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COMPARISON BETWEEN THE CHARACTERISTICS OF WIND POWER CALCULATION AND SOLAR RADIATION AT ONNE

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ABSTRACT

Data on wind speed and global solar radiation over the period 1985 – 1999 for Onne obtained from the International Institute of Tropical Agriculture (IITA) stationed at Onne, Nigeria have been compiled and evaluated, to determine the wind power which is compared with the global solar radiation energies. Monthly and annual data for global solar radiation energies measured at the station were determined. The monthly average solar radiation energies range from 2777.80 Wm^{-2} to 4163.92 Wm^{-2} with an overall average as 3465.58 Wm^{-2}. The derived monthly and annual average wind speeds range from 0.84 ms^{-1} to 1.09ms^{-1} and from 0.64ms^{-1} to 1.28ms^{-1} respectively. The monthly available wind power density and maximum extractable wind power range from 0.33 Wm^{-2} to 1.40 Wm^{-2} and 0.20 Wm^{-2} to 1.10 Wm^{-2}, respectively.

KEYWORDS: Characteristics, wind power, solar radiation.

INTRODUCTION

Nigeria has abundant reserves of the major fossil fuels, as well as renewable energy resources like solar energy, biomass resource, hydropower and wind energy (Akapbio 1992, Akpabio et al 1999, Akpabio and Udoimuk 2003, Akpabio et al 2003, Akpabio et al 2004 and Akpabio et al 2005). One of the most important demands of energy in every society is that it is needed for the cooking of food. In most of the developing countries like Nigeria, cooking takes a very large part of the total energy.

For example in South-South of Nigeria, 80% of the total energy goes into cooking and most of this energy comes from firewood. The people living in rural areas purchase a few percentage of the firewood required for their cooking needs and the rest is got from cutting trees in the forest or in the residential areas causing soil erosion. Plants, as well as producing all the food for both the human beings and their animals, keep the oxygen supply of the earth constant.

A large percentage of the people live in the rural areas in most developing countries and especially in Nigeria, and often in such remote locations they are not accessible to the national grid. The absence of electricity and other social amenities in these areas has brought about migration of the youth from rural to urban centers in search of jobs and good things of life. This paper presents the comparison of solar and wind energy with their possible utilization in Onne and its environ.

MATERIALS AND METHOD

Global solar radiation and sunshine duration during the period 1984 to 1999 were supplied by IITA (International Institute for Tropical Agriculture) station at Onne, high rainfall station located at latitude 4°46'N, longitude 7°10'E with an altitude of 10m. The same data has been used by Akpabio and Etuk 2003 to develop a Page – type formular for Onne as:

$$H/H_o = 0.23 + 0.38\,(S/S_o) \qquad (1)$$

Where H, H_o, S and S_o are the monthly average daily global solar radiation, monthly average daily extraterrestrial radiation, monthly average daily number hours of bright sunshine and monthly average day length in hours respectively. Wind speed data, for the period (1985- 1999) was also supplied by the same station. Wind speed measurements fluctuate in random manner with respect to time, height above ground and terrain roughness. The reference wind speed is therefore generally related to a height of 10m above ground level in flat and open terrain. Since wind data supplied by IITA were measured from a height of 2m above ground level, it is therefore necessary to adjust the wind data to a height of 10m in order to make it directly related to the objectives of people working in the renewable energy sector The correction is done using the power law (Musgrove (1987), Wolde-Ghiorgis (1988), Akpabio et. Al (1999).

$$V_1/V_2 = (H_1/H_2)^{\alpha} \qquad (2)$$

Where V_2 is the mean wind speed at height H_2meters recorded at the station, V_1 is the wind speed at height H_1.H_2 is the anemometer height at the station and H_1 is the anemometer height at 10m. The magnitude of the exponent, α, is given by (Qashou et al, 1986).

