Research Inventy: International Journal Of Engineering And Science
Vol.3, Issue 12(December 2013), PP 10-14
Issn(e): 2278-4721, Issn(p):2319-6483, Www.Researchinventy.Com

The Effect of Temperature on the Performance of A Photovoltaic Solar System In Eastern Nigeria

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ABSTRACT : *This paper presents the influence of the ambient temperature on the performance of a stand-alone photovoltaic solar system at Nnamdi Azikiwe University, Awka, Nigeria. This system composed of a PV generator, DC-Dc adaptor, Deep Cycle Trojan batteries, maximum power point tracking (MPPT) charge control, LED lamp heads and circuit breakers. The MPPT control allows the extraction of the maximum output power delivered by the PV generator. This research was carried out by monitoring the variation in power output of the system with ambient temperature of the area during dry and raining seasons in the year 2013. From the results, there is an indirect proportionality between the power output performance of the system and the ambient temperature. The results indicate that PV solar panels must be installed at a place where they receive more air currents so that the temperature remains low while the output remains high.*

I. INTRODUCTION

It is very common in the recent days that people are now seeking for renewable energy in order to replace the current fossil fuels. This is due to the extinction of fossil fuel in the beneath surface of the earth and people cannot depend on it forever. One of the most potential renewable energy found is solar energy. Solar energy is the radiant heat and light from the sun that has been used by humans since ancient times using a wide range of technologies. One of the wide applications of solar energy is photovoltaic (PV). PV is the field of technology and research related to the application of solar cells for energy by converting sunlight directly into electricity by the photovoltaic effect. Solar panels, photovoltaic arrays and solar modules are made by assemblies of solar cells. Increasing efforts are directed towards reducing the installation costs and enhancing the performance of photovoltaic systems so that the system can be deployed at a large scale. However, PV solar cells are semiconductor devices which directly convert energy into electricity (Muneer, 2005). Solar cells operate as a quantum device exchanging photons for electrons. Photons from the sun with sufficient energy near the depletion region of a p-n junction produce electron-hole pairs. If these electrons have enough energy, they will move to the conduction band, leaving holes in the valence band. The potential difference across the depletion region provides an electric field that pulls the electron to the n-region and hole to the p-region. The newly free electron can then flow from the n-region to the p-region and recombines with the newly created holes. In this way the energy of the incident photon is converted. 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).

The open circuit voltage and short circuit current 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 I_o 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.

II. MATERIALS AND METHODS

For the study the researcher used four photovoltaic solar panels connected in series. Each solar module containing seventy two monocrystalline silicon solar cells rated 42W and 35V each. A 5.7KΩ variable resistor was used as a load in this study. A low resistance ammeter, high resistance voltmeter and five in one Auto Raging Digital Multimeter were used for monitoring and measuring the output current, and voltage. We also used the Davis Weather Vantage Pro 2 installed at UNIZIK STATION I to measure the temperature and other climatological factors.

Experimental Set Up

The PV array includes the four monocrystalline silicon solar modules connected in series configuration. They were mounted horizontally on an iron roof at an angle of 6.06^{o} the latitude of Awka and installed at the two female hostels of Nnamdi Azikiwe University, Awka as shown in fig. 1. The PV generator generates up to 150V daily for powering the security lights in and around the hostels at night.

Fig. 1: The cubicle housing the PV system

A low resistance voltmeter was connected in series while a high resistance voltmeter was connected in parallel to the 5.7KΩ variable resistor used as the load. The circuit diagram of the experimental set up is as shown in fig. 2.

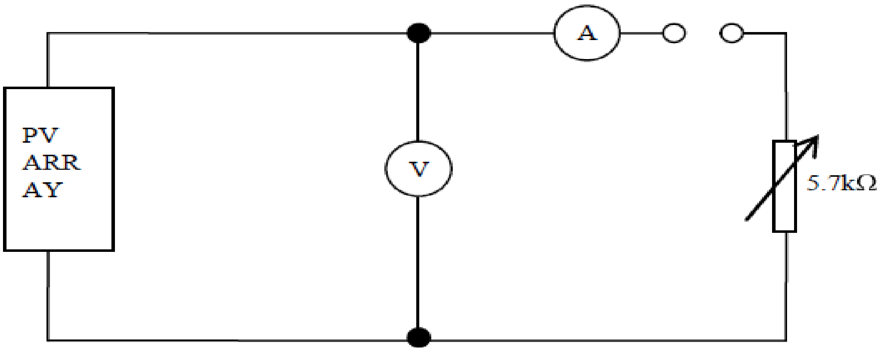

Fig. 2: Circuit diagram of the experimental set up

Measurements

Maximum output current and voltage of the photovoltaic solar array were measured and recorded everyday at interval of one hour during the day with the aid of ammeter and voltmeter. From the recorded values, the researcher was able to estimate the daily and monthly average values of the output currents and voltages. Also daily and monthly values of maximum power outputs of the PV solar system were computed.

