-1}A in the morning hours, >20x10^{-1}A at noon hours and <18x10^{-1}A during evening hours. Efficiencies of; >60% in the morning hours, >90% at noon hours and >70% during evening hours was recorded. Result shows similarities in trend in the effects of relative humidity on the output current, output voltage and power efficiency of solar module in both cities. Observation shows that at low relative humidity, output current increases as well as power efficiency of solar module hence solar electricity generation is high and vice vase. These implies that solar electricity generation is higher in Uyo while relative humidity is low than in Port-Harcourt where relative humidity is high.**

Keywords: **Solar Module, Relative Humidity, Power Efficiency, Current, Solar Electricity.**

1. INTRODUCTION

The sun is immersing power source emitting light energy over a range of wavelengths. The amount of solar radiation reaching the earth surface varies greatly due to changing atmosphere which reflect, absorb and scatter the solar radiation and part of it only reaches the earth surface directly. The local geographical feature, such as mountains, large water bodies, coastlines and plains influences the atmospheric conditions which affect the solar radiation reaching earth surface. The amount of solar radiation received at noon is maximum, because the sun is directly overhead. The solar energy available at earth surface under this condition is at1000 watts /sq. meter for a clearly sky. Ettah, (2008)

The basic characteristics which govern PV module electrical characteristic are mainly maximum power, tolerance rate value (%), maximum power voltage, maximum power current, open circuit voltage, short circuit current, and maximum system voltage. The performance of PV system will not only depend on its basic electrical characteristics but also on the environment that they are used. The system will depend on the effect of high solar panel temperature, relative humidity, and other environmental parameters. Ettah, (2008). The operating temperature of PV module based on its place of use plays a vital role in the photovoltaic conversion process. Both the electrical and power efficiencies of the PV module depend linearly on operating temperature, Omobo-Pepple *et al*, (2009), Ettah *et al*, (2009) and Katkar et al, (2011) The effects of relative humidity on the efficiency of solar panel have been studied in Calabar, Nigeria, Ettah *et al*, (2012). The study reveal that low relative humidity between 69% and 75% favours increase in output current of solar panel hence increase in performance of solar panel. That is efficiency of solar panel is high during low relative humidity.

Hussein et al, 2012 also studied the effect of humidity on PV performance in Oman, in their work three types PV were studied; polycrystalline, monocrystalline and Amorphous silicon. Humidity, current and voltage were measured and analyzed. They observed indirect proportionality between PV performance and humidity. Characteristic distribution of total diffuse and direct solar radiation, relation of radiation with ambient temperature and also instant solar radiation and its dependence on meteorological parameter have been studied; Bajpai and Singh (2009) , Akpabio *et al*, (2003) and Bajpai and Singh (2009). Also different climate have been studied using different types of PV module. Malik *et al*, (2008).

Deviation in performance of solar module under climatic parameters; ambient temperature and wind velocity in composite climate in India have been studied. In the research efforts were made to develop an equation with given data for different seasons of peculiar locations this was helpful in developing a relationship between efficiency of photovoltaic module with major climatic parameters like , temperature, wind velocity, humidity etc. the mathematical equation developed was in good correlation with the measured data. Rahnuma and Usha, (2012).

The main target of this paper is the measurement of relative humidity in Uyo and Port – Harcourt, and compares its impact on solar electricity generation and power efficiencies in these two cities.

Uyo city is located at latitude $5^0 03^1$N and $7^0 57^1$E. She has relatively flat, low – lying landscape. The most prominent feature of physical landscape of Uyo is the ravine that lies in the north eastern part of the city. The ravine contains small perennial streams. These are tributaries of Ikpa River, which is the main water course in the vicinity of the city. Uyo lies within the Niger Delta and so enjoys a humid tropical type of climate with high rainfall, high temperatures and high relative humidity (Akpabio *et al*, 2005).

The mean annual rainfall for Uyo city is about 215mm. the trend is for the monthly rainfall to run to peak in July, and decrease in August (August break) and peak again in September before it finally decreases in December. The mean average temperature is about 29 ± 2^0C. Relative humidity except for a short period of the season remains at average of 70% to 80% throughout the year. Sunshine duration in Uyo is also high (Akpabio *et al*, 2005).

