How is 100% renewable energy possible for Nigeria?

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ABBREVIATIONS AND ACRONYMS

NEPA	National Electric Power Authority (Now PHCN)
PHCN	Power Holding Company of Nigeria
SHP	Small Hydro Power
NESCO	Nigerian Electricity Supply Corporation Ltd., Jos
ECN	Energy Commission of Nigeria
EIA	Energy Information Administration
REMP	Renewable Energy Master plan
WET	Wind Energy Technology
IEA	International Energy Agency
RET	Renewable Energy Technologies
CRM	Combustible Renewable and Waste
MoU	Memorandum of Understanding
SME	Small or Medium Enterprise
RE	Renewable Energy
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization

Power Terminology

1. GWh – GigaWatt hour: The Gigawatt is equal to one billion (10^9) watts or 1 Gigawatt = 1000 Megawatts.
2. kV – kiloVolt
3. kWh – kiloWatt hour
4. PV – Photovoltaic
5. MV –MegaVolt: A *megavolt* is 1 million volts in electronics and physics.
6. MW – MegaWatt: a megawatt is equal to one million (10^6) watts
7. MWe – MegaWatt electrical
8. J – Joule
9. PJ – 10^{15} Joule
10. Ha – hectare
11. Mtoe – Million tonnes of Oil

ABSTRACT

This report analyzes various works reviewing the renewable energy potential of Nigeria. It raises the possibility of having Nigeria's electricity grid powered by 100% renewable energy at the earliest possible date. At present, only 10% of rural households and 30% of the country's total population have access to electricity (the third largest country without access to electricity according to the IEA). Nigeria has one of the lowest net electricity generation per capita rates in the world: 15,000MW peak load demand to 6,050MW available capacity, resulting in an unreliable power supply and a correspondingly heavy dependence on fossil fuels in industries and residential areas.[1]

The majority of electricity generation in Nigeria came from fossil fuels (79%) in 2012, with about two-thirds of thermal power derived from natural gas and the rest from oil, resulting in CO_2 emission growth.[2] Nigeria currently ranks 46th in the world for CO_2 emissions released, with over 73.69 metric tons released in 2011 (World Bank). With global climate change prevailing, shifting to renewables (which would reduce the CO_2 emissions) would be the best rational option to salvage our degrading environment whilst providing a quality power supply to the tens of millions of people in rural areas currently without access to electricity. Harnessing energy from wind and the sun would further help reduce poverty and improve standard of living.

Technical research conducted recently concludes that a 100% stable power supply from renewable energy is possible in Nigeria. Nigeria is positioned perfectly at the moment for investment in renewables, especially as it continues to fight for a stable power supply with several power plants currently under construction and the privatization of the power sector from November, 2013. The feasibility and technicalities are elaborated across the chapters in this report.

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[1] Office of the Presidency of Nigeria, "Roadmap for Power Sector reform, August 2013", Retrieved March 2014.
[2] Office of the Presidency of Nigeria, "Roadmap for Power Sector reform, August 2013", <www.nigeriapowerreform.org/content/RoadmapforPowerSectorReformRevision201.pdf> Retrieved March 2014.

1 INTRODUCTION

1.1 Overview of Nigeria

Nigeria lies in the western region of Africa and is boarded by The Gulf of Guinea to the South, Niger to the North, Cameroon to the East and Benin Republic to the West. Nigeria's land area is 923,768 km^2. Nigeria is the most populous country in Africa with about 170 million people. Due to Nigeria's prime location along the equator, the climatic condition throughout the year is generally favorable, but varies.

Figure 1 Map of Nigeria showing boundaries Source: Google 2013 Map data

Nigeria is also endowed with huge deposits of oil, natural gas and other natural resources. It is the largest oil producer in Africa as well as has the largest gas reserve.[3] Petroleum has been the mainstay of Nigeria's economy since its discovery.[4] Although Nigeria is largely endowed with fossil fuel deposits, it also has immense potential in the renewable energy field; especially in hydropower generation because of is prime location with access to 840 km coastline in the South and two great rivers entering from the Northeast and Northwest. The northern part of Nigeria is also very close to the Sahara, hence enough sunlight and medium winds for substantial power generation.