The daily ambient temperature was measured and recorded at intervals of an hour using the Davis Vantage Pro 2 Data logger for the period under investigation.

III ANALYSIS AND RESULTS

Fig. 3-7 shows the monthly variations of ambient temperature for both the dry and rainy seasons. From the graphs it was observed that we recorded the highest temperature during the dry season hence leading to very power output from our PV system. Since some of the energy produced are lost in form of heat. At night time it was observed that the security lights go out before dawn. During the raining season we do get very good lighting at night from dusk to dawn. Hence we confirm from the pattern of variation, that the ambient temperature varies with the different months of the year throughout the period of study. From the graphs the maximum values of ambient temperature in the months of December, January and February were attributed to the high solar radiation intensity received. It was also observed that the PV generator has maximum power output in the months of March, April and May as a result of little or no cloud, dust free and low humidity.

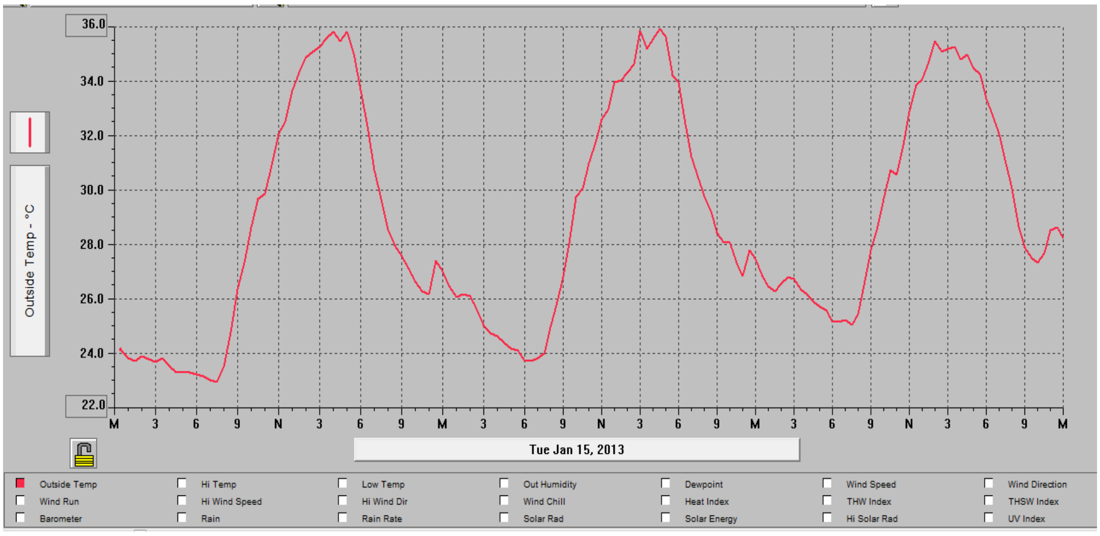

Fig 3: Temperature variation for the month of January, 2013

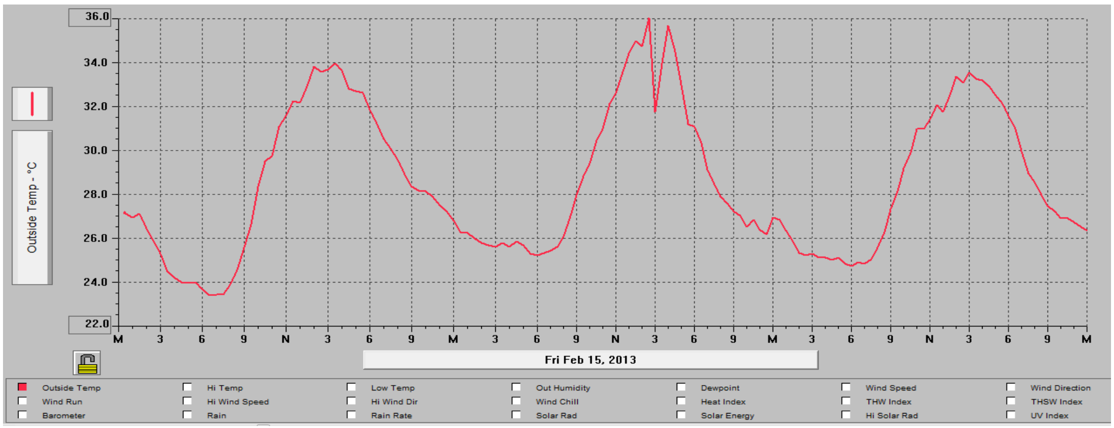

Fig 4: Temperature variation for the month of February, 2013

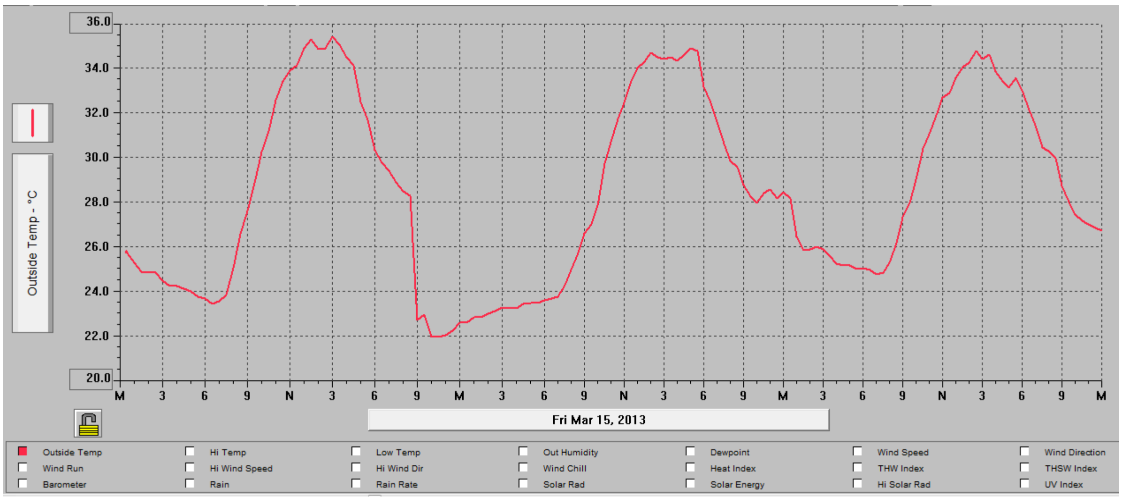

Fig 5: Temperature variation for the month of March, 2013

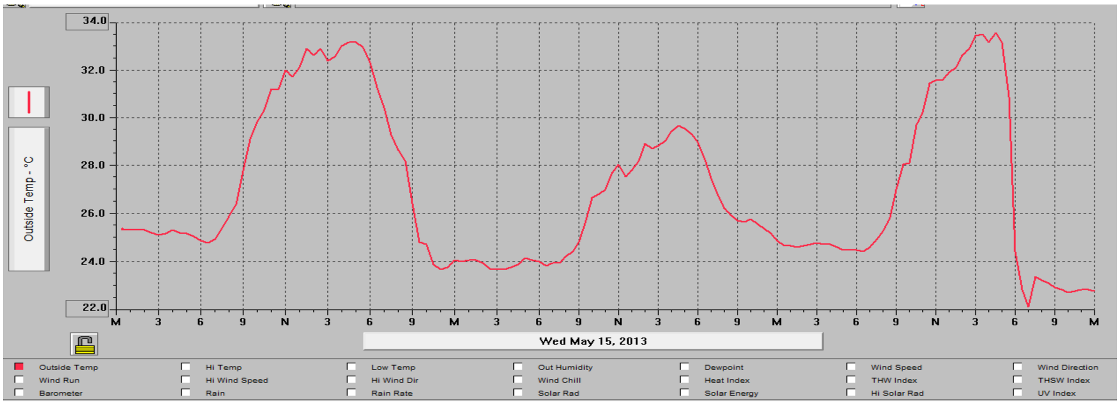

Fig 6: Temperature variation for the month of April, 2013

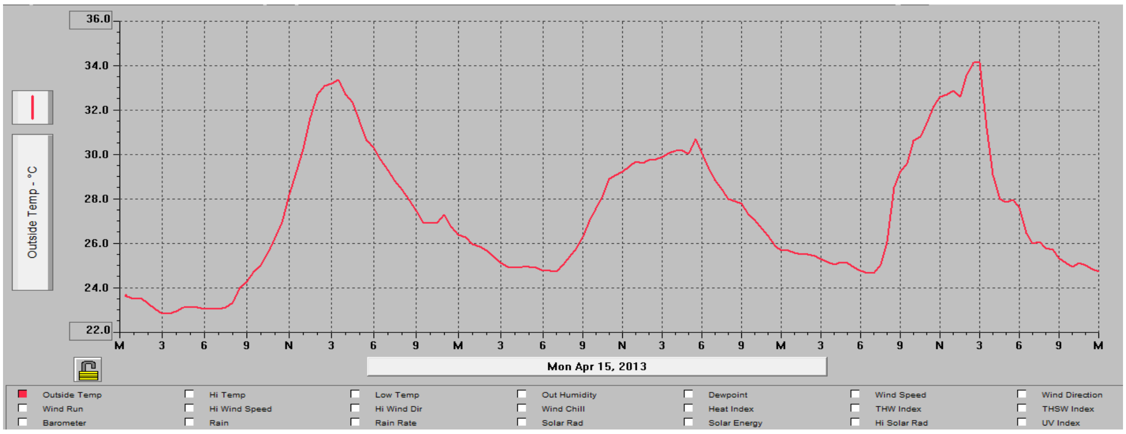

Fig 7: Temperature variation for the month of May, 2013

Moreover, in the case of the second main period, between the months of May and October. The minimum values of ambient temperature recorded were attributed to the reduction in intensity of solar radiation, due to rainy cloud high humidity of air and air blowing from the ocean towards land.

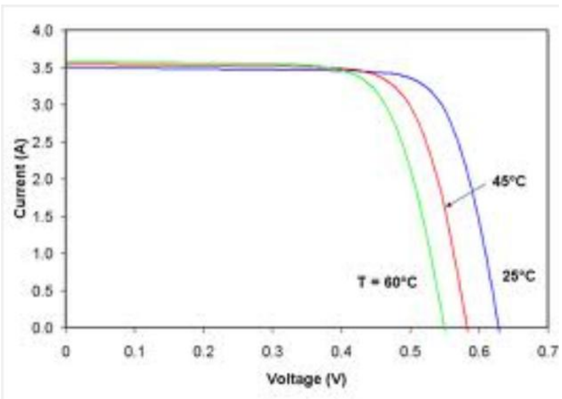

Fig. 8: IV Characteristics for the months of December – February, 2013

