EFFECT OF CLEAR – SKY INDEX DISTRIBUTION AND RELATIVE HUMIDITY ON PV OUTPUT POWER IN OWERRI NORTH L.G.A IMO STATE.

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ABSTRACT
This research paper determine the effect of clear-sky index distribution and relative humidity on PV output power in Owerri local government area of Imo state, data were collected using okta frame to obtained the clear-sky index distribution and digital hygrometer to obtain the relative humidity. There is the reduction of the solar radiation due to increase clear sky index distribution and relative humidity which interrupts the path of beam or direct radiation, and as a result, only diffused radiation falls on the solar PV. The diffused radiation has lesser value of useful radiation which reduced the output power by a significant value. The highest value is at 84.5% by 10.00 local time and lowest value is 45.00% by 14.00 local time, with a positive correlation of 0.41 between output power and clear sky index for 30 days and as relative humidity decreases to 71.80% output power increases steadily with a weak negative correlation of -0.62.

Keyword: **PV system, output power, clear sky index, relative humidity.**

1. INTRODUCTION

A solar cell or photovoltaic cell is a device which generates electricity directly from the Sunlight. However, their efficiency is fairly low. It is a fact that the weather changes every day, and the earth's position towards the sun changes throughout the year. The variation in the power output of a photovoltaic (PV) system is largely because of differing amounts of weather parameters, which play a vital role in the amount of power output of the photovoltaic cell. Parameters such as clear sky index, relative humidity, ambient temperature and dust accumulation etc. affect the total energy a solar panel system can produce.

Since clouds are the largest attenuating factors of solar irradiance in large areas of the globe (Wacker *et al*., 2015), cloud cover is a useful predictor of solar resource (Kasten and Czeplak, 1980). If the sky is cloudless, irradiance can be predicted from the solar geometry, surface albedo, and optical properties of aerosols, ozone and water vapour using a radiative transfer calculation(Műller, *et al*., 2012). The power generation with solar cells system has received great attention in research because it appears to be one of the possible solutions to the environmental problem (Wai, *et al*., 2008; Aribisala 2013).

The clear-sky index exhibits a distribution of values for each cloud cover bin, measured in eighths of the sky covered (oktas) and also depends on solar elevation angle(Anand*et al.* 2009; Smith *et al*., 2017). The working of solar PV panel is totally dependent on the solar radiation falling on it, cloud condition reduces this radiation, thus the need to investigate. In normal condition, the radiation which is falling on the panel is global radiation. Global radiation has two components; one is beam radiation and second is diffused radiation. The beam radiation is direct radiation and it is the major part of radiation which is used to generate the electricity. In cloud

condition, a shadow effect reduces the beam radiation which ultimately affect the output power of a PV system. Humidity as a weather parameter is also an important parameter in the determination of the amount of cloud cover, thus the output power of a solar panel. Generally, high relative humidity is experienced in the morning and evening hours while low relative humidity is experienced in the noon hours (Ettah, *et al*., 2015).

In this paper, we which to determine the effects of relative humidity and the clear sky of Owerri metropolis on the power output of a commercially available PV panel. This study will enable aid proper design and installation of PV panel for effective utilization. Since it is well established that in this energy driven high technological society, photovoltaic system still serves as one of the best form of energy generation which does not pose any threat to the environment.

2. MATERIAL AND METHODOLOGY

Owerri is the capital of Imo state in Nigeria, set in the heart of Igbo land. Owerri area consists of three Local Government Area including Owerri Municipal, Owerri north and Owerri west. It has an estimated population of about 715800 as of 2015 and is approximately 100 square kilometers' (40sq mi) in area. Owerri is bordered by the Otamiri River to the east and Nworie River to the south. The Owerri slogan is the Heartland. The latitude of Owerri, Imo Nigeria is $5^0$28'N and longitude 7^0 1'E.Owerri has a Tropical wet climate according to the Koppen-Geiger system. Rain falls for most months of the year with a brief dry season. The Harmattan affects the city in the early periods of the dry season and it is noticeably less pronounced than in other cities in Nigeria. The average temperature is 26.4^{o}C (Accuweather, 2018).