1.2 Current Energy Consumption

EIA estimates that in 2011 Nigeria's primary energy consumption was about 4.3 Quadrillion Btu (111,000 kilotons of oil equivalent).[5] Of this, traditional biomass and waste accounted for 83% of total energy consumption. This high percent represents the use of biomass

[3] Oil & Gas in Africa – *KPMG 2013 Report*
[4] US Energy Information Administration (EIA), "Nigeria – Analysis, Dec. 2013"
[5] Nigeria – Analysis; *US Energy Information Administration*

to meet off-the-grid cooking heating and cooking needs, mainly in rural areas. Nigeria has vast natural gas, coal and renewable energy resources that could be used for domestic electricity generation, yet lacks policies to harness resources and develop new (and improve current) electricity infrastructure.

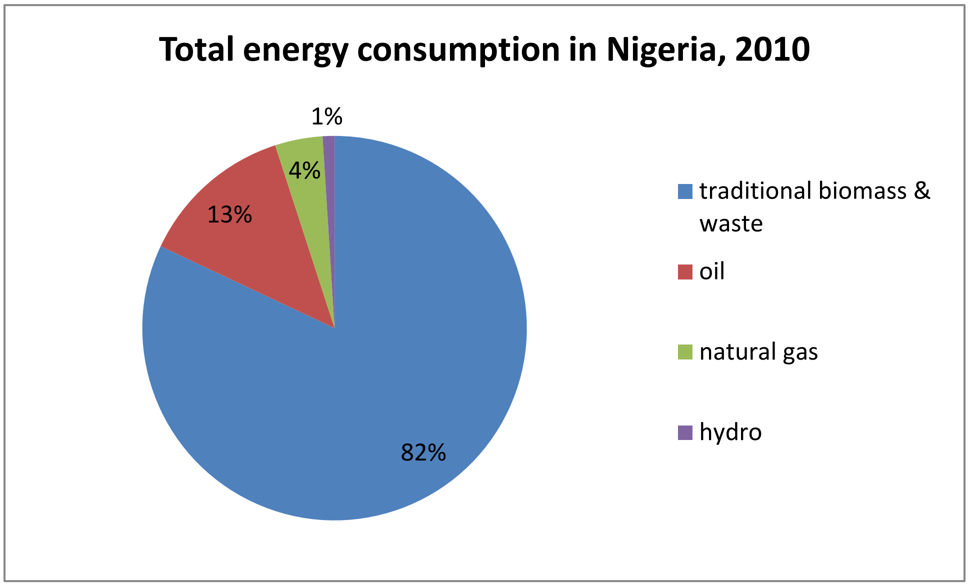

Figure 2 Total Energy Consumption in Nigeria 2010

1.3 Energy situation in Nigeria

The country is located between longitude 8°E and latitude 10°N, and has two major seasons, wet and dry. The seasonality makes water availability at the different hydropower stations variable, leading to an intermittent supply at times of low water levels. Also, the thermal power stations have been bedeviled by lack of adequate supplies of natural gas from the various Niger Delta gas wells, thereby making continuous energy production from these installations difficult.[6] This has left Nigerians at the mercy of private, alternative power generation through the use of diesel and petrol generators.[7]

[6] Iwayemi, A., Nigeria's dual energy problems: *Policy issues and challenges, International Association for energy economics, Fourth Quarter, 2008*
[7] Nigeria consumed about 9,000 short tons of coal in 2010. (EIA)

Figure 3 Nigeria's power grid Source: Google

Nigeria’s electricity sector is relatively small. Brazil and Pakistan, two countries with similar population sizes, generate 24 times and 5 times more power than Nigeria, respectively.[8] The latest EIA estimates show that Nigeria’s net generation was 18.8 billion kilowatt-hours (KWh) in 2009.[9] The graph below clearly illustrates the abysmal population to power ratio in Nigeria (5GW to 170 million people).[10]

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[8] US Energy Information Administration (EIA), “Nigeria – Analysis, Dec. 2013”
[9] Nigeria – Analysis; *US Energy Information Administration*
[10] US Energy Information Administration (EIA), “Nigeria – Analysis, Dec. 2013”

