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Environmental Effects on the Performance of Solar Photovoltaic (PV) Panel

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ABSTRACT

The environmental effects on the performance of solar PV panels have been studied at Edwin Clark University Campus, Kiagbodo, Delta State, South South, Nigeria, by measuring the variation of the output voltage with changes in temperature, irradiance, and relative humidity. Two 85W polycrystalline silicon solar panels, thermometer, mobile online hygrometer, mobile luxmeter and digital multimeter were used. The results from our experiments showed that the increase in temperature affects the output power of the solar PV panels by decreasing the open circuit voltage and increasing the short circuit current linearly. In addition, as relative humidity increases, the output voltage and current decrease spontaneously. The reverse is the case if the relative humidity is decreased. However, as irradiance (or luminosity) increases, the output voltage and current of the solar panel increase leading to the generation of more electrical power. Our study therefore shows that generally low ambient temperature, low humidity and high luminosity are practically favourable to solar cell productivity and efficiency.

Keywords: environmental, effects, humidity, temperature, irradiance, solar, panel

1.0 INTRODUCTION

Solar energy is the most abundant renewable energy resource on the planet. The solar energy that reaches the earth's surface in less than one hour would be sufficient to satisfy the energy requirement of all human activities for more than one year (Saikia, 2016). Energy remains the basic foundation which determines the stability of the economic development of any nation. Fossil fuel reserves, which provide the most part of the energy source for the world, are limited and gradually phasing out. Researchers have developed more efficient way of producing energy from alternative sources. Besides, the environmental degradation, ozone layer depletion, global warming and climate change occasioned by emission of greenhouse gases (GHGs) generated from burning of fossil fuels remain a global problem that can lead to an irreversible damage to our planet earth if the impact threshold is exceeded (Saikia, 2016; Nwankwo and Enyinna, 2018).

The increasing use of renewable energy technologies such as biomass, wind, hydro-electricity, solar thermal and solar electricity, are progressively offering a viable solution to the environmental problem caused by other energy sources (Patel, 1999; Nwankwo and Enyinna, 2018). Solar Photovoltaic (PV), which refers to the generation of electrical power through the use of solar cells to convert the photons of sunlight directly into electric current, has specific advantages as an energy source. Once installed, its operation generates no pollution and no greenhouse gas emissions. It has therefore become a key technology option to realize the shift to a de-carbonized energy supply and it is projected to emerge as an attractive alternative electricity source in the future.

With the increasing use of solar panels particularly in laundry shops, hospitals, classrooms, cyber cafes, homes and offices, it is important to know how environmental parameters namely ambient temperature, relative humidity, irradiance, etc. greatly affect the performance (output energy) of PV panels. The basic electrical characteristics which govern solar PV panel are mainly maximum power, tolerance rated value, maximum power voltage, maximum power current, open-circuit voltage (V_{oc}), short-circuit current(I_{sc}), and maximum system voltage. Determining the performance of a photovoltaic system, however, not only depends on its characteristics but on the environment in which they are placed (Ewona and Udo, 2011). Environmental and weather conditions have been observed to change remarkably from time to time across national boundaries (Nwokocha and Okujagu, 2016)

Some discussions in the literature highlight the various effects environmental factors and weather conditions have on the performance of PV panels. The report of Wysocki, and Rappaport (1960) shows that the performance specifications given by the manufacturers of different types of silicon solar PV modules are usually related to environmental and weather conditions. For Standard Test Conditions (STC) under stimulated sunlight conditions, irradiance of 1,000W/m^2, solar spectrum of Air Mass (AM) 1.5kg and module temperature of 25^{o}C are specified for standard module performance. Such module performance, however, varies with location of use and actual environmental conditions to which the silicon PV panels are subjected.

Olchowik *et al.* (2006) worked on the effect of temperature on the efficiency of nano-crystalline PV modules in a hybrid solar system. They report that the efficiency of a silicon mono-crystalline PV module depends on the sun intensity reaching the panel's surface. They also report that cooling of solar cells during cloudy days as well as in the morning hours decreases the efficiency of solar PV panels.