$$\alpha = (0.37 - 0.008\ \ln V_2)/(1 - 0.088\ \ln(H_2/H_1)) \qquad (3)$$

α depends on the roughness of the terrain time of the day, the wind stability and wind speed level It varies from 0.1 to 0.4 for different stations (Musgrove (1987), Qashou et al (1986) and Rizk (1987) Since site selection plays an important role in the installation of wind energy systems, then the estimate of the wind energy at the projected site must be made (Anyanwu and Iwuagwu (1995), Lewis (1988), Gopalakrish and Sankar (1987), Akpabio et al Accepted for publication in JAS, Qashou et al (1986), Rizk (1987), Wolde-Ghiorgis (1988), Ramachandra et al (1997) and Persand et al (1999)).

SOLAR ENERGY AND WIND POWER ESTIMATION

Solar energy value was measured by IITA station at Onne for the duration under consideration Wind power estimation is carried out as follows: for any wind stream with speed, V (m/s), passing through an area, A (m^2) the theoretical power, P_t, that is available can be obtained from Putnam (1948) and Considine (1977) as

$$P_t = \tfrac{1}{2}\rho A V^3 \qquad (4)$$

Where ρ, the average air density at the location is given as 1.22 Kg/m^3.

However, the maximum wind power P_m which can be extracted by an ideal wind turbine is presented by Goldine

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(1955) as:

$$P_m = (0.593)/2\ \rho AV^3 \qquad (5)$$

Which is 59.3% of the theoretical wind power. Above expression for wind energy estimation has just been employed by Akpabio et al (2005) in their article submitted to Journal of Nigerian Environment Society.

RESULTS AND DISCUSSION

An inspection of Table 1 which represents the wind speed (from 1985 to 1999) shows that;, the yearly mean wind speed varies between 0.64ms^{-1} and 1.28ms^{-1} with an overall mean of 1.26ms^{-1}. The highest wind speed of 1.80ms^{-1} was recorded in March 1985 and highest monthly mean value of 1.09ms^{-1} also occurred in this month. While monthly mean wind speed, vary between 0.84ms^{-1} and 1.09ms^{-1}. The monthly mean available wind power density varies between 0.33 Wm^{-2} corresponding to 2.89 KWhm^{-2} and 1.40 Wm^{-2} corresponding to 12.26 KWhm^{-2}, While the monthly mean maximum extractable wind power by any Wind Energy Conversion System (WECS) varies between 0.20 Wm^{-2} corresponding to 1.75 KWhm^{-2} and 1.10 Wm^{-2} corresponding to 9.64 KWhm^{-2}.

Table 1: Estimated Wind speed (m/s) for Onne

Year	J	F	M	A	M	J	J	A	S	O	N	D	Yearly Mean
1985	1.33	1.42	1.80	1.40	1.60	1.45	1.03	1.16	1.33	1.06	0.90	0.96	1.28
1986	-	1.33	1.42	1.60	1.45	1.36	1.35	1.54	1.70	-	-	-	0.97
1987	-	1.24	-	1.96	1.11	1.03	0.90	1.11	0.94	0.55	0.30	-	0.64
1988	0.32	0.63	0.72	1.50	1.57	1.37	1.34	1.40	1.31	1.10	0.90	0.87	1.08
1989	-	-	1.50	1.42	1.12	1.53	1.40	1.40	1.33	1.14	1.00	0.85	1.06
1990	1.10	1.30	1.52	1.58	1.45	0.96	0.63	1.40	1.14	1.01	0.94	0.96	1.16
1991	0.98	0.87	1.04	1.00	1.26	1.40	1.44	1.46	1.14	0.97	0.77	1.01	1.11
1992	0.25	1.24	1.24	1.18	1.18	1.09	1.04	1.11	1.20	1.04	0.75	0.76	1.00
1993	0.05	1.24	1.18	1.06	1.04	0.94	0.94	1.01	0.94	0.90	0.84	0.63	0.98
1994	0.91	1.15	1.12	1.11	1.00	1.01	0.91	1.05	1.01	0.97	0.77	0.74	0.93
1995	1.24	1.50	1.12	1.46	1.40	1.33	1.14	0.90	0.87	0.61	0.96	0.90	1.12
1996	0.87	1.12	0.97	0.88	0.97	0.75	0.79	0.27	1.33	1.04	0.88	0.97	0.90
1997	0.89	0.99	1.29	1.25	1.07	1.13	1.34	1.32	1.19	1.11	0.78	0.71	1.08
1998	0.91	1.04	1.09	1.29	1.26	1.00	1.17	1.40	1.06	0.97	0.78	0.55	1.05
1999	0.88	1.04	1.24	1.08	1.99	0.98	1.06	1.26	1.26	1.11	0.56	0.83	1.03
Mean	0.86	1.03	1.09	1.09	1.00	0.94	0.98	1.06	1.04	0.84	0.72	0.68	