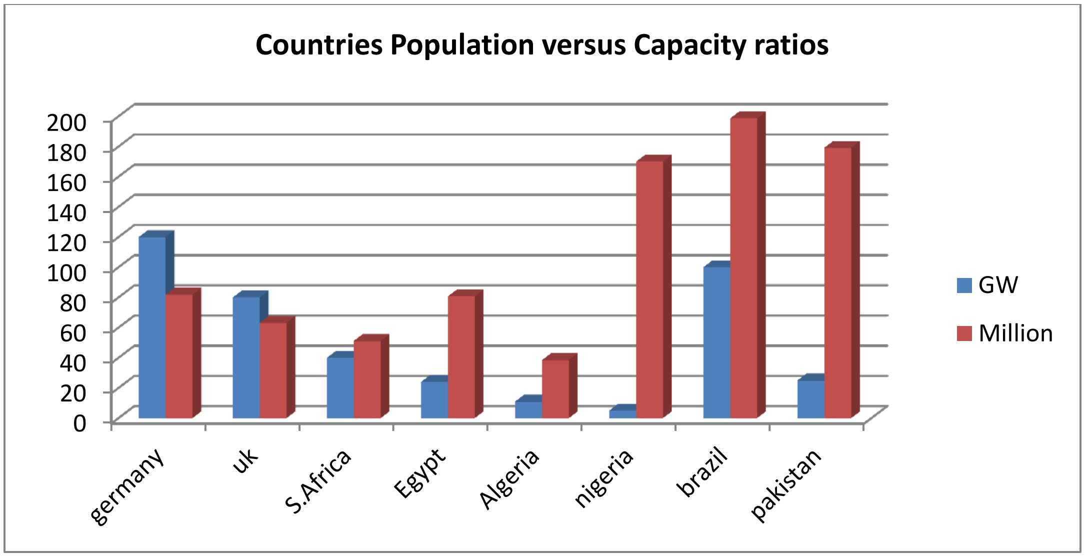


Figure 4 Countries population to generation capacity ratios

The installed power capacity has remained relatively flat over the last decade 10,396.0 MW, although net energy generation has slightly decreased from its peak of 23 billion KWh in 2004, mainly due to a decline in hydroelectric power.[11] The majority of electricity generation in Nigeria comes from thermal power plants (79%), with about two-thirds of thermal power being derived from natural gas and the rest from oil. Hydroelectricity (21%), the only other source of power generation, has decreased from its peak of 8.2 billion kWh in 2009, slightly less than generation, and exported most of the remainder to Niger through an agreement under the West African Power Pool.[12] IEA data for 2009 indicates that the electrification rate for Nigeria was 50 percent for the country as a whole – leaving approximately 80 million people without access to electricity in Nigeria.[13] Other estimates place the countrywide electrification rate as low as 45 percent.

[11] Nigerian Electricity Market; *National Integrated Power Projects*
[12] Office of the Presidency of Nigeria, "Roadmap for Power Sector reform, August 2013"
[13] US Energy Information Administration (EIA), "Nigeria – Analysis, Dec. 2013"

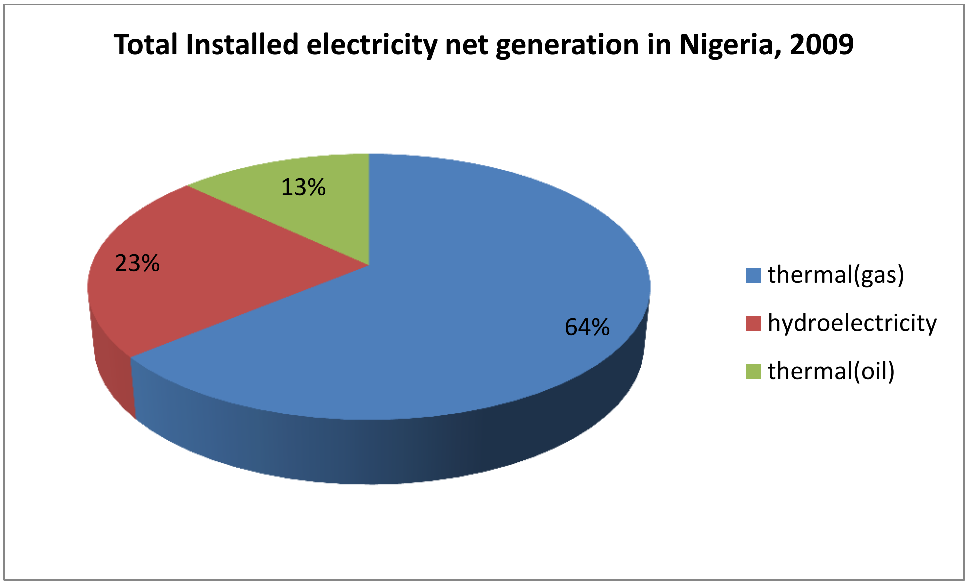


Figure 5 Total installed net Generation, 2009 Source: IEA

The installed capacity for electricity generation, which is 98% owned by the Federal Government, increased six-fold between 1968 and 1991. Capacity plateaued at 5881.6 MW through the 2000's. No further additions to generating capacity were developed over the subsequent decade.