Amusan, *et al.* (2012) show that the amount of energy generated by the solar PV panels depends on how much sunlight is received. However, the position of the sun in the sky undergoes seasonal variation due to the tilt of the earth as it rotates around the sun. Regardless of the size of a typical silicon photovoltaic cell, its productivity depends on the intensity of sunlight striking the surface of the cell at a specified angle of inclination. The percentage of light converted to electrical energy is directly proportional to irradiance (flux of energy per area) and spectrum of the sunlight incident on the tilted surface. They assert that when all parameters are constant (i.e. temperature, humidity), the higher the irradiance, the greater the output current, and as a result, the greater the power and efficiency of a solar panel.

Etah *et al.* (2012) define relative humidity as the percentage of the amount of water vapour present in a volume of air at a given temperature or the amount of water vapour it can hold at that given temperature. An amount of water vapour in warm air will result in a lower relative humidity than in cool air. They report that relative humidity slows the performance of solar PV panels such that when tiny water droplets reside on the solar PV panels, it tends to reflect or refract sunlight away from the solar cells. This in turn reduces the amount of sunlight irradiating the solar PV panels. Furthermore, consistent hot humid weather can degrade both the crystalline silicon cell and thin film solar PV panels over their lifetime. They studied the effect of relative humidity on the performance of solar panels and concluded that low relative humidity between 60% and 75% favours increase in output current from the solar panels. Also voltage output increases with decrease in relative humidity.

Dubey *et al*. (2013) studied temperature dependence of PV panel efficiency and concluded that solar cell performance decreases with increasing temperature. The operating temperature plays a key role in the photovoltaic conversion process. Both the electrical efficiency and the power output of a photovoltaic (PV) module depend linearly on the operating temperature.

Omubo-Pepple *et al* (2013) studied the effect of some metrological parameters on the efficiency of solar panels. They report that solar panels' output current and efficiency are directly proportional to solar flux and that relative humidity reduces the output current and efficiency of the panels.

Park *et al.* (2013) worked on the effect of relative humidity on the degradation rate of a photovoltaic module for which they conducted five types of accelerated tests to derive a relation between effective relative humidity (rh_{eff}) and relative humidity of the backside (rh_{back}) of the photovoltaic module. They concluded that degradation rate of photovoltaic modules is accelerated by temperature and humidity.

Karafil *et al.* (2016) studied the temperature and solar radiation effects on PV-panels power and concluded that the amount of solar radiation falling on the PV panels varies depending on the location of the panel and the intervals in a day. Therefore, solar radiation levels have a direct effect on the power of the panels. A decrease in solar radiation level reduces the panel power. On the other hand, there is an inverse proportion between temperature and panel power. In other words, panel power decreases as the ambient temperature increases.

Joseph (2016) studied the effects of solar luminance/intensity, air temperature, relative humidity, atmospheric pressure and wind direction on the output current (short circuit current), and output voltage (open circuit voltage) and concluded that the output current and voltage rise with increase in atmospheric pressure.

Chandrasiri, *et al.* (2017) state that the ambient temperature can change the speed of propagation of electrons in an electric circuit. This is due to an increase in resistance of the circuit that results from an increase in temperature. Different solar panels react differently to the operating ambient temperature, but in all cases the efficiency of solar panel decreases as temperature increases. The cooler the panel, the more output power is generated.

2.0 MATERIALS AND METHODS

2.1 Materials

The materials used for measurement were two 85Watt polycrystalline-silicon solar panels with model SW85 Poly RNA/D, laboratory thermometer, hygrometer, Digital lux meter and Digital multi-meter

Solar Panels

The solar panels used for the experiment have the following properties:

Rated Maximum Power (P_{max}) = 85W (-5/+10%)

Open Circuit Voltage (V_{oc}) =22.1V

Rated Voltage (V_{mpp}) =17.9V

Short circuit Current (I_{sc}) = 5.02A

Rated current (I_{mpp}) = 4.76A

Power Specifications at Standard Test Conditions (STS):1000W/m^2, 25^{o}C

Measuring tolerance (P_{max}) traceable to TUV Rheinland; +/-2%

Application class: A

Maximum System Voltage (Safety Class II): 1000V_{DC}

Maximum System Voltage (USA NEC):600V_{DC}

Fire Rating Class C, Series fuse:15A

Field Wiring: Cu only, 12AWG insulated for 90^{o}C minimum

Diode: F 1200D

Laboratory Thermometer

The laboratory thermometer used in measuring the ambient temperature of the solar panel is an alcohol in glass thermometer. It ranges from 0^{0}C to 100^{0}C.

