Solar Radiation as a Remedy for Unstable Electric Power Supply in Yola, Adamawa State

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Abstract:- **The Solar Radiation for Yola in Adamawa State of has been studied and evaluated so as to remedy the fluctuating electric power, particularly, in Yola which received an average only about 15 MW instead of 40 MW from the Yola Electricity Distribution Company. The analysis shows that the solar radiation in joule per unit area has a fluctuating pattern with a peak in 2013 (corresponding 811.68J/m^2) and its least value in 2016 (approximately 543.02J/m^2). The mean monthly solar radiation obtained for this region is 677.51J/m^2 which is within the threshold for which PV/ cell can generate power. Comparative analysis using the solar radiation at 0.5m height shows that the value of solar radiation can be categorized as moderate especially when compare with other towns in Nigeria. It is recommended that proper utilization of solar radiation should be encourage as a remedy for fluctuation of electricity in Yola Adamawa State and the neighboring states.**

I. INTRODUCTION

Energy is a vital and important necessity for all earthly processes. The socio-economic activities of modern society revolved around the hub of energy availability. The 1973 oil crises, chaos caused by the Arab oil embargo, in western countries brought a sudden global realization to use renewable energy resources such as solar energy, hydropower, wind energy, wave energy, biomass and biofuels (Animalu and Adekola, 2002). This campaign for using renewable energy resources is becoming stronger today because of the finite nature of fossil fuel energy resources as well as the greenhouse gases emission which many scientists believe cause global warming. (Nwoke*et al.*, 2008). Effective applications of renewable energy resources to augment energy supply from fossil fuel energy resources (using cleaner for fossil fuel technologies) will enhance availability of energy with minimum environmental effect.

Solar energy can be defined as the energy obtains from the sun, which is electro magnetic in nature covering all wavelength of the sun (Ilenikhena, *et al.*,2008). The sun is about 1.4 x 10^{14} m in diameter emits its energy at the rate of about 3.8 x 10^{23} Js^{-1} of solar energy of which about 1.7 x 10^{14} Js^{-1} reaches the earth, warming the ground , ocean ,atmosphere and drilling the photosynthesis process that maintain the biological life . Most of the solar radiation is confined within the wavelength of 3.8 and 0.7nm. Solar energy occupies one of the most important places as many among the various possible alternative energy sources it is the only option left to be developed and utilized. It is an inexhaustible source, potentially capable of meeting a significant portion of the world future energy needs with a minimum of adverse environment consequences. The availability of solar energy has to be considered. The region with greater solar insolation on the earth's surface lies between latitude 20° -30° N and south of the equator (Ilenikhenaand Mordi, 2005). Therefore, the availability of solar energy over the earth surface is not uniform (Eze, 2004). It has been confirmed that Nigeria receives 9.12 x 10s MWm^{-2} of energy per day from the sun. And if solar energy appliance with 5% efficiency is used to only 1% of the country surface area then 2.45 x 106 nJs^{-1} and electrical energy is equivalent to 4.66 million barrels of oil per day (Oparaku, 2007).

In Nigeria, the availability of a reliable power supply is still very minimal because the major source of electricity in the country is the hydropower, which is usually restricted to the generation of shaft power from falling water (Medugu and Malgwi, 2005). The main hydropower station constructed across river Niger at Kainji is designed and managed by the Power Holding Company of Nigeria (PHCN) to deliver the required energy for the expanding Nigeria industry. But the company has been noted for unreliable power supply characterized by low voltage and incessant power cuts often without warning or even apologies to consumers (Ileoje, 1997). This is the major reason among many others prompted the emergence of study.

