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INFLUENCE OF METEOROLOGICAL PARAMETERS ON THE EFFICIENCY OF PHOTOVOLTAIC MODULE IN SOME CITIES IN THE NIGER DELTA OF NIGERIA

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ABSTRACT

This paper reports the investigation of some metrological parameters on the efficiency of photovoltaic module in some areas in the Niger Delta region of Nigeria. Results obtained show that efficiency of solar panel is directly proportional to solar flux and output current. Also, that increase in solar flux results to increase in output current of solar panel and enhance efficiency. It was also observed that relative humidity reduces output current and increases efficiency.

Keywords: Photovoltaic module, Solar flux, Solar panel, Relative humidity, Output current, Efficiency.

INTRODUCTION

The need for alternative sources of energy is attracting much attention because it is believed that all sources of fossil fuels will give way in no distant time. Various sources of energy such as solar, nuclear, thermal, biomass, wind, hydroelectricity, geothermal etc abound. Among these sources, solar and nuclear stand out distinctly with their unique advantage and peculiar disadvantages.

The rate of technological advancement depends to a large extent the availability and sustainability of energy both for domestic and industrial use. Providing the growing society with energy ceaselessly, safely and sufficiently need an increasing amount of research (Zafer and Arif, 2007). (Chow *et al.*, 2007) in their study on the performance evaluation of photovoltaic-thermosyphon system, for subtropical climate application, noted that rapid development of and sale volume of photovoltaic modules has created a promising business environment in the foreseeable future. They concluded that small house hold photovoltaic PV systems can sufficiently meet the initial modest electricity demands of most users in terms of standalone PV power station. This can also be used for solar lighting, street lighting and solar pumps for rural water distribution etc.

Nigeria is among the countries of the world with abundance of fossil fuel reserves, including hydropower resources. It is clear that complete dependence on these conventional energy sources alone would be disastrous, particularly in view of the growing energy demand in the domestic, commercial and industrial sectors of the economy, bearing in mind the finite nature of these resources. Also the capacity utilization of hydropower plants and the spread of the distributed grid-power from thermal have been grossly inadequate and poor in Nigeria (Umar, 1999) . Due to these inadequacies, the Nigerian government has started new energy policies, which include the development of independent power plants made up of gas turbines. Five of these are located within the Niger Delta region. This will further degrade the environment in this region. Nigerian government has recently advocated the use of nuclear power for energy generation, but international politics, security and safety may be a setback, especially with the recent Japan's nuclear disaster of 2011. In the Niger Delta regions, many communities because of their terrain do not have access to the national grid. Umar (1999) reported that as at 1996 that only about forty percent of the nation's population has been linked to national grid and this is largely in the urban areas.

The specifications given by manufacturers of different types of silicon solar PV modules are usually for Standard Test Condition (STC), obtained under stimulated sunlight conditions. Module performance varies with location of use and actual environmental conditions, which they are subjected to. Omubo-Pepple *et al.* (2009) and Bala and Umar (2000) have shown in their works how variation in air mass and other metrological parameters of the local environment like solar flux, temperature and relative humidity affected the module performance. Perez (1990), conclude that the performance of any solar panel in terms of power output is a function of the availability of solar energy resource in such area and that the solar intensity is usually modulated due to the rapid changing cloud cover which accounts for the major difference between the efficiency of solar panels in the field and the efficiency of the same panel under simulated conditions.

Nigeria is endowed with annual average sunshine hours of 6.25 hours, ranging between about 3.50 hours at coastal area (Niger Delta) and 9.00 hours at far Northern boundaries. It has an annual average daily irradiation of about 5,25kWh/m2 per day varying between 3.50 kWh/m2 per day at coastal area (Niger Delta) and 7.00 kWh/m2 per day at the Northern boundaries (Onyegegbu, 1989).

