Energy Generation Factor during Raining Season in Nigeria: A Study on 75 Watt Solar Collectors

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ABSTRACT

This work specifies the effect of atmospheric conditions on solar panel of different ratings. There is adverse effect of atmospheric condition, cloud, wind and rain on a solar panel. This work looks into the energy generating factor on a solar panel. This explains the generation factors of a solar panel, generation rate of the panel and reading. This work with the reading drawn from the experiment conducted with the solar panel setup outside directly under the sun radiation.

KEYWORDS: *Energy, Factor, Generation, Rain & Solar*

1. INTRODUCTION

The importance of energy in achieving sustainable development cannot be over emphasized. Energy availability has been found to be closely related to sustainable development of a country (Awogbemi, O and Asaolu J.I.Towards, 2015). Real sustainable development is about the ability of a society to meet the needs of the present without compromising the ability of future generations to meet their own needs. These need include access to functional, affordable health care and educational systems, access to nutritious food, living in a comfortable house with the basic necessities of life, and living in a friendly environment or planet, to mention just but a few. To meet these needs, energy availability is central. It is required to drive the socio-economic and industrial development of a nation. For example, energy is used in the agricultural sector for irrigation and preservation; in the household sector for lighting, heating, refrigeration, and cooking; in the industrial sector for turning raw materials into finished goods; and in the transportation sector to power cars, trucks, trains, airplanes, etc. Energy contributes in multiple ways to the Gross National Product (GNP) of a country (Awogbemi, O and Komolafe C.A, 2011).

Nigeria, located in West Africa is bordered by Cameroon to the west, Niger to the north, Benin Republic to the west and Atlantic Ocean to the south, lies within latitudes 4.32^{o}N and 14^{o}N and longitude 2.72^{o}E and 14.64^{o}E has a land area of about 924,000km^2 and a population of 165million people (Mohamed, S and Petinrin J.O. , 2014). Nigeria is blessed with abundant energy sources, both renewable and non-renewable. Nigeria has an estimated reserve of 36 million barrels, which is about 4.9 billion ton of oil equivalent (toe), 5210 billion m^3 of natural gas as of 2006, about 4.1 billion toe of tar sands, and 1.52 billion toe of coal and ignite. This place Nigeria among the 10th largest crude oil producer in the world, and among the top 10 countries with the largest gas reserves globally (Mohamed, S and Petinrin J.O. , 2014), (Augustine, C and Nnabuchi, 2009). Exploitation and utilization of these non-renewable energy sources has not been able to meet the country's energy needs as Nigeria is still plaque with epileptic power supply and still imports about 70% of her petroleum products. This is why in the last few years, efforts have been geared towards exploiting and utilizing the abundant renewable energy source available in Nigeria. The recognized Renewable Energy (RE) in Nigeria includes solar energy, hydropower, wind energy, biomass, and biogas. Exploitation and utilization of these RE sources will not only help Nigeria to meet her energy targets, ensure energy sufficiency, but it will also help in stemming the tide of environmental degradation associated with exploitation of non-renewable energy sources.

Having established the unbreakable link between energy availability and sustainable development and the problems associated with exploitation and utilization of non-renewable energy sources, it is obvious the Nigeria's quest for energy sufficiency will be a mirage if RE is not given its rightful place in the country's energy mix. This paper examines the potential of RE, particularly solar energy, in achieving sustainable development in Nigeria. Possible areas of utilization and benefits accruable in exploitation and utilization of solar energy will be highlighted, while useful suggestions that will allow for achieving sustainable development will be offered. Photovoltaic systems have been installed to provide electricity to the billions of people that do not have access to mains electricity. Power supply to remoter houses or villages, irrigation and water supply are important application of photovoltaic for many years to come. In the last decade, PV solar energy system has shown its huge potential. The amount of installed PV power has rapidly increased. Nowadays, nearly 70 GW of PV power are installed worldwide. Perhaps the most exciting new application has been the integration of solar cells into the roofs and facades of buildings during the last decade (Davud Mostafa Tobnaghi and Daryush Naderi, 2015).

