Solar Energy Potential in Nigeria

*1 Ndaceko, U. I; 1Mukhtar, A; 2Muhammed, M. A.; 2Bashir, T. S. and Suleiman F. A.
1Department of Energy Management, Training and Manpower Development and 2Renewable Energy,
Energy Commission of Nigeria

ABSTRACT: In Nigeria, Solar Energy Potential varies from 3.5-7.0kWh/m this work, Nigeria is expected to produce electricity that would be enough to service all parts of the country instead of some people getting access to electricity and others do not because power stations are not enough for the citizens. And it is also expensive to extend national grid to some remote part of rural areas. So, this work deals with the design of solar panels that generated 89,126.0608 mega watts of electricity from solar energy if 0.1 percent of land mass of Nigeria would be used as solar farm. Calculations were also done to find the states that have the highest and lowest solar energy potential in Nigeria.

Keywords: Sola Energy Potential, National grid, generation

1 INTRODUCTION

The sun is the world's largest power plant (Tom Stoflle and Stoven Wilson.2004) It provides more energy to the earth in one hour than that produced by all nations in a year. However, solar power statistics showed that we only use 0.1 % of sun for our electrical needs. Despite the advances in solar power technology, it still costs 5 times as much to produce electricity from solar panels than it does from using dirty coal, gas or nuclear sources. But as energy prices continue to increase, the future looks bright for solar power (Murat, & Khamid, 2007).

Mungai, (2007) in Nigeria, solar energy was accepted in this century while its growth was at a snail pace. Gradually people have started learning how to use energy off grid for the failure of nation's electricity generation but solar has high manufacturing costs of PV cells and the large land area needed to collect sunlight, solar power has the highest cost per Watt of all generation methods. The fact that power is only generated when the sun is shining means this expensive equipment sits dormant during the night, cloudy weather or when debris and dust collect on the surface.

Solar energy is encouraged in Nigeria for its vast land and abundant sunlight energy which serve as fuel for solar energy production. Federal, State, and Local government have started investing in solar energy but do not note the percentage abundance so it is difficult to know the amount solar energy statistics in Nigeria. Human creativity and innovation can help improve these solar power statistics. We are still a few decades away from breaking our addiction to fossil fuels but the promise of using the power plant in the sky is immensely great Solar energy is not only for electricity generation but for solar water heater, and other solar thermal systems.

2 SOLAR RADIATIONS

Solar energy is also one of the oldest renewable energy sources in the world. This energy is taken from the sun in the form of solar radiation. There are basically three ways that we can use the sun's energy. a) Solar cells in which photovoltaic or photoelectric cells are used to convert light directly into electricity. b) Solar water heating in which the heat from the sun is used to warm the water in glass panels of solar energy system therefore no longer requiring gas or electricity to heat the water. c) Furnaces that use mirrors to capture the sun's energy into a concentrated place to produce high temperatures. These solar furnaces can be used to cook food according to (Nafi'u,el at 2012).

The sun's structure and characteristics determine the nature of the energy it radiates into space. The

sun is a sphere intensely hot gaseous matter with a diameter of 1.39x109m and is, on the average, 1.5x1011m from the earth. As seen from the earth, the sun rotates on its axis about once every 4 weeks. However, it does not rotate as a solid body; the equator takes about 27 days and the Polar Regions take about 30 days for each rotation. The sun has an effective blackbody temperature of 5777K. The temperature in the central interior regions is variously estimated at 8×10^6 to $40x10^6$K and the density is estimated to be about 100 times that of water (Aribigbola, 2009).

Folayan, (1988) stated that sun is, in effect, a continuous fusion reactor with its constituent gases as the "containing vessel" retained by gravitational force. Solar radiation is an electromagnetic wave emitted by the sun's surface that originates in the bulk of the Sun where fusion reactions convert hydrogen atoms into helium. Every second, 3.89x1026J of nuclear energy is released by the sun's core. This nuclear energy flux is rapidly converted into thermal energy and transported towards the surface of the star where it is released in the form of electromagnetic radiation.

The power density emitted by the Sun is of the order of 64MW/m^2 of which 1370W/m^2 reach the top of the earth's atmosphere with no significant absorption in the space. The latter quantity is called the solar constant. Radiation reaching the Earth's surface is altered by a number of factors, namely: the inclination of the earth's axis and the atmosphere that causes both absorption and reflection of part of the incoming radiation according to (Holladay, 2006).

Accounting for absorption by the atmosphere, reflection from cloud tops, oceans, terrestrial surfaces and rotation of the Earth (day/night cycles), the annual mean of the solar radiation reaching the surface, is 170W/m^2 for the oceans and 180W/m^2 for the continents. Of this, about 75% is direct light, the balance of which is scattered by air molecules, water vapour, aerosols and clouds.