The electrical specification of PV panel used in the experiment is given in Table 1. Other materials used include: theOkta frame – for measuring the clear sky index; the Digital multimeter – for measuring the voltage and current output of the solar panel that will be used to calculate the output power of the total setup ($P = I \times V$); Digital hygrometer – for measuring the relative humidity; Digital cameras – for capturing the image of the cloud at every interval, since they are not stationary but continuously varying; Incandescent bulb – it serves as a means to measure the direct current load.

In the experiment, solar photovoltaic panel were mounted inoutdoor and away from any obstruction. This experiment was conducted for a period of 30 days from 10.00 hours local time to 16.00 hours local time which is the period of solar radiation and data were obtained at an interval of 30 minutes. The data obtain for the clear sky index through the okta frame (0/8, 1/8, 2/8, 3/8, 4/8, 5/8, 6/8, 7/8, 8/8) were converted to their equivalent percentages and the value of relative humidity were obtained at every 30 minutes interval for a period of 30 days from the hour of 10.00G.M.T to 16.00 G.M.T

Table 1. Electrical specification of PV panel

Specification of Solar Photovoltaic Module	**Rating**
Maximum Power (P_{max})	**40.0 W**
Output Tolerance	**±5%**
Current at P_{max} (Imp)	**2.3 A**
Voltage at P_{max} (Vmp)	**17.5 V**
Short Circuit Current (Isc)	**2.6 A**
Open Circuit Voltage (Voc)	**22.1 V**
Temperature of Module	**25.0^{0}C**
Air Mass (AM) - Assumed	**1.5**
Power Rating/Area	**1000.0 W/m^2**
Dimension	**66.0 cm x 48.0 cm**

3. RESULT, ANALYSES AND DISCUSSION

Table 2: The Average and Logarithm Values of Clear Sky Index Values and Relative Humidity for 30 Days of Solar Photovoltaic Panel in Owerri North. (Cloud Cover (CC), Relative Humidity (RH), Voltage (V), Current (I) and Power (P).