Hygrometer

The hygrometer was used in measuring the amount of water vapour in the air at a given temperature. A software application called Humidity Monitor produced by Cyanclub was employed in taking the readings of relative humidity. The application uses the internet to function accurately.

Lux meter

This instrument was used in taking light intensity measurement. A software application called Space Rocket Luxmeter was used in taking the daily readings of the light intensity. The device's maximum reading is 10240 Lux, while the minimum reading is zero.

Digital Multi-meter

This device was used in taking measurement of current, voltage and other parameters

2.2 METHOD

This research project was carried out at Edwin Clark University Campus Kiagbodo, Delta State, South-South, Nigeria. Firstly, the two solar PV panels were placed at an angle of 30^0C in a fixed position where maximum sunlight could illuminate them. The solar PV panels were connected in series for maximum output voltage to be obtained. Secondly, the ambient temperature, relative humidity, and irradiance, were recorded using a glass thermometer, hygrometer, and digital Lux meter, respectively at interval of 1hour between the hours of 6.00am and 6.00pm (Nigerian time) for fourteen (14) days to ensure effective and accurate data record. Also, a digital multi-meter was used simultaneously to measure the open circuit voltage and the short circuit current from the terminals of the solar PV panels. During the periods of the measurements, the weather was characterized by varied heavy rain, light rain, humid air, dry air, high sunlight intensity, low sunlight intensity, and cloudiness.

2.2.1 Relationship between Output Voltage and Solar Radiation

The output voltage and solar radiation are related mathematically by the expression:

$$\text{Output power} = VI \qquad (1)$$

where

V is the output voltage and I is the output current

The efficiency of the solar panel is given by

$$\text{Eff.} = \frac{\text{solar panel power}}{\text{area of solar panel} \times 1000} \times \frac{100}{1}\,\% \qquad (2)$$

3.0 RESULTS

Results of Hourly Variation of Output Voltage with Parameters

The results of the hourly variation of output voltage with ambient temperature, luminosity, and relative humidity are shown in Tables 1— 14.

Table 1: Variation of Output Voltage and Current with Weather Parameters for Day 1

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient Temperature (^{0}C)	Voltage (V)	Current (A)
6:00am	000	100	23	20.1	00.1
7:00am	1080	98	24	36.2	01.6
8:00am	2600	90	26	38.6	07.4
9:00am	2880	85	27	39.3	12.8
10:00am	4096	70	32	40.7	26.3
11:00am	4197	76	32	40.9	27.0
12:00noon	4320	73	32	41.3	28.8
1:00pm	4500	71	32	47.3	31.2
2:00pm	4096	72	32	39.8	27.6
3:00pm	2999	82	33	39.5	27.9
4:00pm	2600	87	29	38.5	14.3
5:00pm	1300	90	29	37.2	09.7
6:00pm	1020	94	28	36.6	03.1

Table 2: Variation of Output Voltage and Current with Weather Parameters for Day 2

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (^{o}C)	Voltage (V)	Current (A)
6:00am	40	99	25	17.4	00.2
7:00am	1280	96	26	36.9	09.6
8:00am	2600	90	27	38.8	12.3
9:00am	4096	86	30	40.5	46.9
10:00am	3810	88	31	39.0	27.1
11:00am	4500	72	31	40.1	42.1
12:00noon	4096	75	32	39.6	14.6
1:00pm	2600	89	31	38.2	09.9
2:00pm	225	93	28	35.2	06.2
3:00pm	360	91	27	35.5	03.8
4:00pm	1280	89	27	37.0	02.3
5:00pm	1280	89	26	36.8	01.8
6:00pm	1280	98	25	35.4	0.90