3 SOLAR RADIATION IN NIGERIA

In Nigeria, solar energy potential varies from 3.5-7.0kwh/m^2 /day (4.2million Mwh/day if 0.1% of land mass, it can be used to generate electricity. Ausubel, (,2007) Calculated that it would take 150square miles of photovoltaic's(PVS) to equal the output of the 1000 megawatts of electricity. In his paper, photovoltaic remains strict at about 10% efficiency, with no breakthroughs in 30 years. Today performance reaches about 5-6 Kilowatts per square meter.

Nigeria receives an average solar radiation of about 7.0kWh/m^2 (25.2MJ/m^2 per-day). The estimated potential of solar energy in Nigeria, with 5% device conversion efficiency is 5.0×1014 KJ of useful energy annually. This is equivalent to about 258.62million barrels of oil produced annually and about 4.2×10^5 GWh of electricity production annually, in the country.

Given an average solar radiation level of about 5.5KWh (m^2 per day) and the prevailing efficiencies of commercial solar-electric generators, then if solar collectors or modules were used to cover 0.1% of Nigeria's land area of 923,773km^2, it is possible to generate $1850x10^3$ GWh of solar electricity per year, which is over one hundred times the current grid electricity consumption level in the country (Aliyu, 2005)

Effective harnessing and utilization of this abundant solar radiation, using solar energy technologies to augment energy supply from fossil fuel energy resources (using cleaner fossil fuel technologies), would enhance availability of energy for socio-economic activities and subsequently lead the nation to realize its 2020 Transformation Agenda (Shukman, 2007).

4 RESEARCH METHODOLOGY

The land area of the states in Nigeria was taken in km^2 converted to ft^2. The ft^2 was used to calculate the solar energy generation in megawatts. Proposal was made that 0.1 percent of land area can be used for solar energy generation from every state of Nigeria. And the following calculations were made. (Falade, 1995):

4.1 Conversion from Km^2, Ft^2 to Mega Watt

Distance in square feet (ft^2) = Distance in km^2 x 10763900

Sizing for solar panel in watts per ft^2 = $\frac{9\ watt}{Area\ in\ ft^2}$ i

Solar sizing for each state = $\frac{0.1\%\ of\ Stand\ Area\ of\ the\ State}{Sizing\ solar\ panel\ per\ ft^2}$ ii

Solar sizing in mega watts = $\frac{Solar\ sizing\ of\ a\ state}{1000000}$ iii

4.2 Assumption

1. Each states in Nigeria 0.1% of land area used for solar electricity generation.
2. One ft^2 generates 9watt of solar energy.

5 RESULTS AND DISCUSSION

S/No	States	Surface Area In Km^2
1	ABIA	6320
2	ADAMAWA	36917
3	AKWA IBOM	7081
4	ANAMBRA	4844
5	BAUCHI	49119
6	BAYELSA	2110
7	BENUE	35518
8	BORNO	70898
9	CROSS RIVER	20156
10	DELTA	17698
11	EBONYI	5530
12	EDO	17082
13	EKITI	6353
14	ENUGU	7161
15	GOMBE	18768
16	IMO	5530
17	JIGAWA	23154
18	KADUNA	46053
19	KANO	20131
20	KATSINA	24192
21	KEBBI	36800
22	KOGI	29833
23	KWARA	36825
24	LAGOS	3475
25	NASARAWA	27117
26	NIGER	76363
27	OGUN	16762
28	ONDO	15500
29	OSUN	9251
30	OYO	28454
31	PLATEAU	30913
32	RIVERS	11077
33	SOKOTO	25973
34	TARABA	54473
35	YOBE	45502
36	ZAMFARA	39762
37	FCT	7315

Mega Watts Per State

612.230052
3576.338067
685.9725831
469.2629844
4758.408037
204.406461
3440.809802
6868.25084
1952.614516
1714.49552
535.719303
1654.820458

(Ojo, 2000)

5.2 Discussion of Results

The results shown above indicate 0.1% the thirty six states including federal capital territory Abuja was proposed to be used for solar panel farm. The solar energy will be installed in such area that will not affect the economic viability of each state or other sector of the economy (Williams and Carl, (1990).