Due to the effect of atmospheric conditions on solar panel, a higher material (solar plate and battery) has always been recommended for use. Meanwhile, if atmospheric condition can be handled depending on the one posing challenge and if the atmospheric condition can be identified on time, then the required material will be used. The system will be setup based on the particular atmospheric condition e.g. Nigeria (Segun, 2017).The aim of this study is to examine the energy generation factor of a solar backup system by identifying the capacity of energy generation of a 75 watts solar panel. In order to achieve our aim and objectives, we will this work focus strictly to the solar panel backup system and it will be limited to experimenting several atmospheric conditions on the solar backup system.

Solar system has been utilized in many countries for power generation due to its ease of use (especially, after purchase/setup, it does not require funding for fuel to sustain it etc.) and has vital role it plays power generation based on its natural power source (Sun) (Segun, 2017). The importance of the work as related to the experiment carried out is that it will help users, investors and researchers to have a more than average understanding of the energy generation factor, prominent charging time and prominent discharging time of a 75Wattts solar panel. Solar power system has proven its importance all over the world so much that it's now taking over so other power generation or as a support to other power generation. Some years back, it was proposed to invest into solar power system in Nigeria. Solar system has birthed solar power expert of different knowledge in the country, the sell the material, those that setup the system. Also some that takes a critical and close look at the other areas to explore better benefits of solar system (Segun, 2017).

2. RELATED WORK

Nigeria is one of the tropical countries of the world which lies approximately between 4^o and 13^o with landmass of 9.24 x 105 km2 enjoys an average daily sunshine of 6.25 hrs, ranging between about 3.5 hrs at the coastal areas and 9.0 hrs at the far northern boundary (Bala, E.J., Ojosu, J.O., and Umar, I.H., 2000). Her electrical energy consumption in the year 2001 is 15 x 106kWh. Its climate varies from tropical to subtropical. There are two main seasons; the dry season lasting from October to March and the rainy season lasting from April to October. In the north, it is hot and dry, rainy season extends between April and September. In the south, it is hot and wet, rainy season extends between March and December. From December to March there is a long dry season (Ojo, 2000). The utilization of solar energy depends on its availability and appropriate technology (Nasir, 2003). The idea of using the sun's power has held scientist in its grips for centuries (Bradley, 1995).

The sun's power reaching the earth is typically about 1000W/m2. The total amount of energy that the earth receives daily is $1353W/m^2$ (Hoff, 2000). Some 4million tons of the sun's matter will continue to be changed into energy every second. "The sun is the most readily and widely available renewable energy source capable of meeting the energy needs of whole world. It can provide more power than any fossil fuel on the planet. The solar radiation arrives at the earth at a maximum flux density of about 1kw/m2 in wave length of band between 0.3 and 2.5μm.This is called short wave radiation and it includes visible spectrum. For habited areas fluxes received vary widely from about 3 to 30MJ/m2/day, depending on place, time and weather" (Al, 2012).

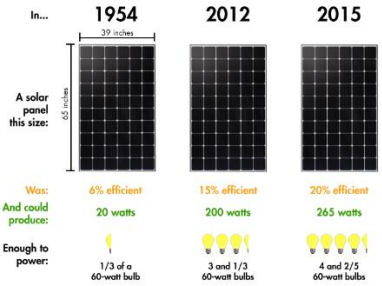

Figure 1: Ranging production of Solar plates (Society)