Yola has been experiencing inconsistent power supply which is mainly due to the nation's dependence on hydropower, which is seasonally dependent. However, the seasonality of this source has made the amount of water available at different power stations variable, thereby making recurrent cut in power supply inevitable. HCN's business operations are inefficient in the sense that the transmission network is overloaded, which bring about a poor voltage profile under-investment, poor maintenance and many others. This erratic nature of electric power supply has caused the economy to fall, unless it is supplemented. The way out of this lies in the use of renewable source of energy for power generation, as they contain enormous, largely untapped and sustained opportunity for meeting the energy need as they are environmental friendly as they do not contribute harmful and toxic emission to it. The solar energy is one of the cleanest and most environmentally sources of energy capable of generating a high amount of electricity.The aim of this study is to investigate solar radiation as alternative energy for unstable power supply in Yola. The specific objectives are to determine the intensity of solar radiation available at Yola and determine if the available solar radiation can generate solar energy for electricity power supply.

II. MATERIAL AND METHOD

Materials

The materials used for this study are data for solar radiation (Table 1). The data were obtained from the meteorological station of Geography Department, Federal University of Technology, Yola, Adamawa state. The data obtained are for six years (2012 - 2017). The measurement will be done using Gunn-Bellini radiation integrator; in $gcalcm^{-2}day^{-1}$ was later converted into $J^{-1}m^{-2}day^{-1}$. This instrument measures the integrated radiation reaching a balanced copper sphere which usually contains water or n-propyl alcohol, and connected to a calibrated condenser receiving tubes. The Equid vaporize when heated by solar radiation and condenser in the graduated receiver. The quantity of the condensate is the measure of integrated solar energy during the interval. The quantity of the Equid is measured in milliliters (ml) and can be converted using a conversion factor of 1.216 given by (Yuguda, 1990). The data for monthly solar radiation and mean annual difference between maximum and minimum temperature are shown in Table 1 and 2 respectively.

Method of data collection

The daily solar radiation data covering nearly the period of six years (2012 - 2017) were obtained from the meteorological station of Geography Department, Federal University of Technology Yola Adamawa State. The data was measured with an instrument called Gun-Bellani radiation integrator in $gcal^{-1}cm^{-2}day^{-1}$ and later converted to into $Jm^{-2}day^{-1}$. The instrument was placed at a height of about 0.5m from the ground level.

Table 1: Data of mean monthly solar radiation at level 0.5m

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2012	555.54	548.10	574.63	588.97	615.19	550.19	539.19	562.74	579.34	453.64	-	-
2013	-	436.86	644.47	719.23	630.38	575.91	624.75	56023	2929.42	620.04	612.39	574.82
2014	485.09	534.33	329.68	740.15	410.42	662.15	501.24	583 33	631.84	402.09	276.11	467.51
2015	676.66	737.58	685.23	764.97	642.03	627.99	532.36	399.23	577.25	691.56	643.36	390.21
2016	-	405.54	815.15	613.37	377.23	451.59	574.68	47759	454.30	627.14	653.68	-
2017	574.42	667.34	619.50	788.23	760.64	518.25	655.27	628.34	519.37	563.05	603.47	485.38

All unit at $Jm^{-2}day^{-1}$

Table 2: Data for mean annul difference between maximum and minimum Temperature.

Years	Maximum Temp. °C	Minimum Temp. °C	Difference in Temp. °C
2012	35.47	22.30	13.17
2013	33.84	24.53	9.31
2014	35.68	24.94	10.74
2015	34.62	23.88	10.74
2016	38.11	24.59	13.52
2017	33.24	24.83	8.41

Method of Data Analysis

Perhaps the most common model equation used for relating solar radiation to climatologically factors is the Angstrom-Prescott- page equation which relates solar radiation to relative sunshine duration in the form

$$\frac{H}{H_o} = a + b\frac{S}{S_o} \qquad 1$$

Where;

H = calculated monthly average of the daily total radiation

H_o = monthly average of extraterrestrial daily radiation on a horizontal surface.

S = monthly average daily hours of bright surface.

S_o = monthly average of the maximum possible daily hours of bright sunshine.

a, b = constants (the Chigstron's regression coefficient) which strictly varies with climate and location.