Table 3: Variation of parameters with Output Voltage for Day 3

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	99	23	11.0	00.1
7:00am	640	97	25	36.6	01.6
8:00am	1280	95	27	39.6	07.3
9:00am	3600	86	28	40.4	18.8
10:00am	1280	90	29	37.4	09.8
11:00am	4096	72	31	38.8	36.6
12:00noon	640	97	25	37.2	02.0
1:00pm	2600	88	29	39.5	09.4
2:00pm	4500	74	35	40.0	23.4
3:00pm	360	91	30	39.0	08.6
4:00pm	3540	89	28	39.1	11.4
5:00pm	1080	89	27	37.3	03.3
6:00pm	640	98	26	35.4	00.9

Table 4: Variation of Output Voltage and Current with Parameters for Day 4

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	000	99	23.5	17.6	00.0
7:00am	640	97	24.2	37.8	02.4
8:00am	1280	86	26.5	39.4	06.7
9:00am	4096	78	26.8	39.9	12.4
10:00am	5320	76	31.5	40.0	34.2
11:00am	2594	80	29.5	39.2	08.7
12:00noon	2600	72	28.5	40.2	10.6
1:00pm	3310	75	28.5	39.9	09.1
2:00pm	4096	73	30.4	40.1	23.7
3:00pm	4096	74	33.2	40.0	18.0
4:00pm	2600	80	29.8	39.4	10.5
5:00pm	1288	88	27.8	37.8	06.2
6:00pm	360	97	26	34.0	00.6

Table 5: Variation of Output Voltage and Current with Parameters for Day 5

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	100	23.0	19.2	00.1
7:00am	1280	93	23.1	37.6	02.1
8:00am	2600	93	25.5	39.5	05.4
9:00am	4096	75	28.2	37.9	09.6
10:00am	2659	100	30.0	38.3	09.1
11:00am	4500	75	32.6	39.0	42.6
12:00noon	2283	83	27.5	38.3	05.1
1:00pm	2959	79	27.6	40.4	17.7
2:00pm	3796	75	30.3	40.3	18.9
3:00pm	3800	94	30.0	40.0	17.3
4:00pm	2440	88	28.8	39.8	12.5
5:00pm	1289	88	29.0	39.3	07.2
6:00pm	1280	99	26.2	37.6	02.9

Table 6: Variation of Output Voltage and Current with the Parameters for Day 6

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	94	23.5	13.5	00.1
7:00am	1024	91	24.5	37.4	01.9
8:00am	1280	80	26.9	40.1	08.3
9:00am	4096	87	29.1	40.3	31.8
10:00am	3689	85	29.5	39.5	13.6
11:00am	4096	88	29.0	40.3	24.5
12:00noon	2600	90	28.0	38.1	05.1
1:00pm	4096	78	29.0	39.4	26.0
2:00pm	4833	75	29.5	39.4	16.3
3:00pm	5510	90	30.0	40.8	21.8
4:00pm	1280	80	28.5	36.7	02.1
5:00pm	640	88	27.3	35.8	01.8
6:00pm	360	100	25.8	33.7	00.6

Table 7:Variation of Output Voltage and Current with the Parameters for Day 7

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	100	23.2	13.2	00.1
7:00am	1280	90	24.5	37.2	02.2
8:00am	2600	80	25.7	39.4	07.2
9:00am	2600	88	26.1	39.4	07.8
10:00am	4096	77	28.5	39.8	21.2
11:00am	5011	74	29.5	39.6	35.0
12:00noon	6000	70	29.5	40.5	39.8
1:00pm	4802	80	31	38.8	17.7
2:00pm	4096	74	30.5	38.7	14.7
3:00pm	4500	70	32.5	39.4	41.3
4:00pm	2600	80	28.4	39	09.4
5:00pm	1280	83	28.0	37	02.5
6:00pm	1280	90	27.9	36.7	02.0