This paper reports on the effects of some active meteorological parameters on the efficiency of the solar panels in the Niger Delta Region of Nigeria. It is also believed that the results obtained will provide information to manufacturers of solar panels that will enable the modification and manufacturing of peculiar solar panels that can cope with the effects of these active meteorological parameters, such as, high temperatures, high relative humidity, heavy rainfall, aerosol and gases in the atmosphere caused by gas flare from oil industries, car, generators, etc and other environmental factors. The availability of solar energy is affected by location, latitude, elevation, seasons and time of the day. However, the most factors affecting the availability of solar energy are cloud cover, and other meteorological parameter, such as solar flux, relative humidity and other conditions which vary with time and location.

When solar energy impinges on a transparent medium or target it is partly reflected, absorbed and transmitted. When solar radiation falls on a solar panel, the reflective values are dependent upon the optical properties of the transparent object and the solar spectrum (Wieder, 1982). Solar radiation is partially depleted and attenuated as it transverse the atmospheric layers, preventing a substantial portion of it from reaching the earth's surface.

The earth is unique among the other planets with respect to the presence of water in liquid and gaseous state, the earth has the greatest deal of water, over 70% of the earth surface is water or ice cover (Acra, 2006) . Relative humidity of air-water mixture is defined as the ratio of partial pressure of ware vapour in mixture to saturation vapour pressure at a prescribed temperature. Relative humidity is expressed (Buck, 1981)Where RH is the relative humidity, P is the partial pressure of water mixture and P* is the saturated vapour pressure of water at the temperature of mixture. According to (Omubo-Pepple *et al.*, 2009), solar panel temperature increases more rapidly than ambient temperature. Photovoltaics is the most direct way to convert solar radiation into electricity and is based on photovoltaic effect. All photovoltaic devices incorporate a pn junction in a semiconductor across which a photovoltage is developed.

Researchers have reported the measurement and analysis of the solar radiation and its components, Akpabio and Udoimuk (2003), focused on the characteristic distribution of total diffuse and direct radiation at Calabar. Olseth and Skartveit (1989) studied hourly and daily global photometric luminance and luminous efficacy at a tropical station in Ile-Ife, Nigeria. Ugwuoke *et al.* (2006) carried out an extensive characterization and performance evaluation of monocrystalline silicon PV (model SM55) on some meteorological parameters such as wind speed, diffuse and global solar irradiance and temperature and concluded that the performance of the module have no strong correlation with wind speed.

INSTRUMENTATION/METHODOLOGY

The instruments used in this research are the KD Precision Model 725 Digital Light Meter, Digital thermometer (model 200), Pocket Weather Digital Meter (model 2555), Digital Multimeter (model AVD890C) and Commercial Photovoltaic Model.

The research was carried out in Bori town and Port Harcourt city in the Niger Delta region of Nigeria. Firstly, data was acquired using the multimeter where the module output performance was monitored, current and voltages measured. Secondly, the meteorological parameters, solar flux, solar panel temperature, relative humidity and ambient temperatures were recorded. Data were collected at both stages at interval of 30 minutes between the hours of 6.00am to 6.00pm for seven days to ensure effective and accurate data record. The photovoltaic module and the meteorological sensors were placed on the same horizontal test plane at a height 3m facing the sun.

RESULTS AND DISCUSSION

Figures 1, 2, 7 and 8 show that the relationship between the solar flux, output current, and efficiency. In the relationship, solar flux is directly proportional to both output current and efficiency such that increase in the solar flux increases output current and efficiency.

