Towards Improving Solar Panels Delivery; Re-Validation Of The Effect Of Relative Humidity And Light Intensity On Monocrystalline And Polycrystalline Photovoltaic Modules

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Abstract: With advancement in technology, constant power supply is an essential means to sustainable economic growth. Power is mostly generated from fossil fuel which has the disadvantages of health risks and also its supply is not sustainable as it is limited in supply. Thus, the need to explore other alternatives that are sustainable, reliable and of less health risk factor. Solar energy is one of the most utilized alternate power source. However, its energy cannot be converted directly into a useful form, solar panels consisting solar cells are utilized in the conversion process. The objective of this study is to investigate the effect of environmental factors on output power of monocrystalline and polycrystalline solar panels with focus on relative humidity and light intensity. Results showed that increase in light intensity is a favorable factor for increase in output power and the current produced by the photovoltaic module while increase in relative humidity results in decrease in output current. It was concluded that, increase in light intensity and decrease in relative humidity results in a higher efficiency of monocrystalline PV module when compared to a polycrystalline PV module.
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Introduction

With advancement in technology, constant power supply is an essential means to sustainable economic growth. Nearly every technological apparatus requires power for its optimal performance (Amajama J. 2016). Hence more than ever, there is greater demand for power and this will continue to increase. Nowadays, we get approximately 80% of our energy from non-renewable energy sources, e.g. fossil fuels. The unsustainability of the present production-consumption energy model highlights the finite nature of conventional energy sources. The environmental degradation occasioned by the emission currently generated by the use of fossil fuels creates serious environmental problems, such as acid rain, greenhouse effect and ozone layer depletion, which in many cases are irreversible, (Dincar, 2003). Pollutants and greenhouse gases increase when fossil fuels are converted into electricity or heat. Therefore, atmosphere is damaged and global warming developed (Tobnaghi *et al.*, 2013). Hence, the need to source for other means of providing efficient and safer means of generating energy. Solar energy is considered to be an inexhaustible carbon-free energy source and it can be converted into electrical energy having advantages of being renewable, reliable, with low cost of maintenance and also its impact on ecological environment is very minimal.

The sun radiates an overwhelming volume of energy onto the earth to meet the global energy demand for a whole year. However, out of 100% energy coming from sun approximately 30% of the energy is either reflected back or is absorbed by clouds, oceans and land masses. (Panjwani & Narejo, 2014). The solar energy converts into three forms of energy such as electricity, chemical fuel, and heat energy (George et al., 2007). However, solar energy cannot be used directly as a source of power but must be converted into a useful form (electrical energy). This conversion of solar energy to useful electrical energy occurs through solar modules. Solar module is a group or collection of photovoltaic (PV) cells also referred to as solar cells. Solar panels produce energy less than a tenth of one percent of the entire global energy demand. The cells are made of semiconductor materials like those found in computer chips. When sunlight strikes the cells, it extracts and excites the electrons from their atoms and electricity is then generated from the flow of electrons through the cell. One of its drawback is that it is considered as a dilute energy since the solar flux rarely have a value more than 1 KW/m^2 in the very hot regions in the earth (Foster et al., 2010) and to overcome this disadvantage, it is important to use modules from solar cells for the technological applications.

There are essentially 3 different types of PV Panels, Crystalline Silicon, Amorphous Silicon and Thin Film technology PV Panels. Crystalline Silicon panels are the oldest, most reliable and highly efficient PV panels in the market today. Crystalline Panels can be further divided into Mono-Crystalline and Poly-Crystalline panels while solar cells (PV cells) are devices that convert photons into electric potential in a Positive-Negative (PN) silicon junction (or other material). A PV cell is a basic unit that generates voltage in the range of 0.5 to 0.8 volts depending on the cell technology being used. Light of certain wavelengths is able to ionize the atoms in the silicon and the internal field produced by the junction separates some of the positive charges (holes) from the negative charges (electrons) within the PV device. The holes are swept into the p-layer and the electrons are swept into n-layer. Although these opposite charges are attracted to each other, most of them can only recombine by passing through an external circuit outside the material because of the internal potential energy barrier (Kanevce, 2007).

