

---

---

## Solar Radiation Potential for Electricity Generation in Potiskum

By

*\*Abdullahi Madu, \*\*Sulaimon Shodiya and \*\*Abdulraheem Toyin*

*\*Federal College of Education (Technical) Potiskum.*

*\*\*Department of Mechanical Engineering  
University of Maiduguri. Maiduguri. Nigeria.*

---

---

### ABSTRACT

*Potiskum, located on latitude 11.42 °N, longitude 11.02 °E and Altitude 414.8m<sup>2</sup> was evaluated for solar radiation for the possibilities of it as a remedy to the fluctuation of electricity in the area. Gunn-Bellani radiation integrator was used to evaluate the solar radiation for this region. Data obtained from the period of 1990 to 2004 was analyzed for clearness index as well as Global solar radiation. This been the only data available using Gunn-Bellani at the station. The result produced was found to be within the allowable value with an average clearness index of 0.66. This means that the sky in this location is clear for most part of the year for solar radiation to be received on a horizontal surface. Hargreaves - Samani's equation was used as a method of estimating Global solar radiation using climatologically data's. The mean monthly solar radiation was obtained as 23.59MJ/m<sup>2</sup> which is within the threshold for which Photovoltaic cell can be used to generate power.*

### INTRODUCTION

Solar radiation has been identified as the largest renewable resource of energy on earth. The energy source is more evenly distributed in the World than wind or biomass, allowing for more site locations (Muhammad, Shodiya and Ngala, 2015, Muzathick et. al., 2011, Gungor and Yildirim, 2012, Okonkwwo, 2014). The maximum intensity of solar radiation at the earth's surface is about 1.2 kW/m<sup>2</sup> but it is encountered only near the equator on clear days at noon. Under these ideal conditions, the total energy received is from 6-8 kWh/m<sup>2</sup> per day (Gungor and Yildirim, 2012, Okonkwwo, 2014, Garba, Amusat and Ngadda (2015). Solar energy is not available continuously because of the day/night cycle and cloud cover. Its intensity varies according to season, geographical location

and position of the collector (Musa, Zangina and Aminu,2012).

Studies on solar radiation have become an important issue for renewable energy stemming from oil crises, global warming and other environmental problems, thus increasing the need for reliable measurements of surface solar radiation (Tiwari, 2012). The increase in energy consumption worldwide coupled with the grim fact that fossil fuels are finite, has led to an intensive search for alternative primary energy sources.

Solar radiation was historically monitored by measuring the sunshine duration with Campbell-Stokes recorders. An estimate of the global solar radiation was then obtained through the well-known Angstrom-Prescott equation (Holman and Gajda, Jr, 1978). Although pyranometers are

nowadays available to directly measure the global solar radiation, the sunshine duration is still an essential climatologically parameter that is still monitored in many meteorological stations in order to extend the historical time series.

There are two chief ways that sunlight may be converted into electric power firstly by a process called photovoltaic conversion and secondly by thermal conversion, which converts; light into heat and then to electric power. Nearly all the energy that we use is actively solar energy. For example solar energy stored in plants millions of years ago makes such fossil fuel as coal, petroleum and natural gas. The sun's heat evaporates moisture so that it falls as rain and other forms of precipitation. Global wind and ocean current are examples of nature's use of solar energy.

In photovoltaic conversion, the solar energy is converted into heat by using a collector to absorb solar radiation. This heat can be used directly in residential and agricultural operations. Like solar cell, solar thermal system uses solar radiation. Most solar systems use solar energy to produce electricity, but as the name suggested solar thermal use solar collector with mirrored surface to concentrate sunlight on to a receiver that heat a liquid (Walker, 2007). The superheated liquids is used to make steam that drives a turbine to produce electricity in the same way that coal, oil or nuclear power plant does. One main advantage of solar thermal plants systems is that they are clean and produce no environment pollution.

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).

Recently however, the rate at which these fuels are being consumed is so staggering that it has become a matter of great concern to all nations. The great increase in energy consumption worldwide coupled with the grim fact that fossil fuels are finite, has led to an intensive search for alternative primary energy sources, while at the same time efforts are being made to conserve and utilize fossil fuel more efficiently. Solar energy in the form of sun heat, sunlight and wind is now increasingly being adopted as primary energy sources especially in the generation of electricity. Those energy sources are abundant, renewable and cost virtually nothing. (Ishaku 1999).