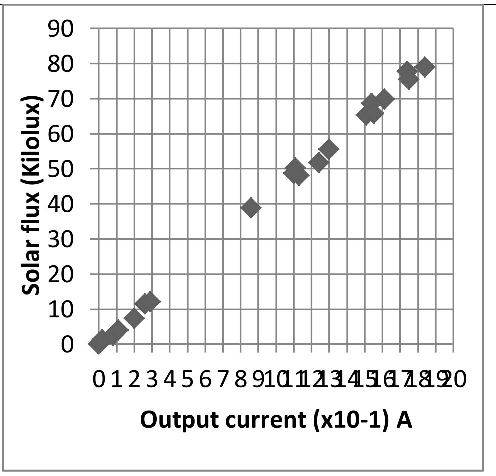

Fig.-1. Graph of solar flux against output current in Bori

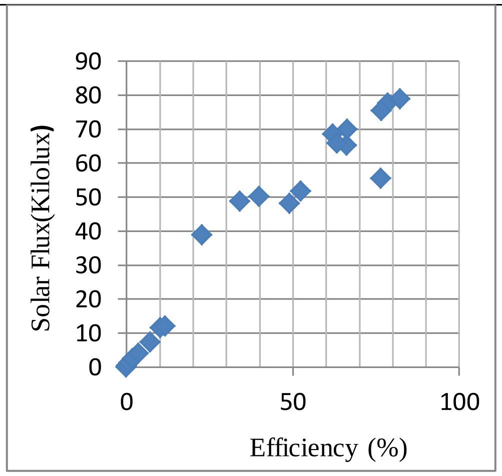

Fig-2. Graph of solar flux against efficiency in Bori

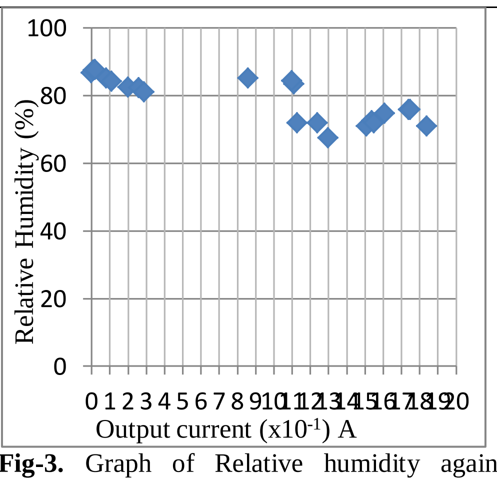

Fig-3. Graph of Relative humidity against output current in Bori

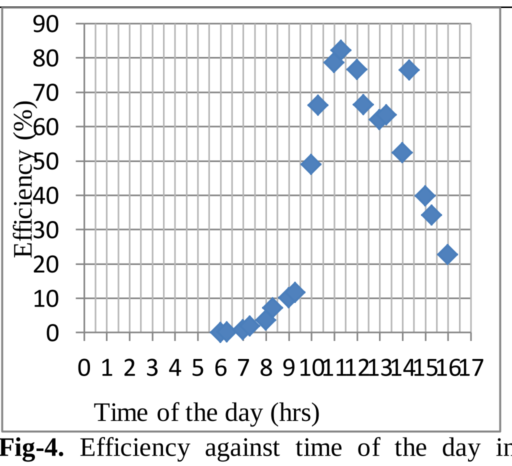

Fig-4. Efficiency against time of the day in Bori.