The PV solar cells output performance varies with atmospheric factors. Since sunlight is intermittent, solar cells cannot produce energy at a constant rate and the power delivered at a certain instant is still very much a function of climatological factors (Awachie, 1985). As a result, knowledge of effect of these environmental factors on the output power efficiency of solar modules is important.

The open circuit voltage (Voc) and short circuit current (Isc) depend on parameters like solar irradiance and the temperature as shown in equations 1 and 2.

$$V_{oc} = \frac{KT}{q} \ln \frac{I_{sc}}{I_O} \qquad (1)$$

$$I_{sc} = bH \qquad (2)$$

Where Io is the saturation current, q is the electronic charge, K is the Boltzman constant, T is the absolute temperature, H is the incident light intensity and b is a constant depending on the properties of the semiconductor junction.

Several researches have been carried out on the investigation of the environmental factors that influence output performance of solar PV modules. Kerr and Cuevas, (2003) presented a new technique that can determine the current–voltage (I–V) characteristics of PV modules based on measuring the open-circuit voltage (Voc) as a function of light intensity. Dzimano (2008) investigated the effects of temperature and radiation intensity on the performance parameters of amorphous hydrogenated silicon (a-Si:H) photovoltaic module. Likewise, Mustapha et al., (2009) investigated the effect of air mass factor on the performance of different types of PV modules.

This paper investigates experimentally the effect of relative humidity and light intensity on the output performance of monocrystalline and polycrystalline solar photovoltaic modules to account for the likely differences in the performance of the photovoltaic modules under the same physical conditions.

Materials and Methods

The instruments used in this research are the T720 Digital Mutimeter for measuring the light intensity, Reed CM-9930 200A True RMS AC/DC clamp meter for measuring the short circuit current (Isc),1 monocrystalline photovoltaic module and 1 polycrystalline photovoltaic Module. This research work was carried out at Owode area of Ogbomoso, Oyo state, Nigeria for a period of one month. The research work was performed by placing the monocrystalline and polycrystalline solar panels horizontally side by side on a specially designed stand of 2m height with their receiving flat surface facing sunlight directly. A multimeter was connected in series with each of the solar panels so as to take measurements of the maximum output voltage. Also, a clamp meter was connected in parallel to the solar panels so as to take measurements of the maximum current, Isc when shunt occurs (at the point when the voltage is zero). Secondly, measurements of the meteorological parameter under consideration with the aid of the T720 Digital Multimeter were recorded. Then, the power output for the two solar panels were calculated. All data were collected at interval of 30 minutes between the hours of 9.00am to 3.00pm for a period of one month 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 2m facing the sun. The average of the collated data such current, voltage, relative humidity and light intensity was estimated using Microsoft excel. The estimated data were further analyzed using Origin Lab Pro8.

Results and Discussion

The result shown in figure 1 (a & b) reveals that relative humidity decreases with changes in time of the day (9:00am to 3:00pm). **Whereas, the revers case transpired for** light intensity. As the time of the day changes the light intensity increased. It was then deduced that the luminous intensity increases with decrease in relative humidity, that is, the brighter the day the decrease in amount of water vapour in the air as presented in figure 2.

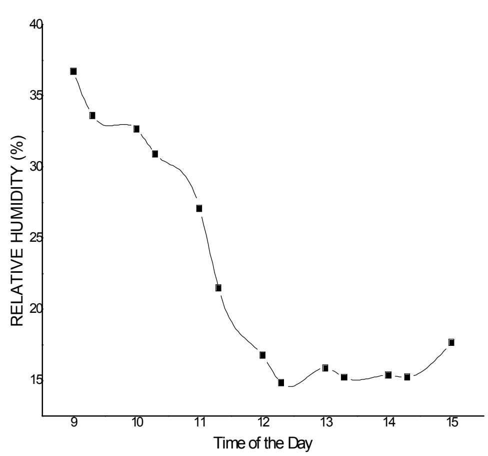
From figure 3 (a & b), the increase in light intensity has no significant effect on the output voltage. As recorded in the experimental work, voltage remains almost constant despite increase in light intensity. Hence, it can be said that light intensity has a direct effect on current. Increase in current is directly proportional to light intensity as recorded on both monocrystalline and polycrystalline solar panel used. Decrease in light intensity leads to decrease in current. This is because increase in light intensity causes an increase in number of photons from the sun which strikes the solar cell junction, thus increasing the electron pair production and the mobility carriers. The output current measured on monocrystalline photovoltaic module is slightly higher that of polycrystalline photovoltaic module as presented in figure 3 (b).