Table 8: Variation of Output Voltage and Current with the Parameters for Day 8

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	100	23	09.3	00.0
7:00am	225	94	24.3	31.3	00.3
8:00am	640	86	24.5	35.7	01.1
9:00am	1596	84	27	39.2	05.2
10:00am	1832	80	27.8	39.3	09.0
11:00am	2180	80	31.5	39.5	10.6
12:00noon	2600	80	32.5	38.8	12.0
1:00pm	4096	70	33.5	38.9	44.4
2:00pm	2779	78	31.5	38.3	15.1
3:00pm	2600	80	29	37.6	12.9
4:00pm	1280	87	28.3	34.9	06.4
5:00pm	640	90	26.5	34.9	03.1
6:00pm	360	95	25.1	32.6	00.3

Table 9: Variation of Output Voltage and Current with Parameters for Day 9

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	000	98	23.9	10.5	00.0
7:00am	1280	94	25.5	36.7	01.6
8:00am	2283	94	26.4	39.1	05.7
9:00am	2600	95	28.3	39.9	22.0
10:00am	2600	94	27.5	38.6	08.9
11:00am	4096	88	31	40.1	43.6
12:00noon	5570	62	32	40.3	41.2
1:00pm	5620	78	35.8	38.9	55.2
2:00pm	1280	90	28	35.5	01.4
3:00pm	1260	95	26.5	38.2	03.1
4:00pm	640	90	26.5	33.9	06.1
5:00pm	343	80	25.8	32.0	00.3
6:00pm	225	91	25.3	27.5	00.1

Table 10: Variation of Output Voltage and Current with Parameters for Day 10

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	000	100	24	15.2	00.2
7:00am	1280	94	25.1	36.4	01.4
8:00am	1596	90	25.5	39.8	07.2
9:00am	2600	90	27	39.7	16.2
10:00am	2600	94	28.5	39.0	07.3
11:00am	4096	83	28.7	39.7	15.6
12:00noon	4096	79	26	38.8	16.3
1:00pm	2600	70	25.7	38.9	16.7
2:00pm	1280	80	26	38.7	10.9
3:00pm	2600	80	27	38.9	06.7
4:00pm	2124	90	28.5	37.5	03.0
5:00pm	2600	83	28	38.5	05.4
6:00pm	360	90	27.5	35.2	01.1

Table 11: Variation of Output Voltage and Current with Parameters for Day 11

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	98	23.9	18.4	00.2
7:00am	1280	92	24.3	36.3	01.5
8:00am	1520	90	24.6	39.7	06.1
9:00am	4096	84	27	39.9	18.1
10:00am	4096	85	28	39.8	16.4
11:00am	4096	78	30.1	37.1	14.3
12:00noon	4833	73	30	38.0	16.7
1:00pm	5100	62	30.7	39.8	28
2:00pm	5097	64	31.5	39.8	23.8
3:00pm	4096	60	31	39.9	24.3
4:00pm	2600	70	30.5	38.7	19.0
5:00pm	1280	76	28.8	37.2	09.2
6:00pm	1280	80	27.5	35.1	01.3

Table 12: Variation of Output Voltage and Current with Parameters for Day 12

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	000	98	23.9	18.4	00.2
7:00am	1280	92	24.3	36.3	01.5
8:00am	1520	90	24.6	39.7	06.1
9:00am	4096	84	27	39.9	18.1
10:00am	4096	85	28	39.8	16.4
11:00am	4096	78	30.1	37.1	14.3
12:00noon	4833	73	30	38.0	16.7
1:00pm	5519	62	30.7	39.8	28.0
2:00pm	5510	64	31.5	39.8	23.8
3:00pm	4096	60	31	39.9	24.3
4:00pm	2600	70	30.5	38.7	19.0
5:00pm	1280	76	28.8	37.2	09.2
6:00pm	1280	80	27.5	35.1	01.3

Table 13: Variation of Output Voltage and Current with Parameters for Day 13

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	40	100	23.3	13.3	00.1
7:00am	1128	96	24.6	38.1	03.1
8:00am	1280	94	24.8	39.0	04.2
9:00am	2600	94	25.9	39.0	06.1
10:00am	4096	90	27.0	39.6	14.4
11:00am	3916	95	27.3	39.4	12.9
12:00noon	4096	75	28.6	40.4	31.2
1:00pm	4090	82	29.0	40.0	17.0
2:00pm	3689	85	29.3	39.5	11.8
3:00pm	2800	85	29.5	39.5	11.5
4:00pm	2600	88	28.5	39.7	11.8
5:00pm	1702	93	27.5	38.8	05.9
6:00pm	225	98	26.5	36.7	02.1