DAYS	CC (%)	Log CC	RH (%)	Log RH	V (V)	Log V	I (A)	Log I	P (W)	log P
1	46.1	1.664	74	1.869	23.3	1.367	0.57	-0.244	13.4	1.127
2	53.3	1.727	70	1.845	23.-0	1.362	0.75	-0.125	17.4	1.241
3	54.8	1.739	84	1.924	22.8	1.358	0.34	-0.469	7.13	0.853
4	54.8	1.739	68	1.833	22.7	1.356	0.88	-0.056	20.2	1.305
5	59.6	1.775	80	1.903	22.7	1.356	0.61	-0.215	14.0	1.146
6	57.6	1.760	76	1.881	23.3	1.367	0.79	-0.102	18.6	1.270
7	61.5	1.789	73	1.863	24.7	1.393	0.80	-0.097	19.5	1.290
8	69.2	1.840	73	1.863	23.1	1.364	0.62	-0.208	14.4	1.158
9	59.6	1.775	70	1.845	22.9	1.360	0.84	-0.076	19.6	1.292
10	48.0	1.681	79	1.898	22.8	1.358	0.77	-0.114	17.9	1.253
11	91.3	1.960	75	1.875	22.8	1.358	0.70	-0.155	14.6	1.164
12	84.6	1.927	73	1.863	23.1	1.364	0.76	-0.119	19.6	1.292
13	81.7	1.912	75	1.875	22.8	1.358	0.79	-0.102	18.3	1.262
14	92.3	1.965	86	1.934	23.6	1.373	0.54	-0.268	12.7	1.104
15	99.0	1.996	83	1.919	23.1	1.364	0.41	-0.387	9.6	0.982
16	46.1	1.664	73	1.863	24.9	1.396	0.76	-0.119	22.7	1.356
17	60.5	1.782	81	1.908	23.2	1.365	0.73	-0.137	17.2	1.236
18	99.0	1.996	81	1.908	23.2	1.365	0.49	-0.310	11.6	1.064
19	99.0	1.996	79	1.898	23.0	1.362	0.55	-0.260	12.8	1.107
20	12.5	1.097	71	1.851	23.1	1.364	0.83	-0.081	19.2	1.283
21	35.5	1.550	77	1.886	22.7	1.356	0.61	-0.215	15.8	1.199
22	18.2	1.260	81	1.908	23.1	1.364	0.72	-0.143	16.8	1.225
23	37.5	1.574	76	1.881	23.5	1.371	0.69	-0.161	16.4	1.215
24	54.8	1.739	73	1.863	22.4	1.350	0.74	-0.131	15.0	1.176
25	76.9	1.886	69	1.839	23.0	1.362	0.67	-0.174	16.6	1.220
26	23.0	1.362	71	1.851	23.2	1.365	0.71	-0.149	16.5	1.217
27	49.0	1.690	78	1.892	23.3	1.367	0.86	-0.066	20.4	1.310
28	89.4	1.951	78	1.892	23.9	1.378	0.56	-0.252	13.5	1.130
29	51.9	1.715	74	1.869	23.8	1.377	0.73	-0.137	22.9	1.360
30	65.3	1.815	76	1.881	23.5	1.371	0.78	-0.108	18.3	1.262

In Table 2, we show the daily average and the corresponding logarithm values used in the analysis of the observed clear sky index and relative humidity with the measured current, voltage

and the estimated output power by using the observation made at the interval of 30 minutes from 10.00 hours local time to 16.00 hours local time for 30 days period in the Month of March 2018. The use of the logarithm values is necessary due to the expected large variation in the observed values. We also carry out a one dimensional regression analysis on the observed/ estimated parameters to determine dependence of the parameter on one another. The power law index for any two parameter (x, y) is given by $y \propto x^{m \pm n}$, where m the power law index determines the strength of the relation and n the associated error determines the level of scatter in the relation.

The correlation coefficients r, and the power-law index values between P/CC, P/RH and RH/CC is shown in Table 3, while the plots of the of the scatter plots between the parameters is shown in figures 1-3. The correlation coefficient results indicate that a mild direct relation between cloud cover and relative humidity, an inverse but relatively strong correlation between the output power of a PV and cloud cover, but a strong and inverse correlation between humidity and output power for the month of March for Owerri metropolis.

Table 3: Correlation Coefficient and the Power-law fit to the Observed Parameters

Parameter	r	Power-Law fit
CC/RH	0.31	$RH \propto CC^{1.97 \pm 0.21}$
CC/P	-0.41	$P \propto CC^{0.16 \pm 0.02}$
RH/P	-0.62	$P \propto RH^{2.57 \pm 0.09}$