The equation was first proposed by Angstrom (1924) and later modified by Prescott (1940) and Page (1964). The monthly average of daily extraterrestrial radiation is given as;

$$H_o = \frac{24\times3600\, I_{sc}}{\pi}\left[1+\frac{0.003\cos 360\pi}{360}\right][\cos\varphi\cos\delta\sin\omega] + \left[\frac{2\pi\omega}{360}\right]\sin\varphi\sin\delta \qquad 2$$

Where I_{sc} is the solar constant in extraterrestrial region (1367 Wm^{-2}); n is the day of the year; (p is the latitude; 5 is the declination; and w is the hour angle. Declination may be calculated by the following relation (Cooper, 1969).

$$\delta = 23.45m\left[\frac{260(284+n)}{365}\right] \qquad 3$$

Home angle can be expressed as

$$\omega = \cos^{-1}[-\tan\varphi\tan\delta] \qquad 4$$

The number of day light (sunshine) hour is given by

$$S_o = \frac{2}{5}\cos^{-1}[-\tan\varphi\tan\delta] \qquad 5$$

The monthly clearness index is given as $K_T = \frac{H}{H_o}$ 6

According to Iheonu (2001), the solar radiation reaching the maximum temperature through the relation,

$$\frac{H}{H_o} = a + bT_{max} \qquad 7$$

The data H and T_{max} are from the measurement while H_o and K_T is the clearness index.

III. RESULTS AND DISCUSSION

Results

Table 3: Meteorological data and global solar radiation for Yola from (2012 – 2017)

Month	S (hours)	S_0 (hours)	S/ S_0	H/ Ho
Jan	5.28	11.69	0.4565	0.5444
Feb	5.48	11.80	0.5682	0.5611
Mar	5.17	11.94	0.5461	0.5174
Apr	5.34	12.09	0.6554	0.5098
May	5.52	12.22	0.6515	0.5085
Jun	4.39	12.28	0.3675	0.4539
Jul	3.11	12.25	0.2522	0.3791
Aug	3.24	12.14	0.2193	0.3702
Sep	3.33	12.00	0.2918	0.4029
Oct	4.22	11.84	0.3831	0.4803
Nov	5.75	11.72	0.4990	0.5593
Dec	5.78	11.66	0.5046	0.5761

Table 4: Mean annual solar radiation and maximum temperature

Years	Mean annual solar radiation H (JM^{-2})	Maximum Temp. °C
2012	556.79	35.47
2013	811.68	33.84
2014	776.99	35.68
2015	614.03	34.62
2016	543.02	38.11
2017	625.27	33.24

The graphical analysis of Mean annual solar radiation and maximum temperature (T_{max}) are presented in figures below respectively.

Figure 1: Relationship between the monthly average values of H/Ho and S/So.

