Impact of Wind on the Output of Photovoltaic panel and Solar Illuminance/Intensity

Joseph Amajama[1], Julie C. Ogbulezie[2], Nsed A. Akonjom[3], Victor C. Onuabuchi[4]

[1 & 2]Electronics and Computer Technology Unit, Department of Physics, University of Calabar – Nigeria

[3]Department of Physics/Geology/Geophysics, Federal University Ndufu-Alike Ikwo – Nigeria

[4]Department of Science and Computer Education, Enugu State University of Science and Technology – Nigeria

joeamajama2014@yahoo.com; +234-7036357493

Abstract— The impact of Wind on the output of photovoltaic panel and solar illuminance/intensity has been probed. The collision of the molecular particles of the air with that of the photonic particles of the sun results in a change in the propagation direction of the falling photonic particles towards the opposite direction of the incident air particles. Hence, at near constant air temperature of 87 $\pm$ 3 ^{0}F, air pressure of 29.87 $\pm$ 0.04 inHg, relative humidity of 72 $\pm$ % and solar illuminance/intensity of 18000 $\pm$ 6000 Lux; photovoltaic panel outputs (short circuit current and open circuit voltage) and solar illuminance/intensity are favoured by increase in wind speed: that is, when the wind is towards the front of an observer (or panel) with the sun, some distance away in front and when the wind is towards the back of the observer (or panel) and the sun is behind. But, it is unfavourable when the wind's direction is towards the back of an observer (or panel) and the sun is some distance in front of the observer (or panel) or the sun is some distance behind the observer (or panel) and the wind direction is towards the front of the observer (or panel). For short, under same weather conditions, solar illuminance/intensity is favoured when the direction of the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase. Similarly under similar weather conditions, the output of a photovoltaic panel is favoured when the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase.

Keywords— Impact, Wind, Output, Photovoltaic panel, Solar illuminance, Solar intensity, Weather parameters and Particles.

INTRODUCTION

The photovoltaic panel is one of the green power generation technologies. Today, it finds application more than ever before in space crafts, marine navigation aids, telecommunication, cathodic protection, water pumping, remote area power supply (RAPS) systems and many others [1]. There is an ever-growing quest by power generation scientists and engineers to enhance the power efficiency of photovoltaic panels.

Photovoltaic cells are made of semiconductors materials such as Silicon (Si) or Cadmium Telluride (CdTe) [2]. Solar radiation is the energy that drives the photovoltaic cells. Solar radiations consist of high energetic particles [3]. These particles from the sun are observed in the form of light. As the particles rain on photovoltaic panels, electrons (or holes) are extracted and excited and generate current. The design of the semiconductor diode ensures that the released electrons move in a single or uniform direction and produces electricity [4]. Sets of solar cells are combined to make a solar panel. The amount of solar radiation/particles (solar illuminace/intensity) has a marked effect on the output of photovoltaic panel [5].

The amount of solar radiation reaching the earth's surface varies greatly because of changing atmospheric conditions and the changing position of the sun [6]. The atmospheric condition of a place at a particular time defines the weather of that place [7]. Weather parameters: air temperature, air pressure and relative humidity affect the output performance of the photovoltaic panel [8] [9] [10]. Wind is one of the weather parameters. This paper seeks to search the effect of wind on photovoltaic panel.

RESEARCH METHODOLOGY

Measurement of weather parameters: air temperature, air pressure, relative humidity and wind speed and direction were done intermittently in the course of daylight and simultaneously, solar illuminace/intensity and output voltage and current (open circuit voltage and short circuit current) of the photovoltaic panel.

The coordinates of the location in Calabar Metropolis where the experiment was carried out is: 4057'31.7"N, 8020'49.7"E. The measurements of the weather parameters: air temperature, air pressure, relative humidity and solar illuminance/intensity were done only when the direction of the wind was in the (west south west) WSW direction. This is because; the location where the experiment was carried out was WSW to the rising sun from the east (E). The measurements were done between the hours of 6 am and 2 pm just before the sun starts sailing towards the west (W). This was done to reach a verdict on the wind speed effect on the photovoltaic panel output.

The photovoltaic panel is the mono-crystalline cell type with 1.5 W, 12V rating. The dimension of the photovoltaic plate, excluding the metallic frame of the panel is 45 cm by 14.5 cm. The panel was mounted on a platform of about 105 cm and exposed to direct sunlight. The outputs of the photovoltaic panel (current and voltage) were measured with the aid of a multi-metre and the solar illuminance/intensity was measured with a Digital Illuminance Meter (DT-1309 model).