The ranging production of solar plates as shown in figure 1 shows the capacity of each solar plate wattage to the load it can carry. Energy radiated from the sun is about 3.8 x 1023 Kw per second, which is equivalent of 1.082 million ton of oil equivalent (mtoe) per day (Awogbemi, O and Komolafe C.A, 2011). Nigeria has an average of 1.7544.851 x 1012 kWh of incident solar energy annually based on Nigeria land area of 924 x 103km2 and an average of 5.535kWh/m2/day. Solar radiation is well distributed throughout the country by virtue of Nigeria's location on the globe. The sun shines on the average for 5.5hr/day. The annual solar energy value is about 27 times the country total fossil energy resources in energy unit and is over 115,000 times the electric power produced. This means that only about 3.7% of Nigeria's landed area is required to collect an amount of solar energy equal to the country's conventional energy reserves (Mohamed, S and Petinrin J.O. , 2014), (Augustine, C and Nnabuchi, 2009).

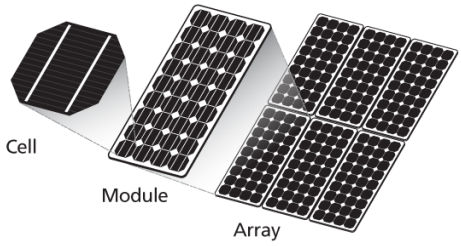

Figure 2: Different stages of solar cell

Each cells as shown in figure 2 above are arranges to make up a solar module and in the same way, they are arranged to make an array of solar panel.

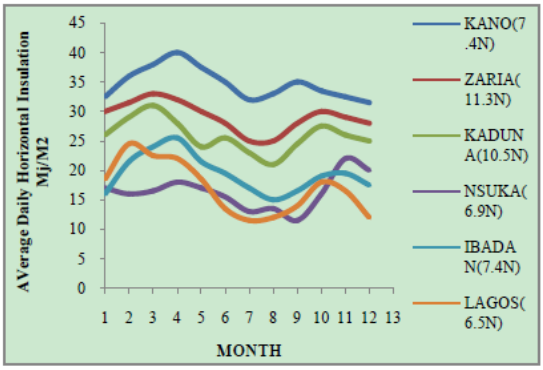

Figure 3: Variation of daily total radiation in some Nigerian cities (Bamiro, 1999)

Figure 3 above shows different Average Daily Horizon Insolation per month of sun radiation at different cities in Nigeria.

2.1 Power Generation Technologies

Power generation is the process of converting energy from an available source to electrical energy in a form that is suitable for distribution, consumption and storage. Solar energy can be used to generate power in two ways; solar thermal conversion and solar electric (photovoltaic) conversion.

i. Solar-Thermal Conversion

Solar-thermal is the heating of fluids to produce steam to drive turbines for large-scale centralized generation. Like solar cells, solar thermal systems, also called concentrated solar power (CSP), use solar energy to produce electricity, but in a different way. Most solar thermal systems use a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to make steam to produce electricity in the same way that coal plants do. Albeit, the Renewable Electricity Action Program (REAP) of the Federal Ministry of Power and Steel (2006) published by the International Centre for Energy, Environment and Development did not cover this aspect of power generation (Federal Ministry of Power and Steel, 2006).

ii. Solar Electric (Photovoltaic) Conversion

Solar-electric (photovoltaic) conversion is the direct conversion of sunlight in to electricity through a photocell. This could be in a centralized or decentralized fashion. Solar-electric (Photovoltaic) technologies convert sunlight directly into electrical power. Photovoltaic system is made up of a balance of system (BOS), which consists of mounting structures for modules, power conditioning equipment, tracking structures, concentrator systems and storage devices. Photovoltaic conversion could be small scale for stand-alone systems or large scale connected to national grid (Al, 2012).