Fig. 8 shows the IV characteristics in the months of December to February 2013 which indicates low output power as a result of loss of energy in form of heat, also the IV characteristics indicates high output power for the months of March to May, 2013. Fig. 9 shows the indirect relation between the solar cell’s output power and the ambient temperature.

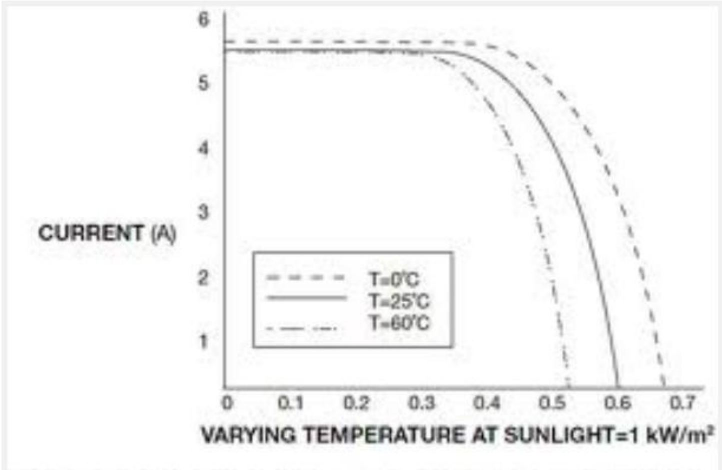

Fig 9: The solar cell's output voltage decreases with an increase in temperature

IV CONCLUSION

The effect of ambient temperature on the performance of a stand-alone photovoltaic solar system installed at the two female hostels of Nnamdi Azikiwe University, Awka was investigated. The results show that there is an indirect proportionality between the power output produced by the system and the ambient temperature of the locality. Thus the application of photovoltaic technology in the conversion of solar energy to electricity is not favourable during the period of very high ambient temperature than the period of low ambient temperature. The results indicated that PV solar panels must be installed at a place where they receive more air current so that the temperature remains low while the power output remains high.

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