The uses of solar Energy to generate electricity can be achieved using either the thermodynamic based cycles or using photovoltaic panels. The photovoltaic panels method is preferred as it offers a direct conversion of solar radiation to electricity in addition to having lesser plant complexity compared to the thermodynamic based method. As a result of declining supply of natural gas, increase emphasis on the use of solar energy and other renewable energy sources in generating electricity should be developed in order to eliminate problems associated with the use of convection energy resources. Solar energy is abundant, free and clean.

The Aim of the study is to determine the potential of solar energy for the purpose of Electricity generation which could be achieved through; data Collect on solar radiation, estimate of the global solar radiation and radiation clearness index.

**MATERIALS AND METHOD**

Potiskum of Yobe State was selection due to the availability of the solar data of the location. The geographical location of Potiskum was on latitude 11.42°N, Longitude 11.02° E and Altitude 414.8m in the North-Eastern Nigeria.

**DATA COLLECTION**

The following parameters were collected from the available Archives of Nigerian meteorological Agency, potiskum

from (1990-2004). Which is the available Solar radiation data.

- 1) The daily global solar radiation.
- 2) Sunshine hour

**Data Analysis**

The solar radiation outside the atmosphere incident on a horizontal surface (Extraterrestrial Radiation on a horizontal Surface) is given by the following expression (Duffie and Beckman, 1994):

$$H_o = \frac{24 \times 3600}{\pi} I_{sc} [ 1 + 0.033 \cos \frac{360 d}{365} ] [ \cos \phi \cos \delta \sin w_s + \sin \phi \sin \delta \frac{2\pi W_t}{360} ] \tag{1}$$

$H_o$  is the extraterrestrial insolation on horizontal surface where  $I_{sc}$  is the solar constant;  $\phi$  the latitude,  $\delta$  the solar declination,  $w_s$  is the sunset hour angle. The value of  $1367 \text{ Wm}^{-2}$  has been recommended for solar constant  $I_{sc}$  (Frolich and Brusca, 1981). The hour angle  $w_s$  for horizontal

surface is given as (Duffie and Becman, 1994):

$$S_{max} = \frac{2}{15} w_s \tag{2}$$

The day length  $S_{max}$  is the number of hours of sunshine or darkness within the 24 h in a given day. For a horizontal surface, it is given by (Duffie and Becman, 1994):

Declination is calculated as (Cooper, 1969):

$$\delta = 23.45 \sin \frac{360(284+d)}{365} \tag{3}$$

and hour angle

$$w_s = \cos^{-1} (- \tan \phi \tan \delta) \tag{4}$$

**The Global Radiation at Horizontal Surface**

$$\frac{H_g}{H_c} = a + b \left( \frac{S}{SMAJ} \right) \tag{5}$$

Where  $H_g$  is the monthly average daily global solar radiation falling on a horizontal surface at a particular location,

The monthly global solar radiation  $H/H_o$  falling on a horizontal surface at particular location is given as below;

$H_o$  the monthly mean daily radiation on a horizontal surface in the absence of atmosphere,  $S$  the monthly mean daily

number of observed sunshine hours,  $S_{max}$  the monthly mean value of day length at a particular location and “a”, “b” the climatologically determined regression constants to be determined as follows:

$$a = - 0.110 + 0.235 \cos \phi + 0.323 \left( \frac{S}{S_{MAX}} \right) \tag{6}$$

$$b = 1.449 - 0.553 \cos \phi - 0.694 \left( \frac{S}{S_{MAX}} \right) \tag{7}$$

In equation  $S/S_{max}$  is often called the percentage of possible sunshine hour.

$$K_T = \frac{H_g}{H_0} \tag{8}$$

Where  $K_T$  represents clearness index

**RESULTS**

**Table 1:** Solar Radiation parameters.

Months	Day length	$S_{max}$ . (hours)	Percentage Sunshine Hours $S/S_{max}$	$H_g$ (MJ/M <sup>2</sup> /day)	$H_0$ (MJ/M <sup>2</sup> /day)	$K_t$
Jan.	6.9	11.51	0.59	16.3	32.32	0.50
Feb .	8.8	11.76	0.75	22.4	34.71	0.64
Mar .	8.0	12.09	0.66	28.1	36.99	0.76
Apr.	6.8	12.28	0.55	26.1	37.91	0.69
May	8.3	12.61	0.66	27.9	37.37	0.75
Jun.	8.8	12.55	0.70	26.0	36.74	0.71
Jul.	6.6	12.51	0.53	24.8	36.89	0.67
Aug .	6.5	12.21	0.53	21.9	37.46	0.58
Sep.	7.1	11.89	0.51	22.8	37.15	0.61
Oct.	7.8	11.48	0.68	27.9	35.35	0.79
Nov .	9.4	11.41	0.82	21.4	32.79	0.65
Dec.	10.1	11.37	0.89	17.5	31.42	0.56