RESULT AND ANALYSIS

The following figures where deduced from the experiments. Figs 1, 2, 3, 4, 5 and 6 show: Output Current versus Wind's Speed (WSW) without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity; Output current versus Wind (WSW) at near constant Air temperature (87 $\pm$ 3 ^{0}F), Air pressure (29.87 $\pm$ 0.04 inHg), Relative humidity (72 $\pm$ 6 %) and Solar illuminance/intensity (18000 $\pm$ 6000 Lux); Output Voltage versus Wind's Speed (WSW) without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity; Output current versus Wind (WSW) at near constant Air temperature (87 $\pm$ 3 ^{0}F), Air pressure (29.87 $\pm$ 0.04 inHg), Relative humidity (72 $\pm$ 6 %) and Solar illuminance/intensity (18000 $\pm$ 6000 Lux); Output Voltage versus Wind' Speed (WSW) without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity and Output current versus Wind (WSW) at near constant Air temperature (87 $\pm$ 3 ^{0}F), Air pressure (29.87 $\pm$ 0.04 inHg), Relative humidity (72 $\pm$ 6 %) and Solar illuminance/intensity (18000 $\pm$ 6000 Lux).

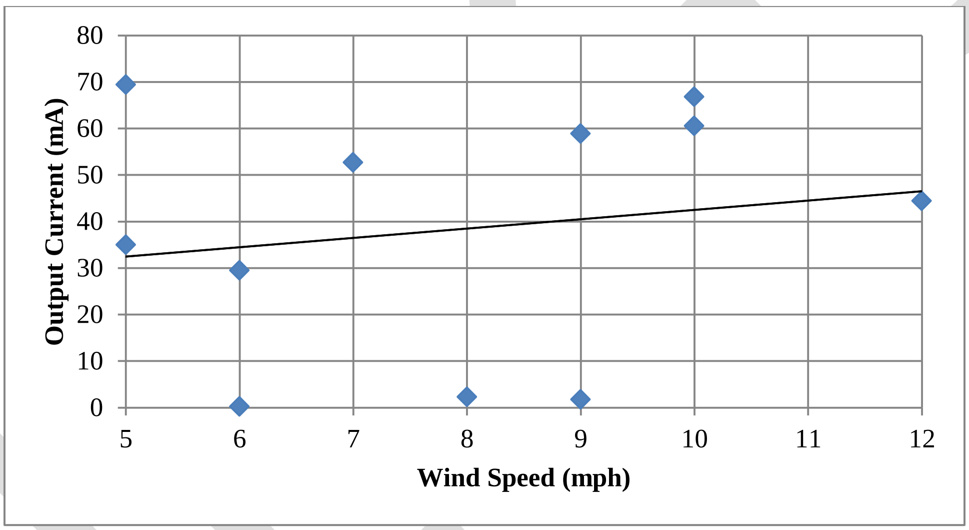

Fig.1: Output Current versus Wind's Speed (WSW) without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity

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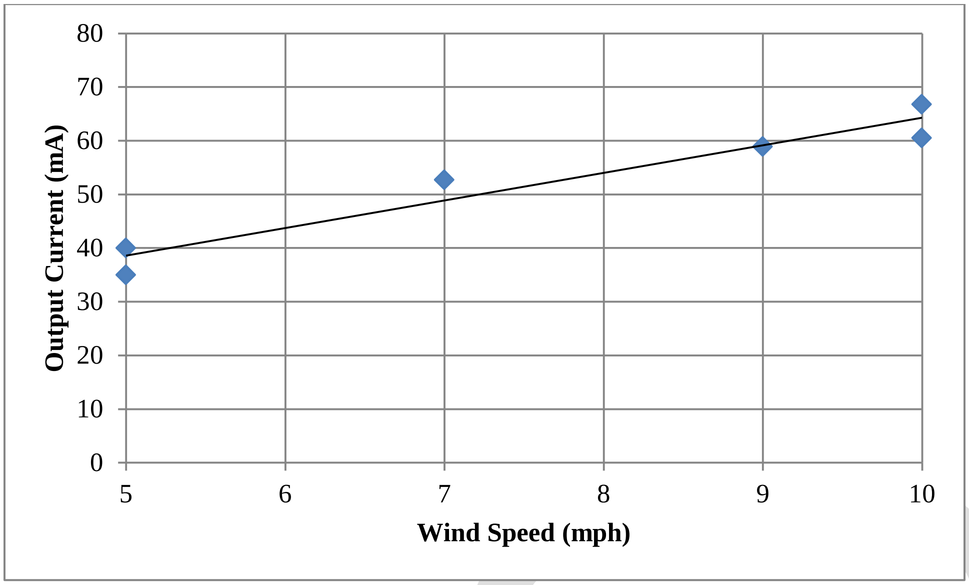