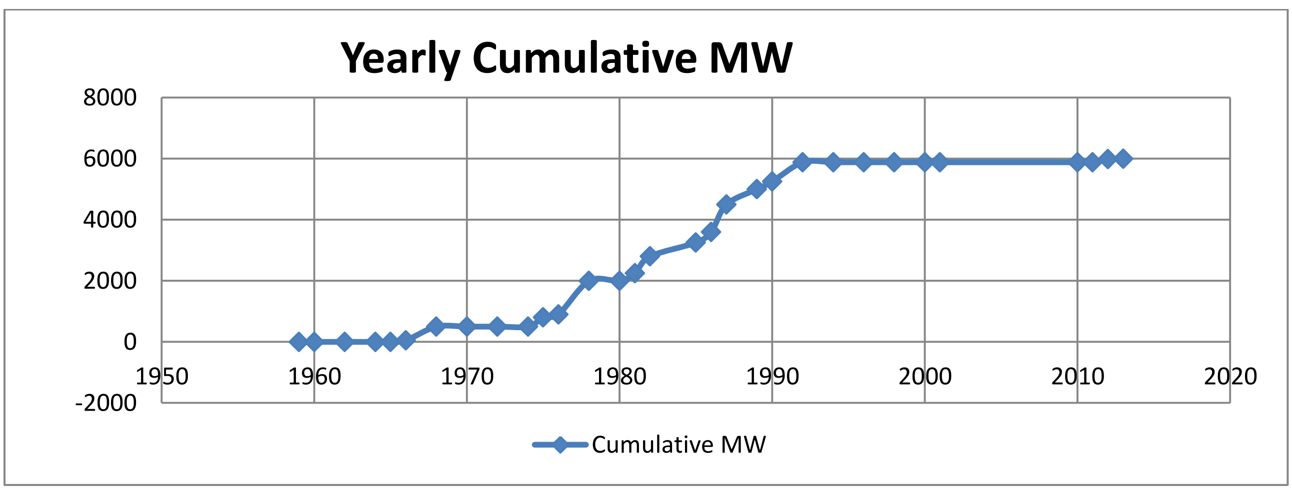


Figure 6 Cumulative yearly generating capacity

Between 1990 and 1999, no new power plants were built and the government substantially under-funded both capital projects and routine maintenance operations.[14] Hence, increased pressure on existing generation and inadequate overhauling of the generating stations

[14] Renewable Energy Potentials of Nigeria; *Vincent-Akpu, Ijeoma, University of Stirling*

proved to be an albatross as most units began to fail (see graph above). Nigeria has been marked by an unstable and epileptic power supply for the past two decades. Power supply to homes average about 6 hours per day. Electricity is largely supplemented by private producers or the use of individual generators powered by fossil fuel for the privileged classes. Over 90% of businesses and companies have private generators, leading to high production costs.[15] For Nigeria to meet its energy needs, it requires per capita power capacity of 1000 Watts or a power generating/handling capacity of **140,000 MW** compared with the current deliverable capacity of just 5,000 MW. Nigeria's development is severely hampered by this deficiency.

President Goodluck Jonathan's administration is poised to boast an additional 40,000MW by 2020, as indicated in the Roadmap for Power Sector Reform (RFPSR), which would require an annual investment of $3.5 billion per annum from the private sector.[16] To this end, the generation and transmission sectors have been privatized. In late 2013, the Nigerian government sold the 15 electricity companies under PHCN (5 Generation and 10 Distribution).[17] The purchasing companies—mostly international—are expected to take physical ownership of the infrastructure. Nigeria's two remaining state owned electricity companies under PHCN are also expected to be sold within 6 months. The proposed prime mover of this leap in generation is natural gas, ready to be harnessed from Nigeria's huge reserves. According to the August 2013 Roadmap, Nigeria plans to increase generation from fossil fuel sources to more than 20,000MW by 2020. Unfortunately, as at October 2013, only about 6,056MW of electricity generation capacity was available.