This works by permitting photons, or particles of light, to knock electrons free from atoms, generating a flow of electricity. Solar panels literally consist of numerous, compact units of cells that converts sunlight into electricity. These cells are referred to as Photovoltaic (PV) cells. A "Photovoltaic cell is a semiconductor device that converts solar radiation into direct current electricity." (Mulanax). Out of all these peripheral parts that make up a solar power system, the solar panel is selected to perform several experiments on it. Figure 5 shows some various types of solar panel that has been produced, meanwhile, each cell has its advantages and disadvantages (Al, 2012). It stores electricity to provide energy on demand at night or on overcast days. The batteries are rated in amp hours usually at 20 hours and 100 hours. Like solar panels, batteries are wired in series and/or parallel to increase voltage to the desired level and increase amp hours (Al, 2012). Inverter is required to convert the direct current (DC) power produced by the PV module into Alternating current (AC) power. Most solar power systems generate DC current which is stored in batteries while nearly all lighting, appliances, motors and so on, are studied to use AC power, so it takes an inverter to make the switch from battery-stored DC to standard power (120VAC, 60Hz) (Al, 2012). A charge controller monitors the battery's state-of-charge to insure that when the battery needs charge current it gets it, and also insures the battery isn't over charged. Connecting a solar panel to a battery without a regulator seriously risks damaging the battery and potentially causing a safety concern (Al, 2012).

2.1 Effect of Atmospheric Condition on Solar Power Production

The dust particles were deposited on a PV surface at a controlled surface-mass density, and the power output was measured (Priyank Srivastava, Pankaj Gupta and Amarjeet Singh, 2010-2015). There is no such thing as a perfect technology. Research reveals the different factors that can affect the efficiency of solar panel. Some of these factors have been studied to either increase or decrease the power production. When the sun is in its peak (intense), during midday, the most solar energy is collected; therefore, there is an increase in the power output.

3. THE STUDY SETUP

The methodology adopted in this research work is based on experimental analysis that shows energy generation factor on a solar panel output. Different measurements will be experimented using different factors of atmospheric conditions as the case may be. The data, Table 1 and 2, were analyzed (see Figure 7 and 8) with Autocorrelation output from GMDH Shell Statistical software, Field Survey, 2017

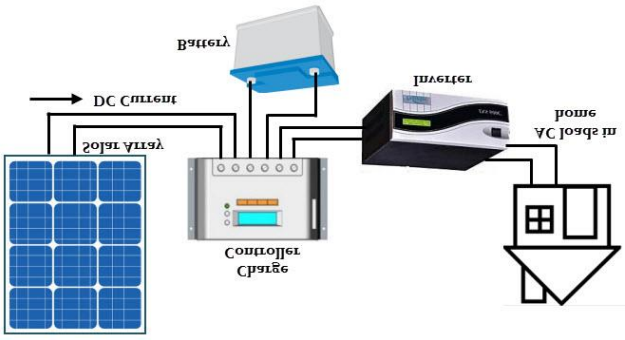

Figure 4: Basic Standalone-Solar-Electric-Systems

Figure 4 is the working block diagram of a basic solar power system. From the solar panel, it directly connects to the charge controller, then to the battery which stores the charge from the solar panel. The battery is then connected to the inverter which converts the direct current to alternating current. Afterwards, the load can be plugged to the inverter. How much energy can a solar panel generate over a period of time at wet season in south-western part on Nigeria? The power generation rating of a solar panel is also given in Watts. To calculate the energy it can supply to the battery, multiply Watts by the hours exposed to sunshine, then multiply the result by 0.85 (this factor allows for natural system losses). This experiment is carried out in Ode Remo, Ogun State Nigeria. Ode Remo, located at Latitude and longitude 6° 58' 0" N and 3° 41' 0" E respectively to degrees minute's seconds. For the solar 10W panel in 4 hours of sunshine, 10 x 4 x 0.85 = 34Wh. This is the amount of energy the solar panel can supply to the battery.