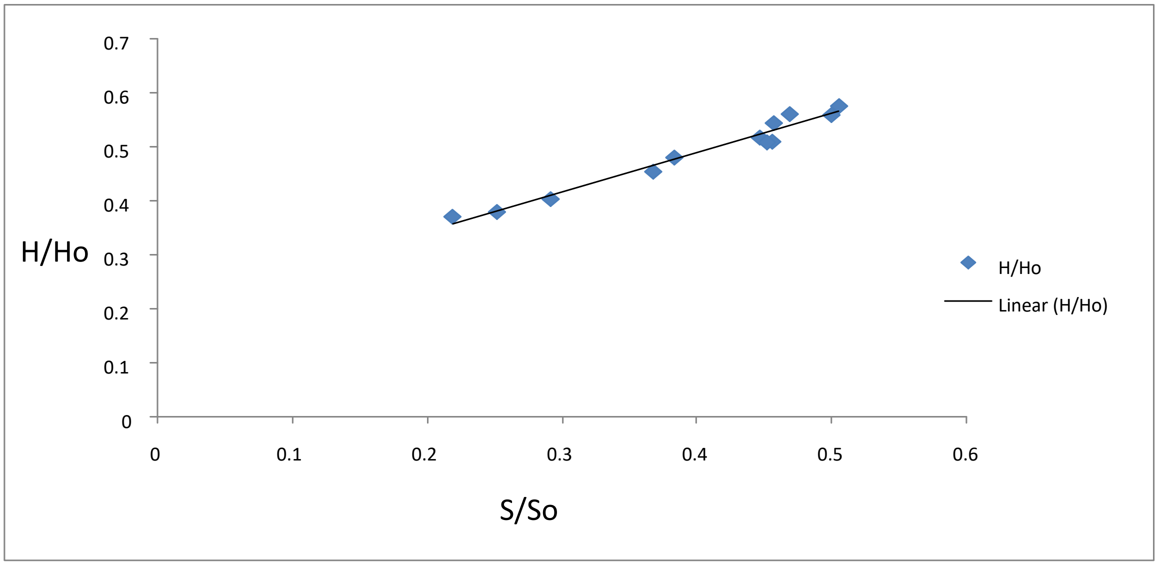


Figure 2: Average monthly variation of sunshine hours in Yola.

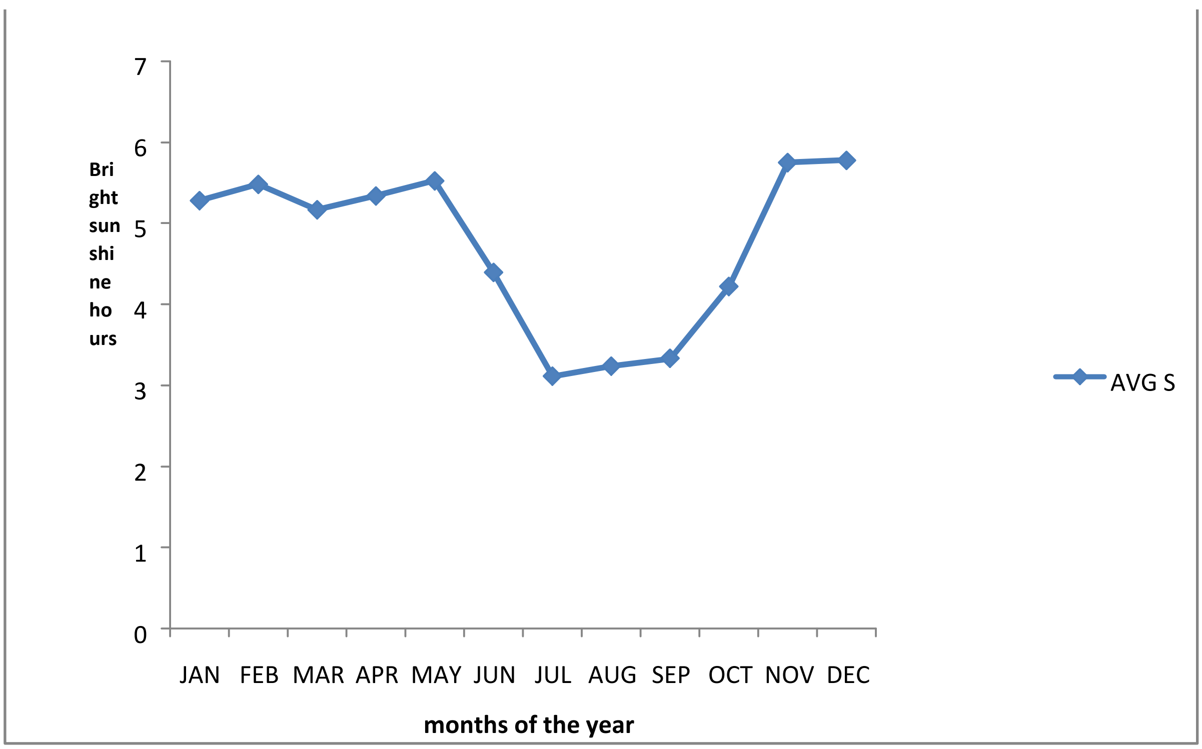
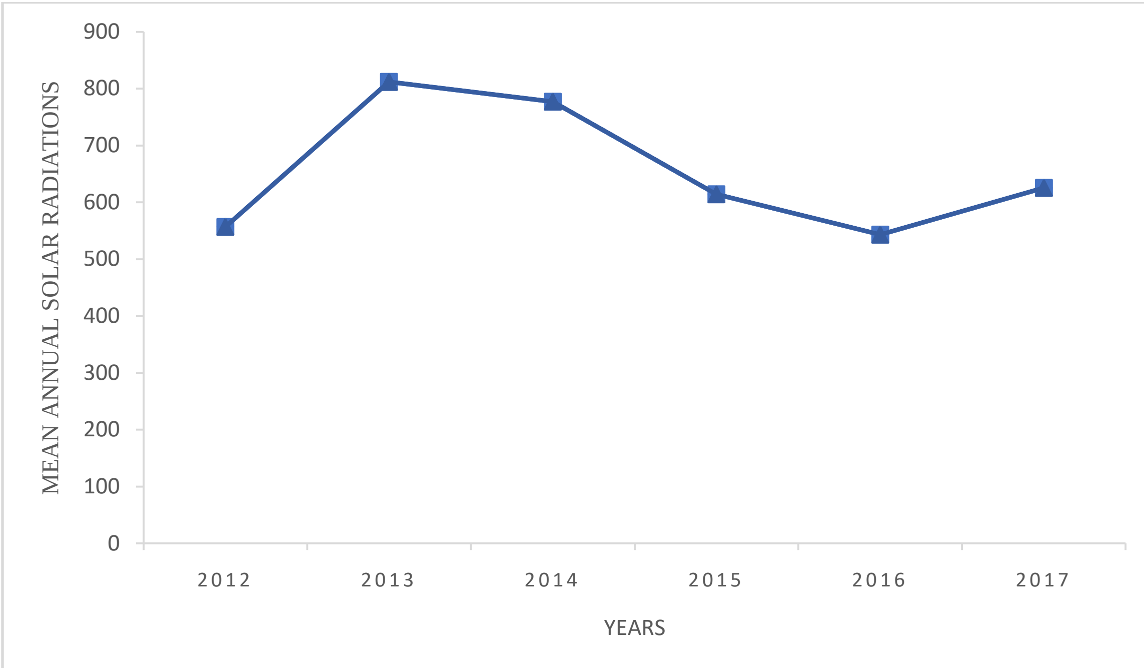