A very similar result was verified experimentally by El-Shaer *et. al.* 2014 in "Effect of Light intensity and Temperature on Crystalline Silicon Solar Modules Parameters" where a solar simulator was used to carry out the experiments under any constant light intensity and temperature. In the simulated work, it was recorded that for the two modules (monocrystalline and polycrystalline), the short circuit current, I_{SC} increases with increase the light intensity and that current parameters of silicon solar module are highly dependent on the light intensity level. Also, it can be noted from the result of El-Shaer *et al.,* (2014) that light intensity level has a crucial impact on current parameters of solar module rather than the voltage parameters. This is also similar to the results in our experimental work.

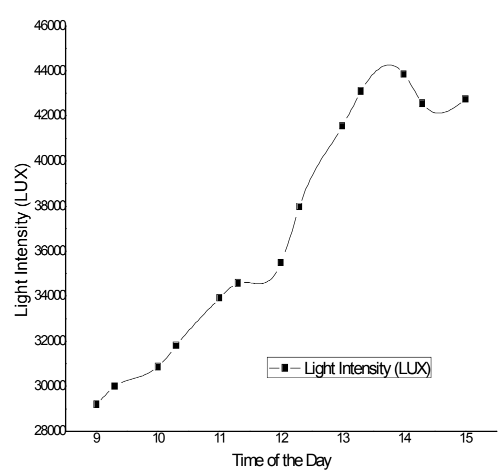
The result obtained in figure 4 (b) shows that relative humidity and output current are inversely proportional. With increase in relative humidity, there is decrease in output current of a PV module and vice-versa. Relative humidity has insignificant effect on output voltage for both monocrystalline and polycrystalline PV modules as shown in figure 4 (a). The result of the experimental work was in line with the discovery of Omubo-Pepple *et al*., (2013) which shows that when the relative humidity is low, output current increases.

In Figure 5 (b), it was also noted that, at the same value of light intensity the maximum power of monocrystalline solar panel was higher than that of polycrystalline solar panel. At an average light intensity of 29185LUX, the output power for monocrystalline photovoltaic module was 49W while that of polycrystalline photovoltaic module was 42W. This claim is also supported by the result from the experimental work of Abdelkader *et al.,* (2010) in "A Comparative Analysis of the Performance of Monocrystalline and Multicrystalline PV Cells in Semi-Arid Climate Conditions: The Case of Jordan". According to their work, while the efficiency of mono crystalline PV cells can reach 18%, the efficiency of multi –crystalline (Polycrystalline) PV cells reaches 16%. Hence the conclusion that the output power of mono crystalline is higher than that of multi crystalline PV cells.

Figure 5 (a) showed a higher output power for monocrystalline photovoltaic module but lower output power for polycrystalline photovoltaic module under the influence of relative humidity. It was observed that with a high relative humidity, there was decrease in the output power of polycrystalline PV could be as a result of the reduction in the output current on the PV. It can therefore be concluded that output power of a PV depends on the current produced in the PV and not necessary on measured voltage. The relative humidity and light intensity limits the current produced in a polycrystalline PV module hence resulting in its less effective performance.