[15] Omokaro O. (2008). Energy Development in a Fossil Fuel Economy: The Nigerian Experience. The report of a National Dialogue to Promote Renewable Energy and Energy Efficiency in Nigeria. 55p.
[16] Office of the Presidency of Nigeria, "Roadmap For Power Sector Reform, August 2013"
[17] US Energy Information Administration (EIA), "Nigeria – Analysis, Dec. 2013"

2 RENEWABLE ENERGY POTENTIAL OF NIGERIA

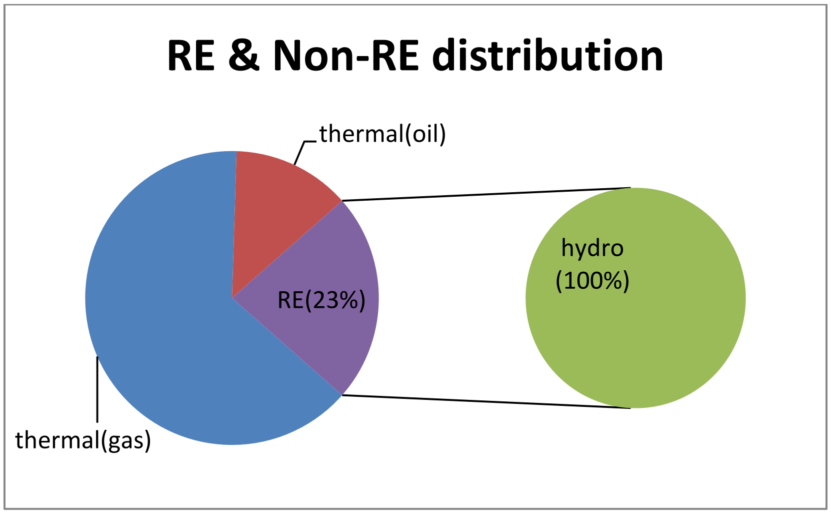


Figure 7 RE & Non-RE Distribution

Nigeria is endowed with sufficient renewable energy resources to meet its present and future development requirements. However, hydropower is the only sustainable resource currently exploited and connected to the grid.[18] Interest in renewable energy development and dissemination in Nigeria is driven by, among other things, the recent increase in oil prices, and the unavailability of electricity to majority of the population and the high cost and energy losses associated with grid extension. The government has made efforts through several power reform programmes and policies to attract private participation, thus encouraging renewable energy RE development. However, there are hindrances, mainly due to technical and financial barriers, that need to be overcome for this to be a reality. Renewable energy sources have contributed to Nigeria's energy mix for centuries now, albeit in a largely primitive way. Fuel wood, what is commonly referred to as woody biomass, is the primary energy source for rural Nigeria, and indeed, for much of the African continent. Large hydropower has also featured substantially as an energy source, providing about 19 percent of Nigeria's national electric grid supply.[19]

[18] The country possesses the second largest crude oil reserve in Africa. It is increasingly an important gas province with proven reserves of nearly 5000 billion cubic meters. Coal and lignite reserves are estimated to be 2.7 billion tons, while tar sands reserves represent 31 billion barrels of oil equivalent. From: US Energy Information Administration (EIA), "Nigeria – Analysis, Dec. 2013" and Nigeria Renewable Energy Master Plan (REMP), ECN & UNDP – November 2005

[19] Temilade Sesan, *Status of Renewable Energy Policy and Implementation in Nigeria, University of Nottingham, 2008*

2.1 WIND ENERGY POTENTIAL

Today, wind power is not used in Nigeria for electricity production. However, the desire to seek for a lasting solution to the energy situation of Nigeria has prompted the government as well as independent researchers to assess the nation's potential for wind energy.[20]