The solar panel (PV Array) is a 75 watts solar panel with power amplifier used to amplify the charges drawn from the sun to give a higher voltage and current. The solar plate connecting wire (red and black) is connected to a charge controller which controls the charges drawn from the sun. The charge controller is used to reduce or amplify the voltage and current output from a solar panel to a moderate reading. The charge controller has 3 live and neutral connector that allows the solar plate, battery and inverter to come to a single device and it distributes the input and output supply accordingly. When the solar plate connecting wire enters the appropriate connector prepared for collecting charge input, it passes the charges to the battery which is also connected to the charge controller. It then continues to charge the battery. The battery keeps on charging and furthermore, the charge controller has the third (3^{rd}) live and neutral connector that can be connected to the inverter then to the load at any time so far the battery is charged and the sun is out. The inverter as it implies converts DC current to AC current. The load can only be connected to the inverter due to its capability to convert from DC to AC. Figure 11 is a basic well connected solar power system.

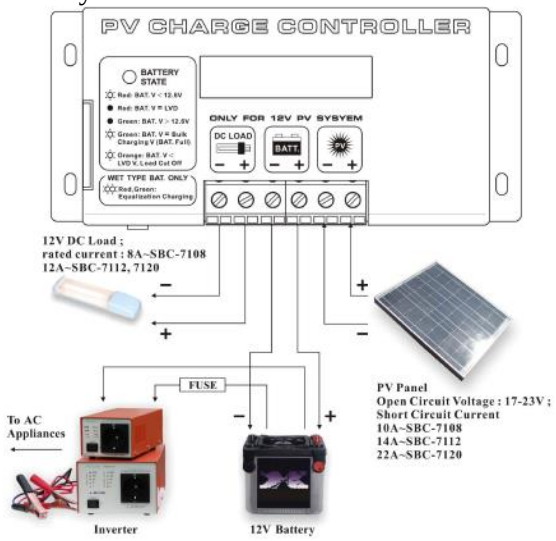

Figure 5: PV charge controller connection to other components, (PV Charge Controller)

This method is used to measure the energy generation factor of a solar panel output. This output differs based on different criteria's for example, when there is much heat on the panel, efficiency will reduce or when there is thick duct on the panel. This are some of the experiments we will be looking at. The experiments details are as follows:

a) The experiment was started around ten (10:00am) in the morning with the setup of the solar panel facing the sun and also other materials connected to it.
b) A multimeter was connected to the connected wires to the battery to check the reading of the voltage running t through the system.
c) Same procedure in b above was repeated to check the current flow.
d) The reading was taking down at several time.
e) After taking necessary readings, the product of the voltage and current was determined on an analytical system.

The study setup that shows the setup of the solar backup system is shown in figure 6 below.

Figure 6: Study setup of solar power system, Field survey, 2017

The solar panel includes the monocrystalline silicon solar modules connected to a sola charge controller directs the flow of current to the battery and finally to the load. The solar panel generator generates up to 45V daily. Figure 4 above is the setup of a 75watts solar panel system prepared for experiment during the time of taking various readings at different time ranges.

4. RESULT AND DISCUSSION

Table 1: Energy generation factor of solar on latitude and longitude reading, Field survey, 2017

S/N	TIME(MINS)	VOLTAGE (V)	CURRENT(I)	POWER(P)
1	10:00-10:30am	18.54	1.53	28.37
2	10:30-11:00am	18.79	1.55	29.12
3	11:00-11:30am	19.01	1.71	32.51
4	11:30-12:00nn	19.99	1.79	35.78
5	12:00-12:30pm	20.34	1.84	37.43
6	12:30-1:00pm	20.31	1.83	37.17
7	1:00-1:30pm	19.96	1.78	35.53
8	1:30-2:00pm	20.11	1.77	35.59
9	2:30-3:00pm	21.41	1.88	40.25
10	3:00-3:30pm	20.13	1.77	35.63
11	3:30-4:00pm	20.00	1.75	35.00
12	4:00-4:30pm	17.99	1.41	25.37
13	4:30-5:00pm	17.54	1.37	24.03
14	5:00-5:30pm	17.29	1.23	21.27
15	5:30-6:00pm	17.02	1.11	18.89

Table 1 above is the reading of voltage and current carefully taking down to proof the prominent charging time of a 75Watts solar panel at different time span. Table 2 carefully analysis the readings maximum, minimum, median, mean, standard deviation values.