(a)



(b)

Figure 1 (a & b): Variation of Relative Humidity and Light Intensity with Time of the Day

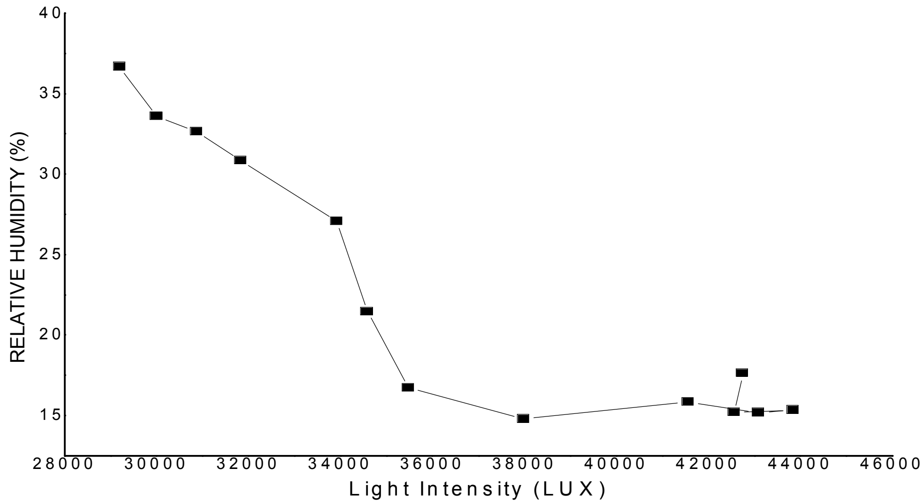


Figure 2: Variation of Relative Humidity with Light Intensity

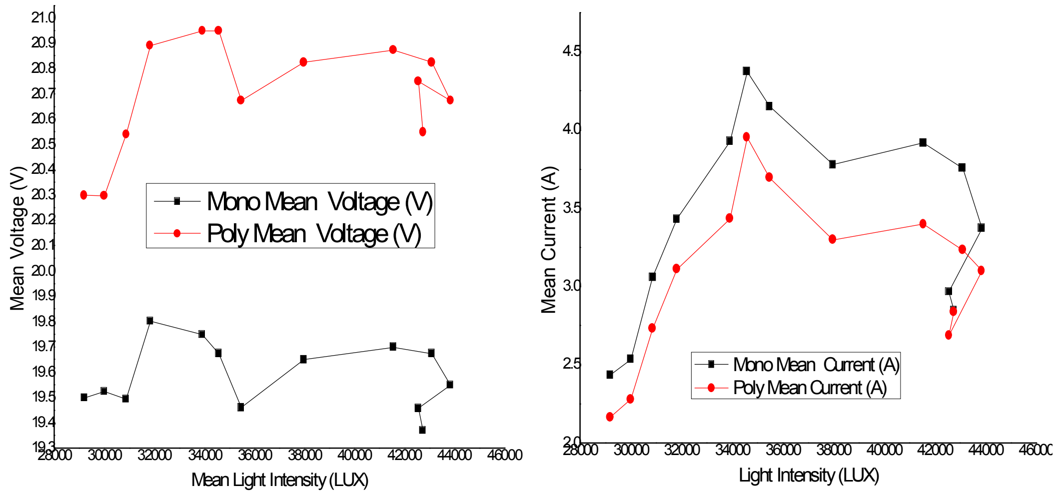


Figure 3 (a & b): Variation of measured current on Monocrystalline and Polycrystalline photovoltaic modules with Relative humidity and Light Intensity respectively