For power demands above 10 KW, it is usual to retain the diesel engine (for industrial or communal purposes), which provides the certainty of power on demand; the main usefulness of the wind turbine will be to save diesel fuel and to reduce the overall cost of energy delivered. At lower power levels (less than 10KW) as what is obtained at Onne, wind turbines with battery storage may replace diesel engines. Such wind/battery systems could be used in a wide range of applications such as lightning, radio and television receivers and in communication.

From Table 2, we have the values of global solar energy as obtained from Akpabio and Etuk (2003). The annual mean solar energies measured at Onne lies between 2777.80 Wm^{-2} corresponding to 10.00 MJm^{-2}h^{-1} and 4163.92 Wm^{-2} corresponding to 14.99 MJm^{-2}h^{-1} with an overall average of 3455.58 Wm^{-2} corresponding to 12.44 MJm^{-2}h^{-1}. To illustrate the variety in shape and range of the monthly mean wind and solar energy, the corresponding data for the location are shown in Figures 1 and 2.

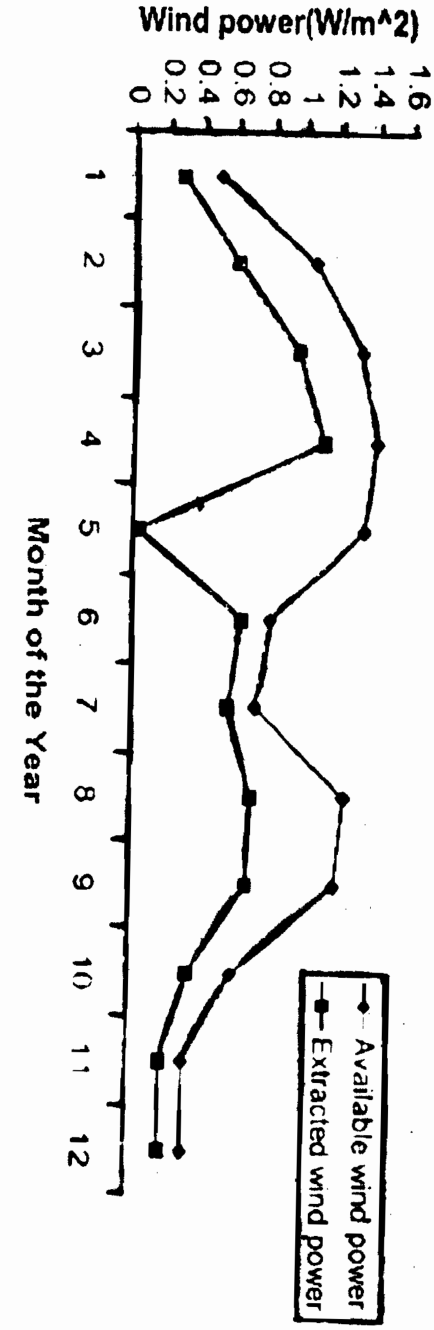

Fig. 1: Monthly average Wind power density

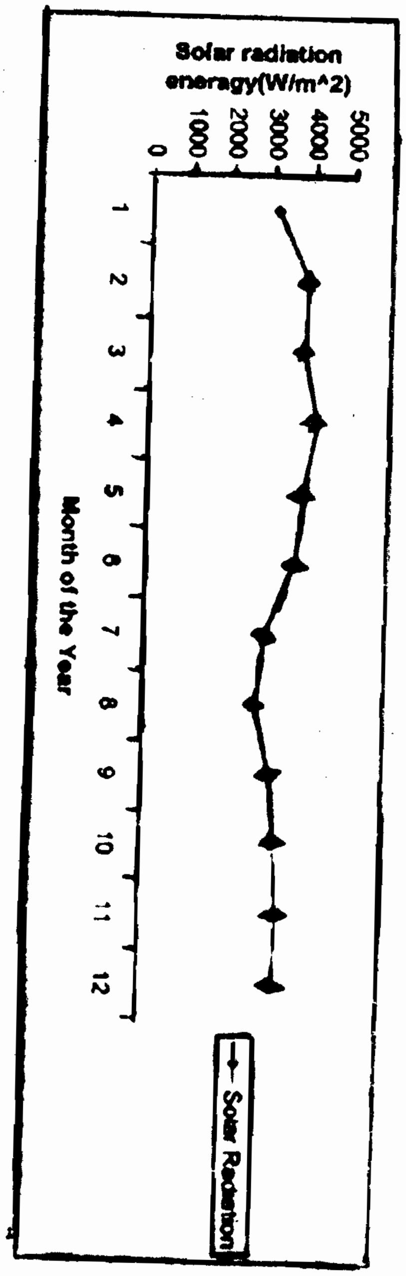

Fig. 2: Monthly average solar radiation energies

As observed from the figures, the monthly mean power pattern tends to be higher during the periods February – April, but wind power is relatively small when compared with solar energy. Hence, the power pattern is lower during the rainy season (May to October) than that of the dry season (November to April). From these results wind energy is quit attractive for water pumping, for the provision of electricity for communal television viewing, refrigeration of drugs and for powering small-scale industries

Table 2: Monthly average measured values of H for Onne during 1984 – 1999 (Akpabio and Etuk, 2003)

Months											
Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep	Oct	Nov	Dec.