Port-Harcourt is the capital of River State. It lies on latitude $4^0 45^1$ and $4^0 60^1$N and longitude $6^0 50^1$ and $7^0 30^1$E of the equator. It is bounded by Bayelsa state in the west, Abia state in the East Imo in the North and the Gulf of Guinea in the south and lies along the Bonny River. Port – Harcourt has a population of about four million people (2007 population estimate).The climate condition is characterized by high temperature, high humidity and rainfall with high solar radiation. The climate is humid tropical. It is marked by wet and dry season. Mean ambient temperature is between 28 ± 2^0C and 26 ± 2^0C for dry and wet season respectively.

Relative humidity is above 80%. Mean annual sunshine in Port – Harcourt is about 1436 hours, while mean monthly values varies between 53.5 and 180.2 hours in the month of July and December respectively. Port – Harcourt experiences high rainfall almost throughout the year with over 80% occurring in the months of May to September with peak in July. The city houses the highest number of petroleum industries in Nigeria and has high gas emission from these industries, gas flare and car from the very high populated environment (Ebipade, 2008).

2. MATERIALS AND METHOD

Kestrel model 3000 Pocket Weather Digital Meter a simple hand held instrument with the features of data hold function, backlight, and an automatic power – down function, this instrument at a press of one key can measure directly wind speed, ambient temperature, wind chill, relative humidity, heat stress and dew point, this instrument has water proof integrity. The instrument was specifically used to obtain relative humidity in this research.

Voltage and current output readings were taken with an Alda Model AV 890 digital Multimeter .this is an easy to use digital liquid crystal display (LCD) meter , designed to read resistance (R) , Voltage (V), current (I) and capacitance (C) . Results collated were input into equation (i), Kachhava (2003), to calculate solar panel power efficiency output

$$\text{Efficiency} = \frac{powe\ of\ Solar\ panel}{Area\ of\ Solar\ panel\ X\ 1000W/m2} \text{X}100\% \quad \text{..... (i)}$$

The commercial solar module used was designed with a glazed front and back. Glazing was with glass of 4mm thickness. The cell use in the study was a monocrystaline siilicon type with an area of 1.9m^2, and a solar temperature coefficient of 0.005/K, its maximum output current and voltage were 2A and 9V respectively.

The method use for this study involves the instant measurement of current and voltage output data from the solar module, by connecting its output to the digital multimeter (Alda Model AV 0890C) and measurement of relative humidity using the Kestrel model 300 pocket digital meter

The solar module was placed on a horizontal test plain at the height of meter facing the sun. Instantaneous measurements were made at both stages at intervals of 5minute 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.

3. RESULTS

Key: EU = (Efficiency in Uyo), EP= (Efficiency in Port-Harcourt), HU= (Relative Humidity in Uyo), HP = (Relative Humidity in Port- Harcourt), CP = (Current in Port-Harcourt), CU = (Current in Uyo)