Fig. 2: Output current versus Wind (WSW) at near constant Air temperature (87 $\pm$ 3 ^{0}F), Air pressure (29.87 $\pm$ 0.04 inHg), Relative humidity (72 $\pm$ 6 %) and Solar illuminance/intensity (18000 $\pm$ 6000 Lux)

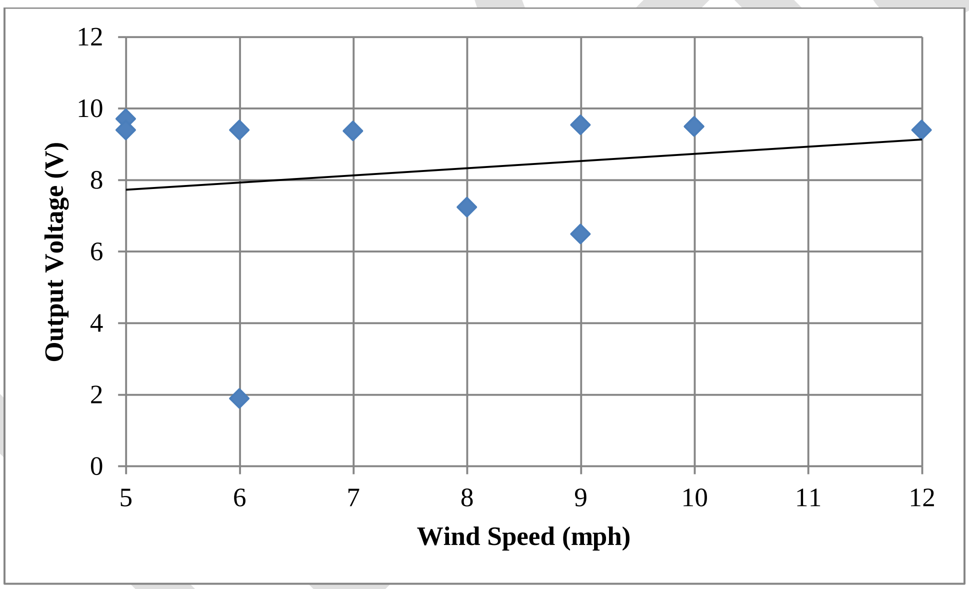

Fig. 3: Output Voltage versus Wind Speed (WSW) without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity

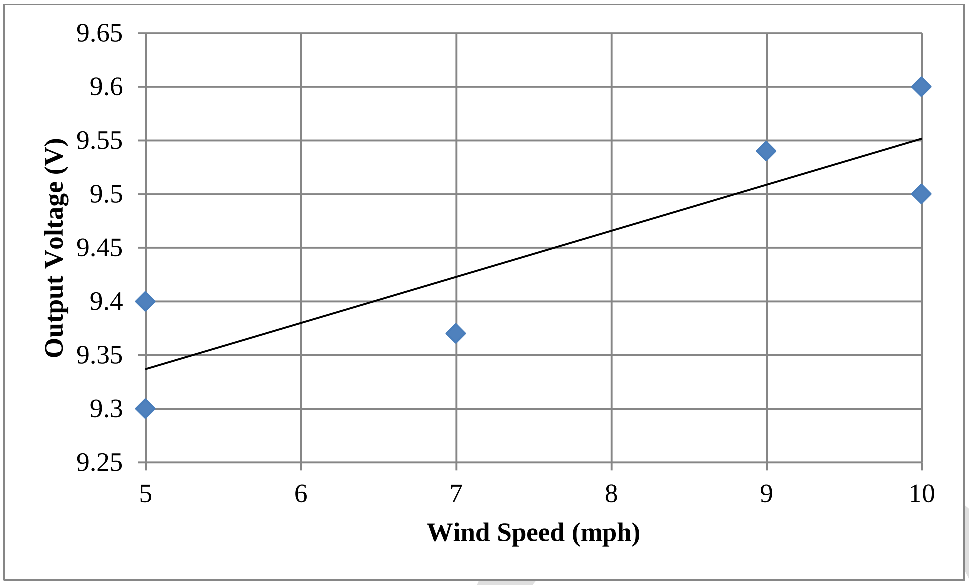

Fig. 4: Output current versus Wind (WSW) at near constant Air temperature (87 + 3 ^{0}F), Air pressure (29.87 + 0.04 inHg), Relative humidity (72 + 6%) and Solar illuminance/intensity (18000 + 6000 Lux)