$H(W/m^2)$	3916.70	3797.25	4163.92	3838.92	3677.81	2961.13	2777.80	3155.58	3302.80	3408.36	3355.58
3119.49											

CONCLUSION

The meteorological parameters (such as global solar radiation, sunshine duration and wind speed data) reported in this paper are mainly intended to verify the climatic conditions likely to affect the operation of solar and wind systems that may be set up at a later date. Most solar and wind energy technologies do require the means and variances of solar radiation and wind speed for design purposes. Summing up the findings, it can be concluded that wind power at Onne is relatively small (but not completely absent) when in comparison with solar energy. This station (Onne) may be poorly observed and it is not located in the windiest environment. Widespread of wind measuring devices located at suitable places would provide more reliable wind power estimation. Cases of roof being blown-off and permanently deformed trees along coastal line in this region indicate that there might exist higher wind speeds than those measured by the nearest meteorological stations. The immediate application of wind power is in water pumping, lighting, and radio and television receivers as well as in communication.

Onne, which is IITA high rainfall station, still has an excellent annual mean solar insolation of 3.5 $KWhm^{-2}day^{-1}$ as what is obtained over Europe or U.S.A (Qashou et al (1986)). Solar energy applications lies on drying of agricultural products and solar distillation units. The data presented in this paper can be considered as the nucleus information for executing research and development of solar and wind energy projects. Finally, several automatic weather stations that record data on a temporal and spatial basis will be needed. These stations will be considered as complementary to the existing stations and will serve as a good source of information for wind and solar energy exploitation in Onne.

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