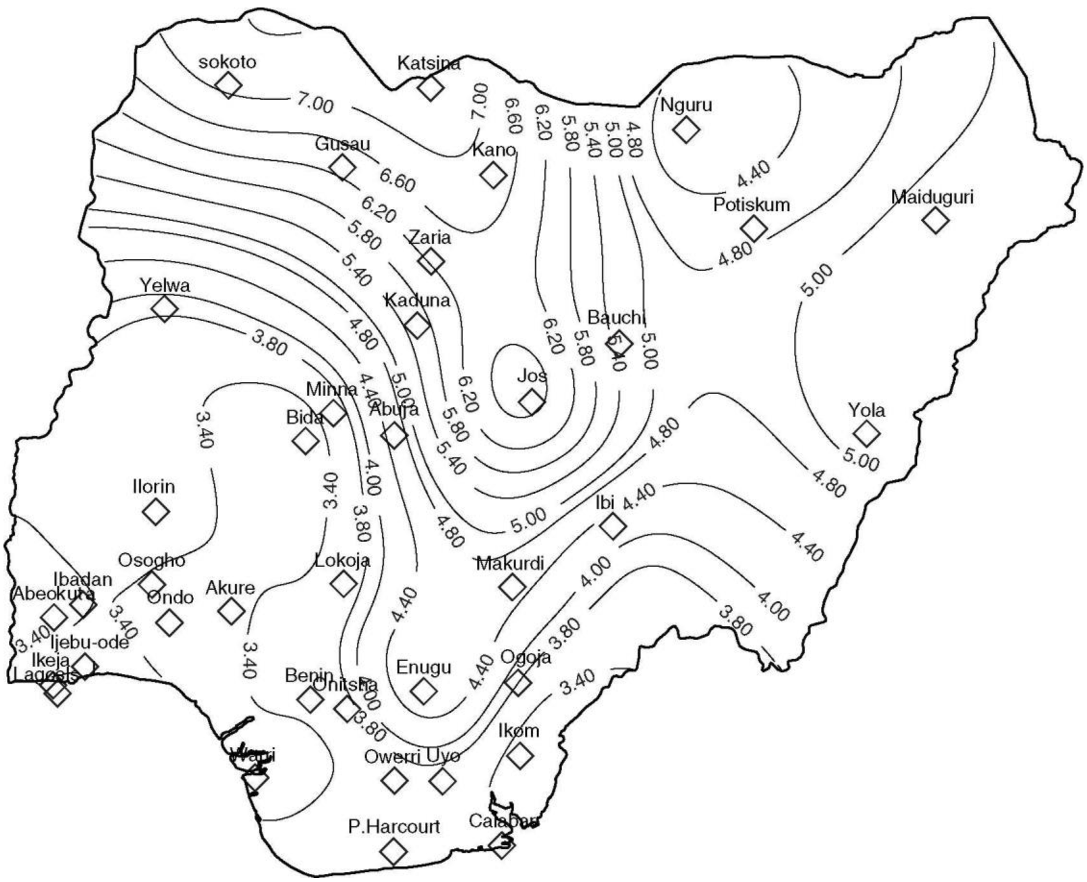


Figure 8: Isovents in m/s determined from 40 year's measurements at 10 m height, obtained from Nigeria meteorological department, Oshodi, Lagos State, Nigeria (NIMET [15]).

Asiegbu and Iwuoha studied the wind in Umidike, South-Eastern Nigeria and assessed its economic viability at a hub height of 65 meters above the ground with annual mean wind speed of 5.36 m/s using 10 years (1994–2003) wind speed data.[21] Fadare carried out a statistical analysis of wind energy potential in Ibadan (a city in Oyo State of Nigeria), using the Weibull

[20] Ajayi, O.O, *Assessment of utilization of wind energy resources in Nigeria, Energy Policy, 2009, 37, 750–753*.
[21] Asiegbu, A.D and Iwuoha, G.S. Studies of wind resources in Umudike, South East Nigeria – An assessment of economic viability, *Journal of Engineering and Applied sciences* 2(10), 2007, 1539–1541.

distribution function and 10 years (1995–2004) daily wind speed data.[22] The outcome was that the city experiences average wind speed of 2.947 m/s and solar power density 15.484 W/m^2.

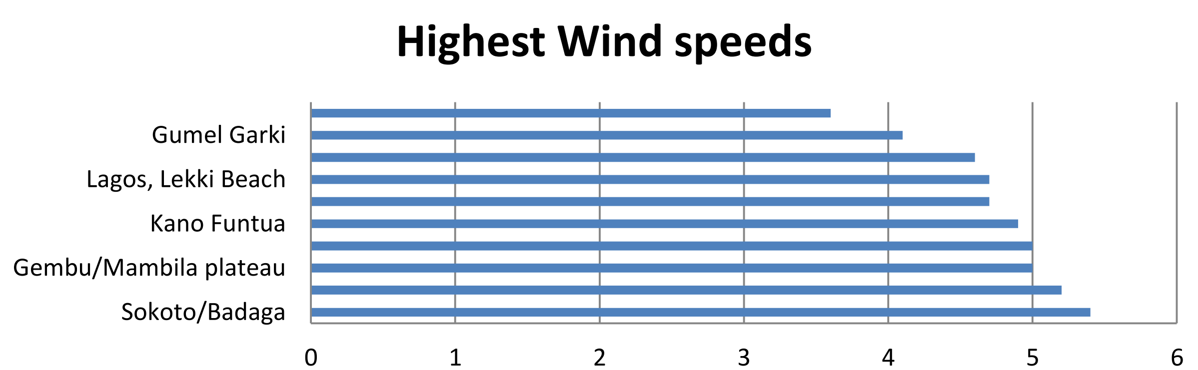
Ogbonnaya et al. on the other hand worked on the prospects of wind energy in Nigeria using 4 years of wind data from seven cities (Enugu, Jos, Ikeja, Abuja, Warri, Sokoto and Calabar).[23] The annual wind speed at 10 m above the ground varied from 2.3 to 3.4 m/s for sites along the coastal areas and 3.0 − 3.9 m/s for high land areas and semi-arid regions. It was also reported that Sokoto is capable of a power potential as high as 97 MWh/yr. Each of these initiatives, in the limits of their uncertainties, identified that great prospects exist for wind energy utilization for power generation. Moreover, wind speeds are generally weak in the south except for the coastal regions and offshore. Offshore areas from Lagos through Ondo, Delta, Rivers, and Bayelsa to Akwa Ibom States were reported to have potential for harvesting strong wind energy throughout the year.[24] Inland, the wind was reported strongest in the hilly regions of the North, while the mountainous terrains of the middle belt and northern fringes demonstrated high potential for great wind energy harvest. However, it was observed that due to the varying topography of the country, large differences may exist within the same locality. The values for the wind speeds range from a low 1.4 to 3.0 m/s in the southern areas and 4.0 − 5.12 m/s in the extreme North, at 10 m height.[25] Peak wind speed was shown to generally occur between April and August for most sites in the analysis.