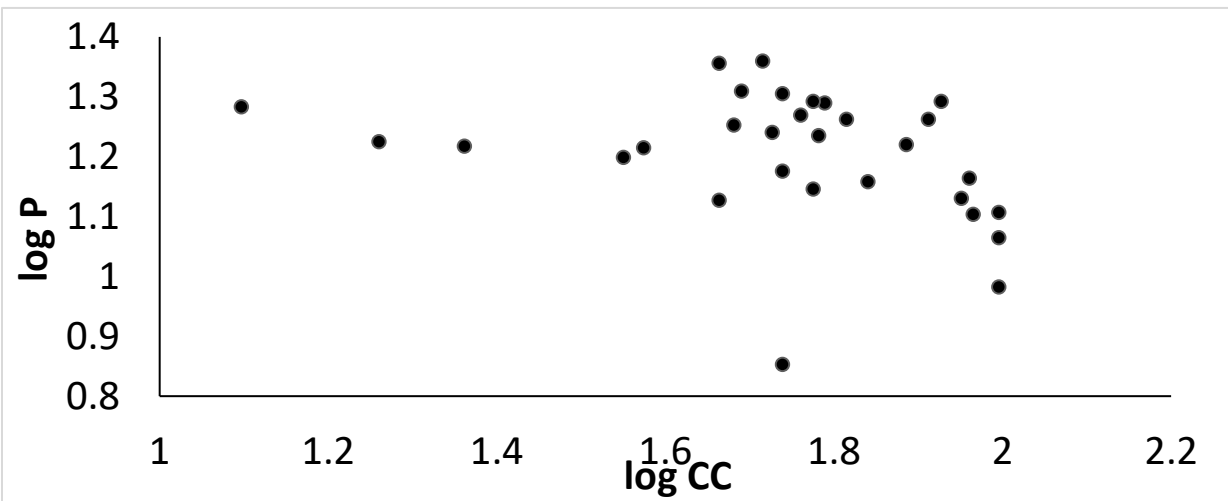

Figure 1: Plot of the variation of output power (P) against CC value (Clear Sky Index) for 30 days.

The plot indicates that output power of a typical PV decreases with increasing cloud cover. This is expected as increasing cloud cover reduces the amount of solar radiation that is effectively incident on the solar PV panel. Figure 2 shows the relationship between log of output power and log of relative humidity for 30 days. It is observed that there is a negative correlation of -0.62. This shows that as the output power increases relative humidity decreases. High humidity were observed to occur mostly in the morning hours. Figure 3 is relationship between log of clear sky index and log of relative humidity for 30 days. It is observed that there is a correlation of 0.31. This does not shows much significant relationship between log clear sky index

and log relative humidity. The trend shows that when the cloud cover increases the relative humidity does not really change even though most of the points occur at lower humidity.

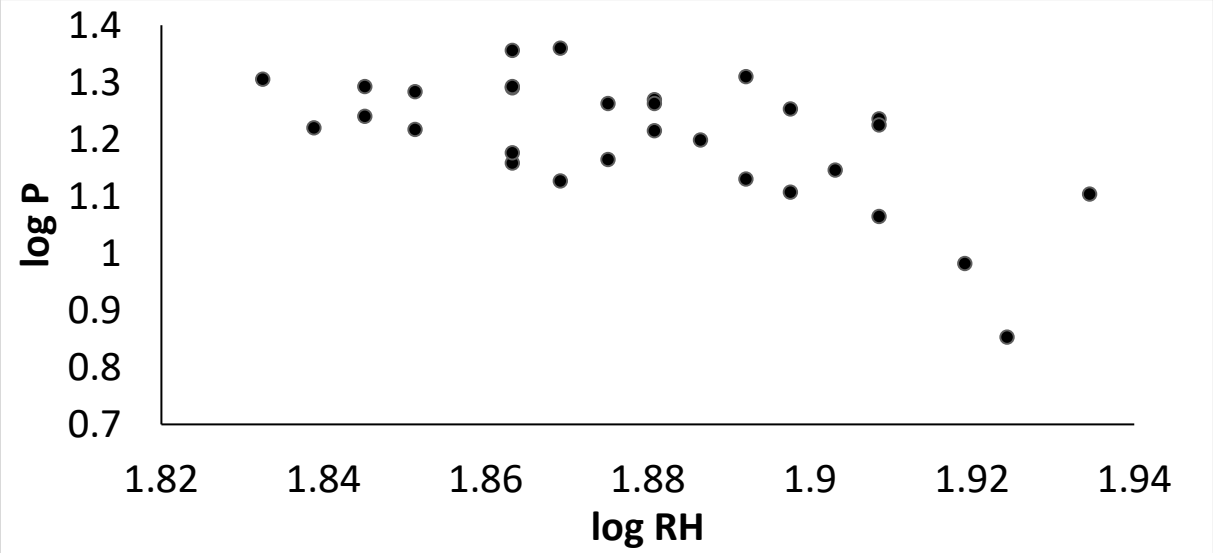

Figure 2: Plot of the variation of log of output power and log of relative humidity for 30 days