Figure 3: Mean Annual Solar Radiations against Years



Discussion

The Annual solar Radiation for the period of six years (2012 – 2017) with corresponding mean solar radiation was analyzed. The annual pattern of the monthly average daily clearness index and relative sunshine is shown with noticeable least values during the wet season specifically around July-August. The linear relationship between the monthly averages values of H/H_o versus S/S_o. The result shows that there is frequently a change in sunshine hours because of changing local weather condition. The June, July and August lie in summer season. This summer season is monsoon season. On the other hand, the sunshine hour is the lowest in August due to the high frequency rainfall in monsoon season. The analysis in figure 3 shows that the solar radiation in joule per unit area has a fluctuating pattern with a peak in 2013 (corresponding 811.68J/m^2) and its least value in 2016 (approximately 543.02J/m^2). The mean monthly solar radiation obtained for this region is 677.51J/m^2 which is within the threshold for which PV/ cell can generate power.Solar energy plays an important role in energy substitution in many countries of the world, even in cold climate and Nigeria, which is blessed with abundant sunshine, must not be left out. The main conclusion of this work is that the analysis of solar radiation and sunshine duration using the Angstrom-Prescott-Page model which seriously underestimated the solar radiation may be improved upon using other models. From table 3 it is seen clearly that in Yola for most part of the year, the clearness index K_T is greater than 0.5. This means that Yola sky remains clear for most part of the year for solar radiation to be received on a horizontal surface. This establishes the potential of Yola for solar energy activities.

IV. CONCLUSION AND RECOMMENDATIONS

Having gone a long way in a study of solar radiation: Remedy for fluctuation of electric power, the following recommendations are deemed necessary.It is recommended that proper utilization of solar radiation should be encourage as a remedy for fluctuation of electricity in Yola Adamawa State and the neighboring states.It is recommended that Federal Government and industries should invest in the ongoing research to improve the solar radiation as a remedy for fluctuation of electricity in Adamawa State.It is also recommended that the management of the institution should encourage prospective students who will like to undertake this type of project.

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