Table 14: Variation of Output Voltage and Current with Parameters for Day 14

Time of the Day	Luminosity (Lux)	Relative Humidity (%)	Ambient temperature (ºC)	Voltage (V)	Current (A)
6:00am	000	100	23.7	16.9	00.1
7:00am	1024	90	24.3	36.4	01.6
8:00am	1080	84	24.5	36.9	02.1
9:00am	1280	77	25.8	37.7	02.9
10:00am	3377	74	27.2	39.7	13.8
11:00am	4500	70	29.3	39.5	58.1
12:00noon	1280	88	27.0	38.1	03.1
1:00pm	2600	83	28.0	39.4	07.6
2:00pm	3198	80	28.5	39.6	11.4
3:00pm	5782	73	29.5	40.6	43.6
4:00pm	5570	78	31.0	40.2	29.2
5:00pm	2600	94	27.5	38.6	07.0
6:00pm	2600	95	27	38.7	06.7

Table 15: Variation of output Voltage with the Parameters for all fourteen (14) days

Days	Light Intensity (Lux)	Relative Humidity (%)	Ambient Temperature (^{0}C)	Mean Output Voltage (V)
Day 1	4500	40	23	38.2
Day 2	2800	45	24	36.2
Day 3	3000	50	25	36.4
Day 4	3096	55	26	37.4
Day 5	3769	60	27	37.5
Day 6	3500	65	28	36.5
Day 7	4096	70	29	36.8
Day 8	2200	75	30	35.0
Day 9	1500	80	31	34.7
Day 10	4000	85	32	36.6
Day 11	2200	90	33	35.1
Day 12	4000	95	34	36.9
Day 13	4096	100	35	37.2
Day 14	4096	105	36	37.1

4.0 DISCUSSION

Table 1 shows that during a clear and sunny weather, a significant output voltage ranging from 40.7V to 43.7V was recorded between the hours of 10:00am to 1:00pm with luminosity ranging from 4096lux to 4500lux, at constant temperature of 32^{0}c, and relative humidity between 70% and 76%. At hours of 2:00pm and 3:00pm the output voltage decreased to around 39.8V and 39.5V respectively when the ambient temperature increased from 32^{0}C to 33^{0}C, luminosity decreased from 4096lux to 2999lux, and relative humidity increased from 72% to 82%, confirming that the productivity is optimally better at low temperature than at high temperature and better with increasing luminosity. The same trend is observed in Tables 2 – 14.

Table 15 shows that ambient temperature and relative humidity have same pattern of effect on the mean output voltage. The mean output voltage (and therefore current) increase during the bright sunny period and gradually decrease as the sun set. These results are consistent with the previous work of Amusan, *et al.* (2012). The maximum mean output voltage of 38.2V was obtained when the ambient temperature was 23^{0}C and a minimum mean output voltage of 34.7V when the ambient temperature was 31^{0}C. The maximum mean output voltage of 38.2V was obtained when the relative humidity was 40% and a minimum mean output voltage of 34.7V when the relative humidity was 80%. This shows that the productivity is better at low relative humidity in accordance with previous works in the literature. Maximum mean output voltage of 38.2V was obtained when the luminosity was 4500lux and a minimum mean output voltage of 34.7V was obtained when luminosity was 1500 lux, showing that luminosity favours panel output.

It is generally observed in this study in consistency with reports in the literature that the output voltage (and hence current) increase with decreasing temperature, decreasing humidity and increasing luminosity. This clearly shows that the ambient temperature, relative humidity and irradiance have measurable effects on the output voltage, current and therefore power generated by solar PV panels.

5.0 CONCLUSION

The environmental effects on the performance of solar panels were studied. It is observed that as ambient temperature increases, the mean output voltage of the solar PV panels decreases. Similarly, as relative humidity increases, the mean output voltage of the solar panel decreases. On the other hand, as luminosity increases, the mean output voltage of the panel increases. Low ambient temperature, low humidity and high luminosity are therefore practically favourable to solar cell productivity and efficiency.

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