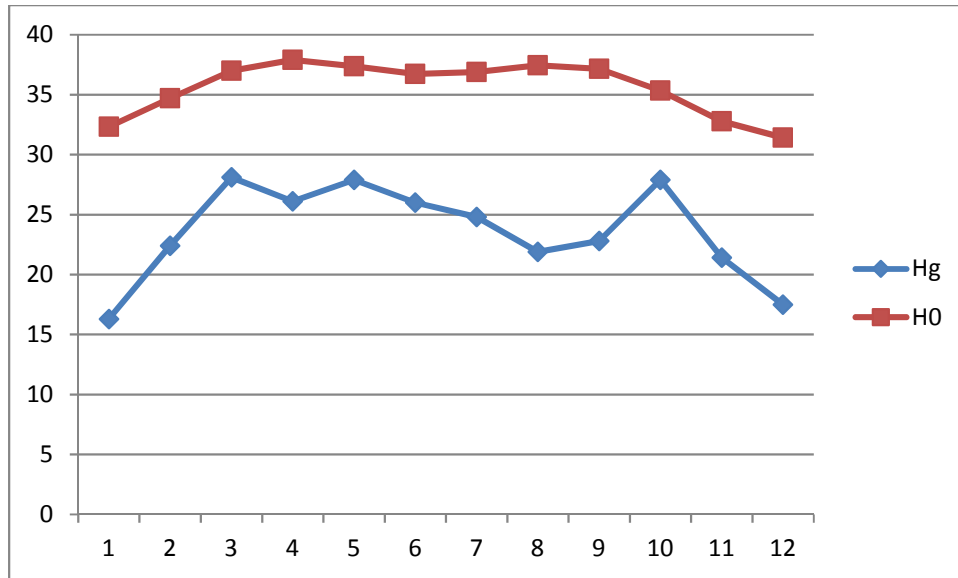


Figure 1. Graph of Monthly Global and Extraterrestrial Radiation Of Potiskum

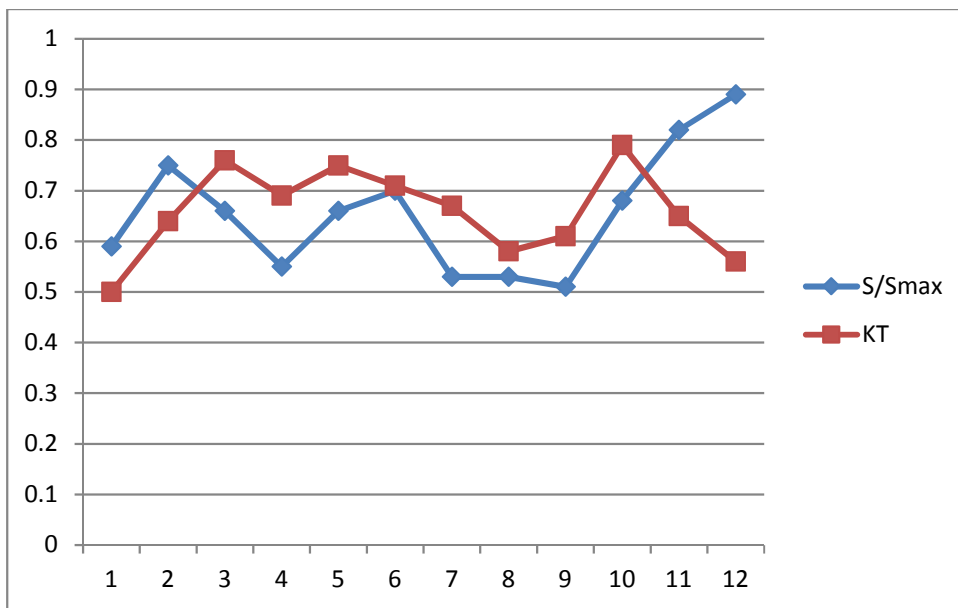


Figure 2. Clearness Index For Potiskum

**RESULTS AND DISCUSSION**

The regression constants ‘a’ and ‘b’ were evaluated using these parameters and were obtained as 0.33 and 0.45 respectively for Potiskum and the mean monthly values for  $H_g$ ,  $K_T$  and  $H_0$  were also estimated as 23.59, 0.66 and 35.59 respectively. From the

observed value of average clearness index, this has indicated that the sky is clear for most part of the months. This provides favorable condition for solar energy. The atmospheric clearness is indicated by fraction of extraterrestrial radiation that reaches the earth surface to that of the global

solar radiation  $k_t$  as well as a measure of the degree of clearness of the sky.