In the analysis above, Niger state has the highest potential of solar energy with potential of 7,497.67megawatts of solar energy because it has the largest land mass in Nigeria with land area of 76,363km^2 and Bayelsa State being the state with the smallest land mass in Nigeria has potential of generating 204.406megawatts of solar energy. The sites of solar energy generation potential in Nigeria can be selected based on the factors affecting the economic viability of a state (Bradley, 1995). In the above analysis, the amount of solar energy potential in Nigeria is proportional to the land area of each state (Branosiki *et al*, 1995). Nigeria has land in square feet of 9.9029×10^{12}ft^2 surface area and has total potential of producing 89,126.0608megawatts of solar energy potential viza - viz the solar energy potential depends on the surface area of the land. In that case, 9.9029 X 10^{12} ft^2 has potential of producing 89,126.0608megawatts solar when 0.1 percent of the surface area of the land is used in solar panels (Ausubel, July 2007)..

6 CONCLUSION

From the above analysis we are able to conclude that the amount of solar energy depends on the land area of each state. This is when only 0.1% of land area was used to produce 89,126.061megawatt of solar energy. This 0.1% of the land area can be from selected economic non viable areas of the state, mounted on the roof of building or water lodged areas.

7 RECOMMENDATION

1. Areas of non economic land should be taken as solar panel farm.

2. This 0.1% land area can be transferred to low populated areas of the country in order to reduce interference with the populace.

3. Places with sun light energy potential should be chosen for installation for solar panels in each state of the country.

REFERENCES

Aliyu M. K. (2005). wrote into *Sweet Crude*, Enugu, from Nuhu Bamalli Polytechnic, Zaria, Kaduna State.

Aribigbola, A. (2009). *Institutional Constraints to Achieving the Millennium Development, Goals (MDGs)*. MDG Workshop (pp. 1-21). Abuja, Nigeria: Federal Ministry of Finance of Nigeria/Economic Commission for Africa.

Ausubel, J. (July 2007). *Renewable energy projects will devour huge amounts of land.* Retrieved from http://www.theguardian.com/uk/2007/jul/25/ruralaffairs.science

Baranoski, G., Ronke, J., Shirley, P., Trondsen, T., and Bastos, R. Bradley, D. (1995). Plants point the way to renewable energy. New Sci. 121 : *8 Distribution of Solar Energy System*. Retrieved from http://graphics.stanford.edu/courses/cs348bcompetition/ cs348b-05/borealis/webpage%20files/writeup.html

Bradley, D. 1995. Plants point the way to renewable energy. New Sci. 121 : 8 *Distribution of Solar Energy System* http://graphics.stanford.edu/courses/cs348bcompetition/ cs348b-05/borealis/webpage%20files/writeup.html

Energy Supply. January 28 to February 1, 2008 http://ec.europa.eu/news/energy/080128_2_en.html

Eskridge, R. E., O. A. Alduchov, I. V. Chernykh, Z. Panmao, A. C. Polansky, and S. R. Doty (1995). A Comprehensive Aerological Research Data Set (CARDS) :

Falade, T. S. (1995*). Solving Housing Problems in Lokoja*. B. Sc. Research Report. Department of Architecture, A. B. U. Zaria, Kaduna State, Nigeria

Folayan, C. (1988). *Estimation of Global Solar Radiation Bound for some Nigeria Cities.* Nigeria Journal of Solar Energy , 3-10.

Holladay, A. (2006). *Solar Energy, Microsoft Student 2007*. Redmond WA: Microsoft

Corporation. Retrieved from http://www.pvsolarchina.com

http://ec.europa.eu/eurostat/.
Mungai, P. (2007). *Comparison of Gunn Bellani Radiometer Data With Solar radiation*. Retrieved March 18, 2010, from meteo: http://.meteo.go.ke
Murat, K., & Khamid, M. (2007). *Solar Energy Storage using Phase Change Materials. Renewable and Sustainable Energy*. Retrieved fom http://www.pvsolarchina.com 1917-1955.

Ojo, O. (2000). *Fundamentals of physical and Dynamic Climatology*, 1st ed., SEDEC Publ., Lagos, Nigeria Second EU Sustainable Energy week puts the focus on
Rough and Systematic errors, Bull. Amer. Meteor. Soc., 76, 1759 – 1775, 1995 Eurostat News Releases on the internet
Shukman, D. (2007). *Power Station Harnesses Sun's Rays*. . Retrieved May 23, 2011, from news.bbc: http://www.news.bbc.co.uk

Williams, R. H; and Carl, J. W. (1990). *Energy from the sun*. Amer. Sci. J. 43 : 41Baranoski, G., Ronke, J., Shirley, P., Trondsen, T., and Bastos, R. Bradley, D. (1995). Plants point the way to renewable energy. New Sci. 121 : 8 *Distribution of Solar Energy System*
http://graphics.stanford.edu/courses/cs348bcompetition/cs348b-05/borealis/webpage%20files/writeup.html