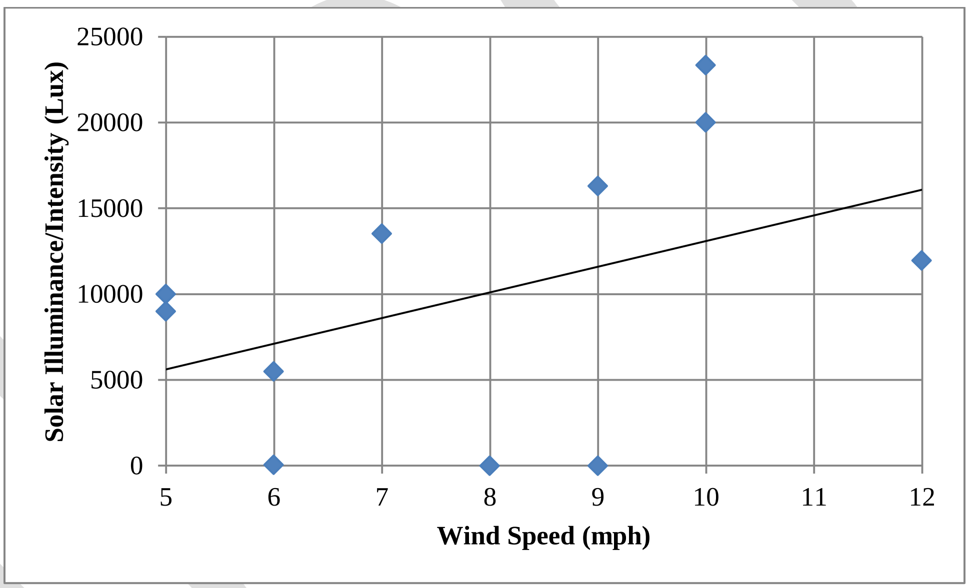

Fig. 5: Wind''s Speed (WSW) and Solar illumination/intensity without observing constant Air temperature, Air pressure, Relative humidity and Solar illuminance/intensity

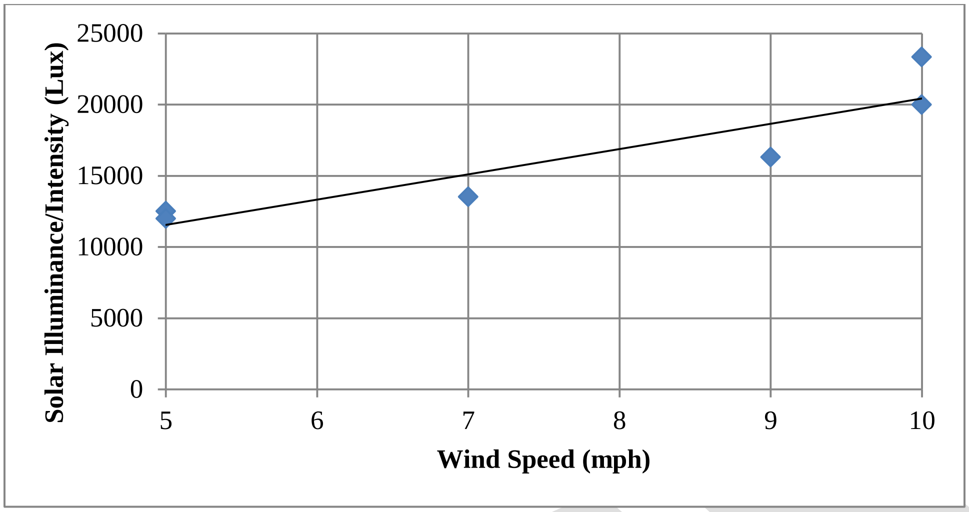

Fig. 6: Output current versus Wind (WSW) at near constant Air temperature (87 ± 3 ^{0}F), Air pressure (29.87 ± 0.04 inHg), Relative humidity (72 ± 6%) and Solar illuminance/intensity (18000 ± 6000 Lux)

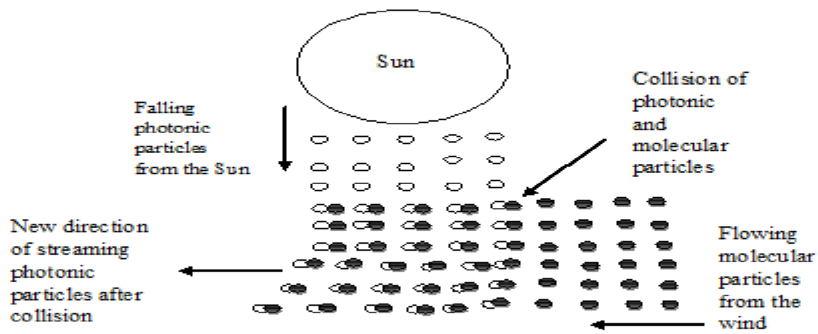

Fig. 7: Reflection of solar particles after collision with air molecular particles