Global radiations obtained in this work are higher with mean value of 23.59 MJm<sup>-2</sup>, this means that there is a greater global solar energy potential in Potiskum. Also, with reference to Offiong that reports an average solar radiation for Nigeria per month as a whole to be as high as 20MJm<sup>-2</sup> depending on the time of the year (offiong, 2003), it can be stated conveniently that the result obtained in this work is in strong agreement with his finding.

## CONCLUSION

The result of this study shows that, there is greater availability of solar radiation in Potiskum and also solar energy devices will function successfully throughout the year in the area, hence there is a good global solar radiation potential in Potiskum location with bright prospects for solar energy utilization.

The result obtained indicates that the solar energy utilization has bright prospects in the North-Eastern Nigeria. The estimated values of global radiation can very efficiently be used to compensate for energy deficits. From the above results and considerations, the maximum values of global solar radiation appear in March, April and May respectively during dry season while minimum values were observed in December and January respectively as a result of hammattan.

## REFERENCES

Cooper P. I. (1969). The Absorption of Solar Radiation in Solar Still. *Sol. Energy* 12(3):333-346.

Duffie J. A, Beckman W. A. (1994). *Solar Engineering of Thermal Processes*.

John Wiley, New York, U.S.A. 2nd Edn. pp. 234-367.

- Frolich C, Brusca R. W. (1981). Solar Radiation and its Variation in Time. *Solar Phys.* pp. 74-209.
- Garba, A. A. Garba, Amusat, R. O. and Ngadda, Y. H. (2015). Estimation of Global Solar Radiation using Sunshine-based Model in Maiduguri, North East, Nigeria. *Applied Research Journal.* 2 PP 20 – 22
- Gungor, A. and Yildirim, U. (2012), Global Solar Radiation Estimation Using Sunshine Duration in Nigde, 16th International Research/Expert Conference. “Trends in the Development of Machinery and Association Technology” PP327 – 328
- Holman, J. P. and Gadjia, W. J., (1978). *Experimental Models for Engineers.* Third Edition; McGraw Hill Kogakusha, LTD; Tokyo; PP 79 – 81.
- Ishaku (1999). Solar Energy for power generation, *Nigerian Journal of Renewable Energy*,
- Medugu D. W. and Malgwi D. I. (2005): A Study of Wind Energy Potential: Remedy for Fluctuation of Electric Power in Mubi, Adamawa State Nigeria. *Nigerian Journal of Physics* 17 pp 40-45.
- Muhammed, A. B., Shodiya, S. and Ngala, G. M. (2015), Feasibility Study of Solar-Wind Hybrid power System for Maiduguri Area of Nigeria. University of Maiduguri Faculty of Engineering Seminar Series Volume 6, December, 2015. pp: 10 – 14.
- Muzathick, A. M., Nik, W.B.W. Ibrahim, M. Z., Samo, K. B., Sopian, K. and Alghoul, M. A. (2011), “Daily Global Solar Radiation Estimate based on

- Sunshine Hours. *International Journal of Mechanical and Materials Engineering (IJMME)*. Vol. 6 PP 75 – 80.
- Offiong A. (2003). Assessing the economic and environmental prospects of stand-by solar powered system. *Nigerian Journal of Applied Science and Environmental Management*. 2003; 7(1); 37-42.
- Okonkwkwo, G. N. (2014). Analysis of Solar Energy Parameters in Bida, Nigeria. *European Scientific Journal*, 10 Pp 116.
- Parlin J. (2002): History of Solar Energy in California, Retrieved March 7, 2017. From [Http://www.CaliforniaSolar.Center.org/HistorySolar](http://www.CaliforniaSolar.Center.org/HistorySolar)
- Tiwari, G. N. (2012). Solar Energy Fundamental, Design, Modeling and Application. First Edition; Narosa Publishing House PVT Ltd. Delhi; pp 17– 29 vol. 1, 1990 pp. 29.
- Walker A. (2007). National Renewable Laboratory. Solar Water Heating Canada. <http://www.Wbdg.org/design/swheating.php>.