Further analysis of these wind resources also revealed that the North, Central and South-East of the nation possesses enormous potential for harvesting wind energy, with possible wind speeds reaching as high as **8.70 m/s** in the north.[26] Hence, the North would be the best strategic location to start an initiative towards harnessing wind energy in Nigeria. At present, the share of wind energy in the national energy consumption has remained nominal with no commercial wind power plants connected to the national grid; only a few number of stand-alone wind power plants were installed in the early 1960s in 5 northern states mainly to power water pumps and a 5 kW wind electricity conversion system for village electrification installed at Sayyan Gidan Gada, in

[22] Fadare, D.A. A Statistical analysis of wind energy potential in Ibadan, Nigeria, based on Weibull distribution function, *The pacific journal of science and technology*, 9(1), 2008, 110–119.
[23] Ogbonnaya, I.O, Chikuni, E and Govender, P. *Prospect of wind energy in Nigeria*, July 16, 2009.
[24] Ajayi, O.O. *The Potential for Wind Energy in Nigeria,* 2010.
[25] Ajayi, O.O, *Assessment of utilization of wind energy resources in Nigeria, Energy Policy, 2009, 37, 750–753*.
[26] Ajayi, O.O, *Modelling the wind energy potential of Nigeria*, Covenant University, Ota, 2007.

Sokoto State.[27] An initial study has shown that total actual exploitable wind energy reserve at 10m height, may vary from 8 MWh/yr in Yola to 51 MWh/yr in the mountain areas of Jos Plateau and it is as high as 97 MWh/yr in Sokoto as these values increases at 30m height.[28] Hence, Nigeria falls into the **poor/moderate** wind regime.

From the wind map above, it can be concluded that Nigeria indeed has the potential for substantial wind energy development and will need to invest in this renewable source starting from the North, as wind speed is highest in the region including Sokoto, Jos, Bauchi and Kebbi States. A number of authors recommended that these potential wind farm areas should be connected to the grid (at the distribution level). The Director General of Energy Commission of Nigeria in a paper presented at International Association for Energy Economics (Third quarter 2009) lamented that these renewable energy resources, most especially wind, have not been integrated into the Nigerian grid.



	Sokoto/ Badaga	Jos Airport/ Kassa	Gembu /Mambi la plateau	South part of jos Plateau	Kano Funtua	Maidug uri/Mai nok	Lagos, Lekki Beach	Enugu/ Nineth mile corner	Gumel Garki	Ibi meterol ogical station
Speed @ 30m (m/s)	5.4	5.2	5	5	4.9	4.7	4.7	4.6	4.1	3.6

Figure 9 Highest wind speeds at various measuring stations

[27] Nnaji, C.E.; Uzoma, C.C. and Chukwu, J.O (2010). *The role of renewable energy resources in poverty alleviation and sustainable Development in Nigeria*. Continental J. Social Sciences 3: 31 - 37, 2010 ISSN: 2141 – 4265.
[28] REMP, 2005

2.1.1. Challenges facing Wind Development in Nigeria

1. **Non-existent policies or regulatory framework relating to wind energy technology:**

The government needs to develop good policy and a framework of legal and regulatory mechanisms that would foster the development of Wind Energy Technology (WET), attract investors—foreign and domestic—and also to set standards for wind farm development. As of today, no regulatory policy exists for WET. Potential investors wait to see the level of seriousness demonstrated by the government and what opportunities will be put in place to enhance marketability of WET within the country before investing their money. Such seriousness is demonstrated in policy documents.[29]

For Nigeria, the policy must contain important market components which will serve as incentives to investors. The act of making a single policy to represent energy sources (combining both renewable and nonrenewable or combining all renewable energy sources together) may not be very reassuring, because individual energy sources have specific dynamics and should be individualized in policy development. In addition, such policy should contain, among other issues, the quota of WET contribution to a national portfolio energy mix, which should be set and fixed for a specific entry year, probably 2020. With this, the nation and the public will be informed at what pace the WET development should go and what level of investment would be required.