Earlier research has shown that wind has an effect on propagating radio waves [11]. The radio waves transmit better if the wind propagates in a similar path as the wave from the transmitter antenna to the receiver antenna, but worse in the contrary direction [11]. That is, the speed of the wind waves aids the radio waves propagation to some extent if it is coursing parallel to the signal, but becomes detrimental when the wind wave is tangential or anti-parallel. In a mathematical light, the wind wave has a direct proportional relationship with the strength of radio waves if both are travelling in a parallel direction from the transmitter to the receiver antenna, but an inverse proportional relationship when they are at a tangent [11].

Electromagnetic radiations share similar properties [12]. Solar radiations are electromagnetic radiations just like radio waves. They are made up of photonic particles that exhibit waves. Similarly, the wind is a natural motion of air, strong enough to be felt [13]. The air is made of molecular particles that also exhibit waves in the form of a wind. The collision of the molecular particles of the air with that of the photonic particles of the sun results in a change in the propagation direction of the falling photonic particles towards the opposite direction of the incident air particles as captured in Fig. 7.

Hence, in the experiment conducted, the wind's direction was observed steady to deduce the effect of the wind' speed on the output of the photovoltaic panel. The position of the area where the experiment was conducted was in the WSW direction to the rising sun from E and measurements were taken when the wind was in the WSW direction. Figs 1, 2, 3 and 4 show that the output of the photovoltaic panel, that is, short circuit current and open circuit voltage increased slightly with increase in the wind's speed. This led to a conclusion, extracted from the representation in Figs 2 and 4 that: assuming all other weather parameters are observed constant: the wind's speed enhances the photovoltaic panel's output, if the wind's direction is towards the front of the panel and the sun is at some position away in front of the panel or the wind is towards the back of the panel and the sun is some distance behind the panel. The contrary of the output performance will be registered when the wind's direction is towards the back of the panel with the sun some position in front of the panel or the sun is some distance behind the front of the panel and the wind's direction is towards the front of the panel.
Also, Figs 5 and 6 have shown that: solar illuminace/intensity increases when the wind's speed is increased, with the wind's wave towards the front of an observer and the sun is some distance in front of the observer, but it is contrariwise when the wind's direction

is towards the back of the observer with the sun some position away in front of the observer or the wind's wave is towards the front of the observer and the sun is some distance behind the observer. Hence, Fig 5 spells; if other weather parameters are observed constant: solar illuminance/intensity is empowered by wind's speed, if the wind is towards the front of the observer and the sun is in front of the observer or the wind is towards the back of the observer and the sun is some distance behind the observer. And, solar illuminance/intensity is depowered when the wind is towards the front of the observer and the sun is some distance behind the observer or the wind is toward the back of the observer and the sun is some distance in front of the observer.

CONCLUSION

The research has shown that wind speed enhances photovoltaic panel's output when the wind is towards the front of the panel with the sun some distance away in front of the panel or the wind is towards the back of the panel and the sun is some distance behind the panel. The contrary of the performance above is the case when the wind towards the panel's front and the sun is some distance away behind the panel or the wind is towards the back of the panel and the sun is some distance in front and of the panel. Also, solar illuminance/intensity strength is increased with wind's speed, when the wind wave is towards the direction of the front of the observer with the sun some distance in front of the observer or the wind's direction is towards the back of the observer and the sun is behind the panel. But, the output performance is contrariwise when the wind's wave is towards the observer's back with the sun some distance in front of the observer or the wind's wave is towards the front of the observer and the sun is some distance behind the observer.

Hence, photovoltaic panel outputs (short circuit current and open circuit voltage) and solar illuminance/intensity are favoured by increase in wind speed when the wind is towards the position of observer's (or panel's) front with the sun some distance away in front of the observer or when the wind's direction is towards the back of the observer (or panel) with the sun behind the observer (or panel), but unfavourable when the wind is towards the position of the front of the observer (or panel) and the sun is some distance behind the observer (or panel) or the wind's direction is towards the back of the observer (or panel) and the sun is in front of the observer (or panel).

For short, under same weather conditions, solar illuminance/intensity is favoured when the direction of the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase. Similarly under similar weather conditions, the output of a photovoltaic panel is favoured when the propagation of the solar photonic particles are in phase with the molecular particles of the wind and unfavoured when out of phase

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