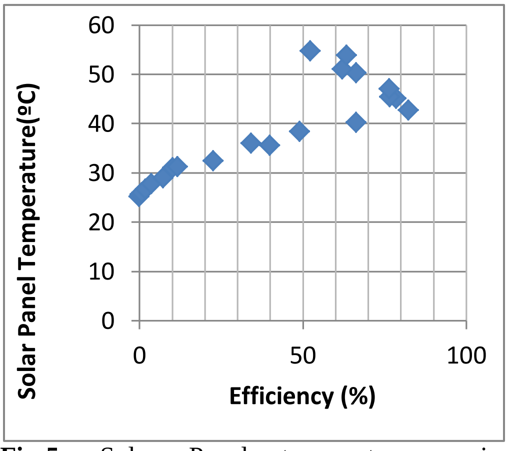

Fig-5. Solar Panel temperature against efficiency in Bori

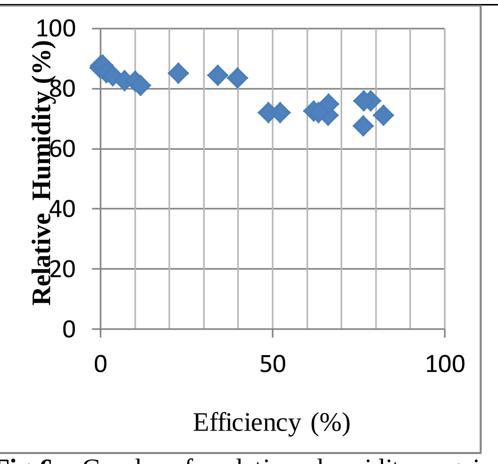

Fig-6. Graph of relative humidity against efficiency in Bori

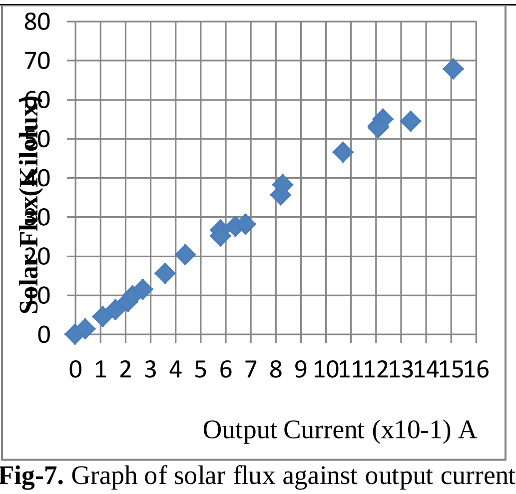

Fig-7. Graph of solar flux against output current in Port Harcourt

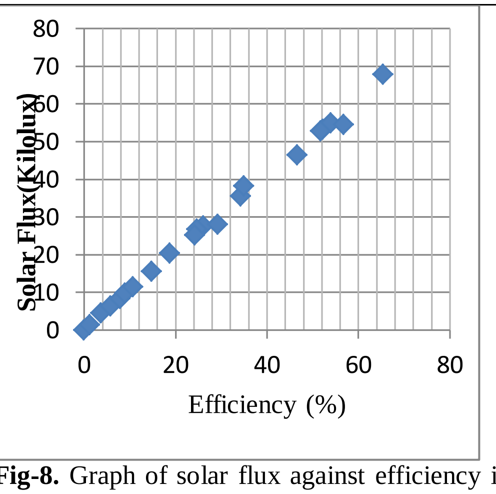

Fig-8. Graph of solar flux against efficiency in Port Harcourt

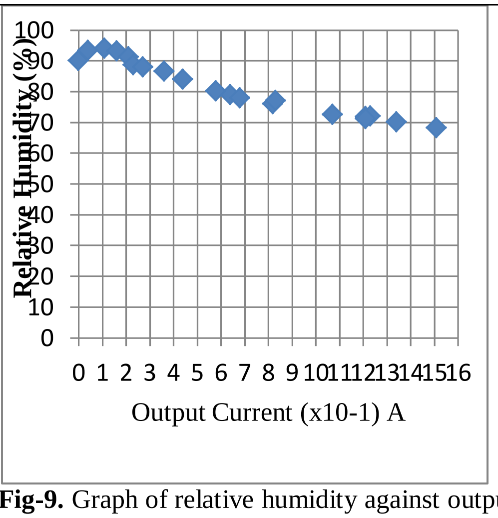

Fig-9. Graph of relative humidity against output current in Port Harcourt

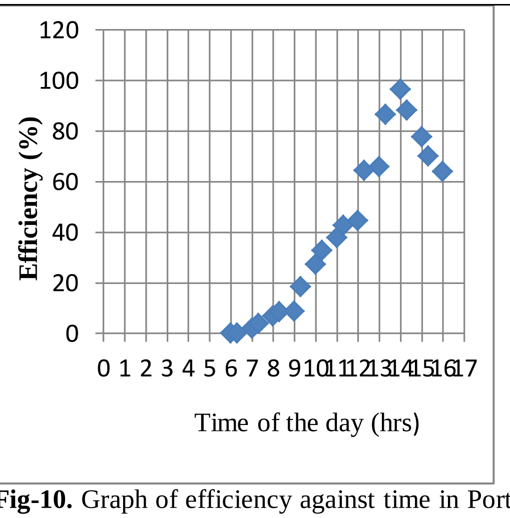

Fig-10. Graph of efficiency against time in Port Harcourt

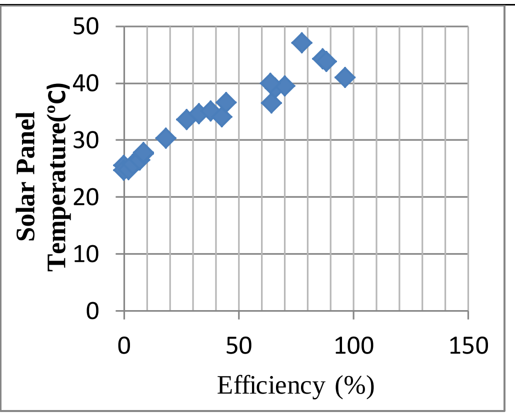

Fig-11. Graph of solar panel temperature against efficiency in Port Harcourt.

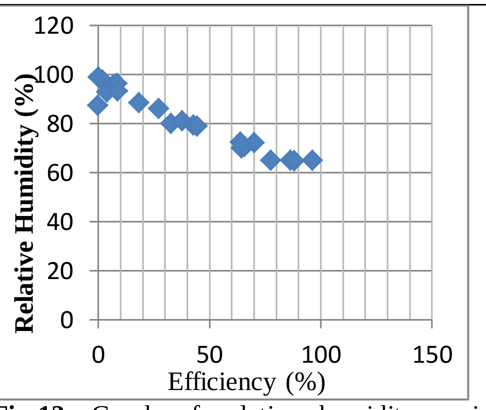

Fig-12. Graph of relative humidity against efficiency in Port Harcourt.

Figures 3 and 9 shows the relationship between the relative humidity and output current. It is observed that when the relative humidity is low, output current increases. Figures 5 and 11 show that as the solar panel temperature increases so also the output current. Figures 6 and 12 show that low relative humidity increases efficiency. Figures 4 and 10 show time dependent efficiency with maximum efficiency recorded between 10am and 3pm of the day.

CONCLUSION

Port Harcourt being a more industrialized city and densely populated, emissions from industries such as gas flare, emission from cars, generating sets prevents solar flux from reaching the solar panel. This effect therefore reduces efficiency.

A higher output current was recorded in Bori. This is because it is located far from the sea shore and therefore has a lower relative humidity. Also, higher solar flux was recorded Bori than in Port Harcourt. This may be due to cloud covers in Port Harcourt than in Bori due to high level emission of dust, aerosols and more anthropogenic activities in Port Harcourt than in Bori associated with industrialization and influx of more people in Port Harcourt than in Bori. Also the high industrialization and more human activities in Port Harcourt than Bori make air pollution level higher and these pollutants mask and reduce solar flux in Port Harcourt.

Low relative humidity between 65% and 73% produce output current up to 22.4 x 10-1A and efficiency up to 96% with solar flux of about 87.8 kilolux in the Niger Delta region of Nigeria. These values vary depending on the location, time and season of the year. Furthermore, low relative humidity leads to increase in solar flux, thus enhancing output current and improving efficiency of solar panel. If the solar panel temperature increases above 45%, the output current will drop and therefore reduces efficiency of the solar panel.

Metrological parameters such as relative humidity, solar flux and temperature have effects on the efficiency of solar panel.

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