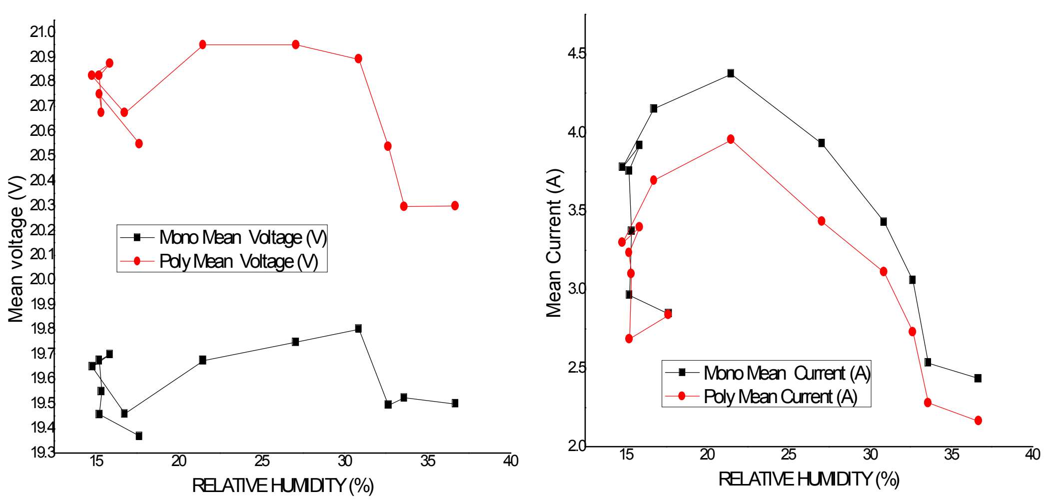


Figure 4 (a & b): Variation of measured voltage and current with Relative humidity and Light Intensity respectively

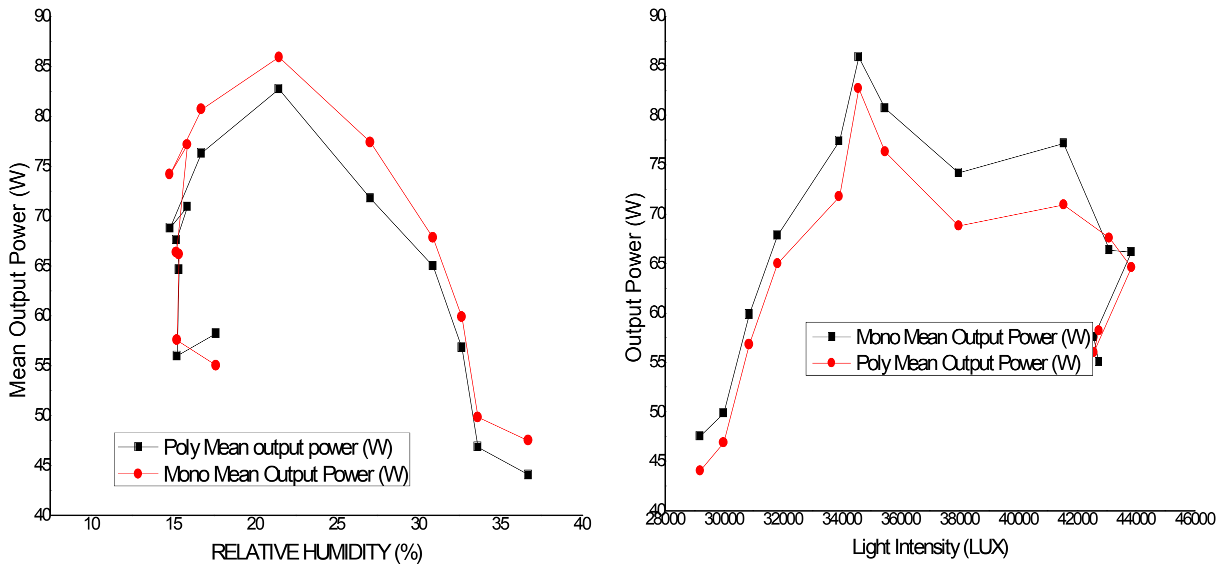


Figure 5 (a & b): Variation of estimated output power on Monocrystalline and Polycrystalline photovoltaic modules with Relative Humidity and Light Intensity respectively

Conclusion

As a result, increase in light intensity is a favorable factor for increase in output power and the current produced by the photovoltaic module. The higher the light intensity, the better the output efficiency of the modules. However, increase in relative humidity results in decrease in output current. Also, it has been established while being supported by other research work that increase in relative humidity and light intensity has no significant effect on the output voltage. In conclusion, increase in light intensity and decrease in relative humidity results in a higher efficiency of monocrystalline PV module when compared to a polycrystalline PV module.

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