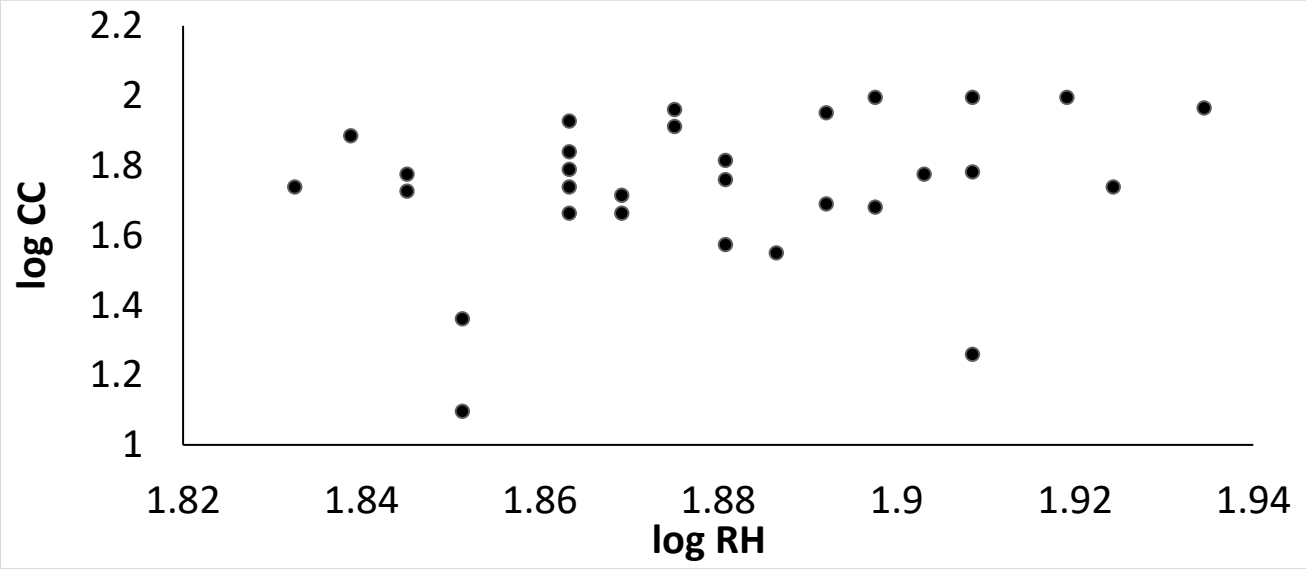

Figure 3: Plot of the variation oflog of clear sky index and log of relative humidity for 30 days.

4. CONCLUSION.

We have studied the effects of clear sky and humidity on the performance of commercially available PV panel. Our results suggest that the dependence of the output power of a given commercially available PV panel is mildly dependent on the extent of clear sky of any given location, but depends strongly on the humidity of location. The high dependence of the output power of PV on humidity is due to absorbance of solar radiation by the water molecules in the air. Our results indicates that the highest cloud cover is 84.5% by 10.00 local time and

with the lowest value of 45.00% by 14.00 local time, with a positive correlation of 0.41 between output power and clear sky index for 30 days and as relative humidity decreases, the output power increases with a strong negative correlation of -0.62.

Since this study was carried out for a period of 30 days at a single location using only one PV panel due to limitations of resources, we recommend further extensive study for the whole year and at several locations. This will enable statistically significant inferences to be drawn from the effect of relative humidity and cloud cover on the output power of a given PV.

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