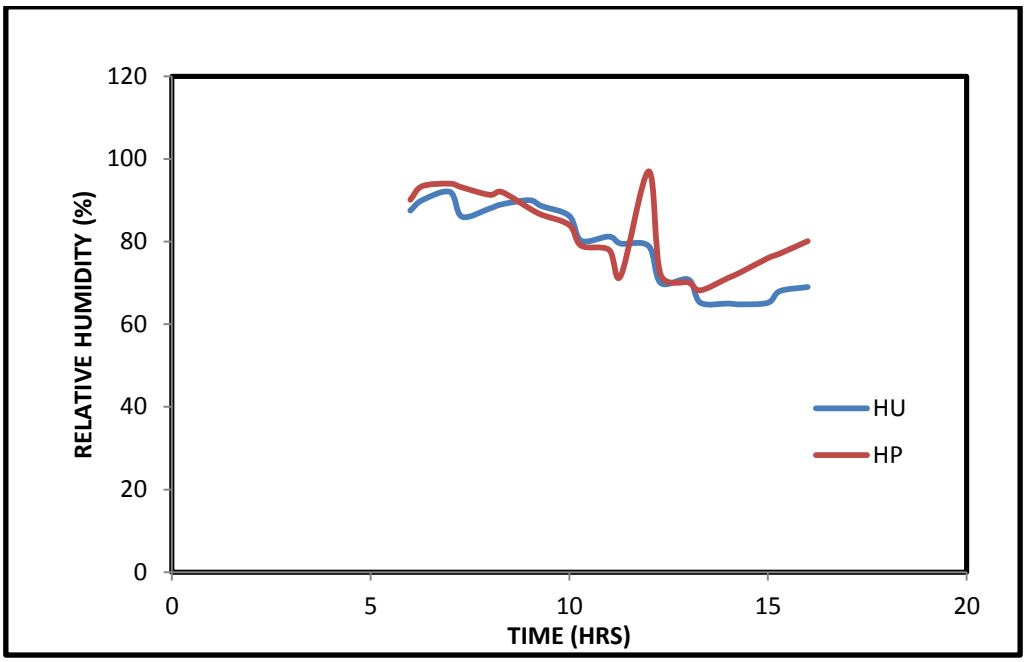

Fig. 1: graph of relative humidity against time in Uyo and Port – Harcourt

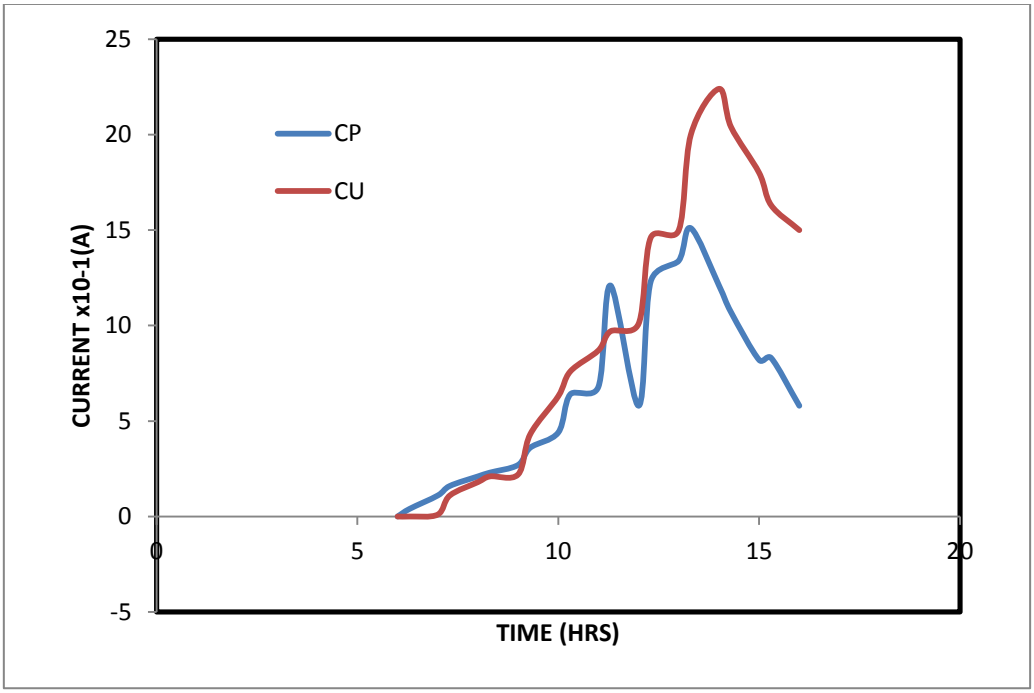

Fig. 2: graph of current against time in Uyo and Port – Harcourt

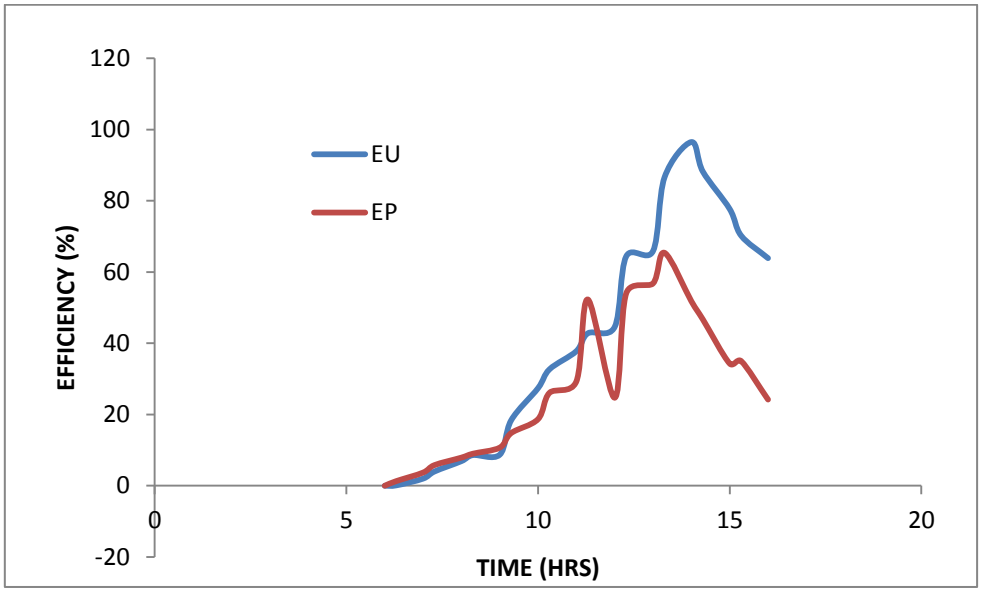

Fig. 3: graph of efficiency against time in Uyo and Port – Harcourt

4. DISCUSSION

Figure 1 shows that relative humidity is the morning hours of both cities with port-Harcourt recording up to 94% between 6am and 10am, 75% between 10am and 1pm there are usually heavy cloud or rain fall during mid day as shown in the graph (pick) before dropping to about 80% during the evening hours. Also fig. 1 shows that relative humidity for Uyo in the morning hours is about 90% but drops to 65% between 10am – 1pm then rises again in the evening hours to about 68%.

Figure 2 Shows generation of photocurrent with time it was observed that photocurrent in Uyo is higher than in port-Harcourt. The morning hours recorded $>15x10^{-1}$A and $<10x10^{-1}$A, noon hours recorded $>18x10^{-1}$A and $<15x10^{-1}$A, while evening hours recorded $<18x10^{-1}$and $<18x10^{-1}$A for Uyo and port-Harcourt respectively

Efficiencies in the morning hours between 6am -10am are below 20% for both cites, but continues to rise in to midday hours maximizing at 90% for Uyo and 65% for Port-Harcourt before dropping to less that 30% in Port-Harcourt due to midday rain or heavy clouding occasioned in coastal cities. From 4.0pm down evening hours decrease in efficiencies is experienced, 70% for Uyo and 35% for Port-Harcourt. See figure 3.

Comparison of results shows that relative humidity on the average in Port-Harcourt is 80% while in Uyo it can drop to an average of 65% this will not unconnected with the coastal location of port –Harcourt cities which is bounded by the Atlantic ocean as compared with Uyo that is land log and far from the sea shores. Large water bodies affect relative humidity, Katkar *et al* (2012).

The amount of photocurrent generated shows that, in Uyo above 20x10-1A was generated which gives power efficiency of above 90% while in Port-Harcourt an average of 15x10-1A of photocurrent was generated producing power efficiency of about 65%.

5. CONCLUSION

Comparative study of the effect of relative humidity on the solar electricity generation was carried out. The following was deduced from the analysis.

1 High relative humidity is experienced in the morning and evening hours while low relative humidity is experienced in the noon hours, because temperature is directly proportional to relative humidity.

2 Relative humidity in Port-Harcourt is of the average of 80% while in Uyo is in the average of 65%. This is due to geographical location.

3 Solar electricity generation is high in Uyo $20x10^{-1}$A than in Port-Harcourt $15X10^{-1}$A.

4 Efficiency in Uyo is high them efficiency in port-Harcourt

5 Efficiency and photo current are inversely proportional to relative humidity, that is low relative humidity enhances photo current generation and efficiency.

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