Figure 7: Time series plot of energy generation factor measure with power, voltage and current with GMDH Shell Statistical software, Field Survey, 2017

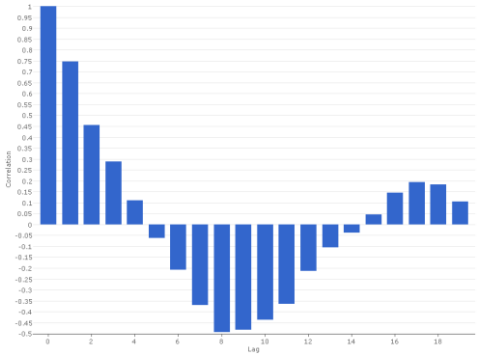

Figure 8: Autocorrelation output from GMDH Shell Statistical software, Field Survey, 2017

Table 2: Statistical analysis of the reading showing the mean value of the capacity of 75watts solar panel

Variable	TIME	VOLTAGE	CURRENT	POWER
Numeric values	0	15	15	15
Text values	15	0	0	0
Missing values	0	0	0	0
Unique values	15	15	14	15
Zero values	0	0	0	0
Most frequent			1.77	
Min. value		17.02	1.11	18.8922
Max. value		21.41	1.88	40.2508
Median		19.96	1.75	35
Mean value		19.22866667	1.621333333	31.46212
Std. deviation		1.270122654	0.233291425	6.314079397
2σ outliers		0	1	0
3σ outliers		0	0	0
4σ outliers		0	0	0

Table 2 above shows the reading of the voltage, current and power which explains the values entered, minimum value, maximum value of reading, mean and median of the reading, the mean value and standard deviation of the readings. This reading will be used to generate Finding shows that the generation factor of any solar panel depends on three things,

i. need to know what appliances you will be using and how much energy they require,

ii. How much energy your battery can store and
iii. Which solar panel will replenish your 'stock' of energy in the battery in line with your pattern of use?

The result shows the energy generation factor of a solar panel at different times of the day with a 75watts solar panel, 12V40AH deep cycle battery, and charge controller. The result shows its mean charge value of 19.23V, 1.62A and 31.46watts respectively between the hour of 10am and 6pm daily. This implies continuous generation of about 31.46 Watt for about 8 hours period daily at the wet season in south west part of Nigeria. Hence, 31.46 Watt x 8 = 251.68 Watt could averagely be generated from 75Watt solar panel daily instead of the maximum power of 600 Watt (75Watt x 8). The generating power factor in this region could estimate to be 251.86 Watt/ 75 = 3.35 during wet season from May to August yearly in Nigeria. With the solar panel efficiency of about 31.46/75 = 42 %.

This research will be useful for users/researchers of solar system to understand the working of solar system in areas where atmospheric conditions is dwindling/unstable and drastic. This will also be of help to students who wants to further in this research. This research is limited to the testing/experimental process carried out to show/proof the effect of atmospheric conditions on solar power system.

4.1 Future work

This research work can be extended to night charging and investigations on other effects of wind, humidity and rainfall on the solar panel. And that, an expository study on the effects of atmospheric conditions or other environmental influence on the solar panel so as to have a better understanding and maintenance routine of the solar panel can be considered. Further research on how to best choose a solar panel can also be explored.

5. CONCLUSION

This work has proven it result in the best possible way, however, solar backup system is still one of the best renewable energy generation means that cannot be forgotten, except acknowledged due to the following reasons.

i. It saves time and labor
ii. It increases reliability and convenience in energy use;
iii. It decreases indoor pollution;
iv. It decreases accidental fire;
v. It improves health and hygiene;
vi. It improves education;

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