2. **Poor Government Motivation on WET**

Although Nigeria's governments have been looking for ways of getting the nation out of energy poverty, they have not done enough to create an enabling business environment encouraging to WET development. It is well known that the initial capital cost for wind and other renewable energy technology is very high compared to other conventional energy sources. If, however, the governments (local, state and federal) would give tax incentives to willing investors, remove/reduce custom duties payable on importation of WET, give subsidies to

[29] An example of such a policy is the Denmark Renewable Energy Policy. This policy is among many other factors has improved wind power development in Denmark for over two decades, making the country one of the leading nations utilizing wind energy. Part of the policy statement includes a favor regulated feed-in tariff for electricity from wind and other renewables, different subsidies and remuneration rates for wind energy investors, the right to connect renewable generation to the national electricity grid, legal obligations for electric utilities to purchase wind energy and promotion of private individuals, farmers and cooperatives to own wind turbine installations. The overall goal of the Danish energy policy was to promote sustainable energy development and to comply with commitments to reduce greenhouse gas emissions to mitigation of climate change. From: N.I. **Meyer**: *Development of RES in* ***Denmark***

sales/purchases of WET applications, provide low or interest free loans through banks for WET investors and restructure the energy framework of the nation to include WET there would be rapid embracing of the technology of wind for power generation.

3. **Lack of Focus on the Renewable Energy Master Plan**

Nigeria's Renewable Energy Master Plan of 2005 (ECN-UNDP) says that the country should endeavor to increase the energy generation capacity from 5000 MW to 16000 MW by 2015 through the exploration of renewable energy resources. At present, there has not been a single grid generation of electricity from renewable energy sources (besides the traditional hydropower generation prequel to the REMP) probably as a result of government's lack of focus and commitment to the plan. The government at all levels needs to be committed to a plan they have initiated and agreed to if there must be meaningful development. The Renewable Energy Master Plan will be a vital resource if there can be serious devotion to the suggestions contained therein. Part of this suggestion includes the suspension of the Renewable Energy (RE) import duties, integration of RE into non-energy sector policies, establishment of national RE development agency, standardization of RE products and establishment of RE fund to provide incentives, micro-credits schemes, training and also funding R & D.[30] Moreover, there may be a need for the master plan to be broken down into renewable source components, with each addressing expected contributions from particular type of renewable resources.

4. **Lack of Adequate Funding**

Lack of adequate funding has been a major setback in the growth of WET and other renewable energy technology in Nigeria. Annually, the percentage of the federal budget to education and science and technology ministries has not been encouraging. With the meager sum made available to these ministries, much productive research and development may not be started or supported. Corporate bodies also need to be encouraged to collaborate with research institutions to fund research aimed at national development, some of which include wind-for-power projects (both small and medium scale turbines), nationwide wind energy resource assessment, development of adequate and explanatory national wind atlas/map that would provide information on quantity, distribution, quality and utilization possibilities to determine the commercial feasibility of wind energy generation and decision making on investment and

[30] Nigeria Renewable Energy Master Plan (REMP), ECN & UNDP – November 2005

development of national wind turbine tests and certification.[31]

5. Other Challenges

Apart from all the earlier mentioned challenges, which if overcome will move the nation forward in utilizing wind for power generation, there are other challenges which include lack of awareness and technical ineptitude. The level of awareness on the viability of wind power is very low in the country. The majority of schools' curriculum lack adequate information on wind and other renewable resources. Mass media too has not helped in any way, hardly any information regarding wind energy utilization or technology may be seen on the pages of newspaper or heard discussed on television or radio. This lack of awareness has also led to high level technical ineptitude, thereby making adoption of wind as veritable source of power generation a difficulty.[32]

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[31] Nigeria Renewable Energy Master Plan (REMP), ECN & UNDP – November 2005, & N.I. **Meyer**: *Development of RES in* ***Denmark***

[32] Ajayi, O.O, *Modelling the wind energy potential of Nigeria*, Covenant University, Ota, 2007.

2.2 SOLAR ENERGY POTENTIAL

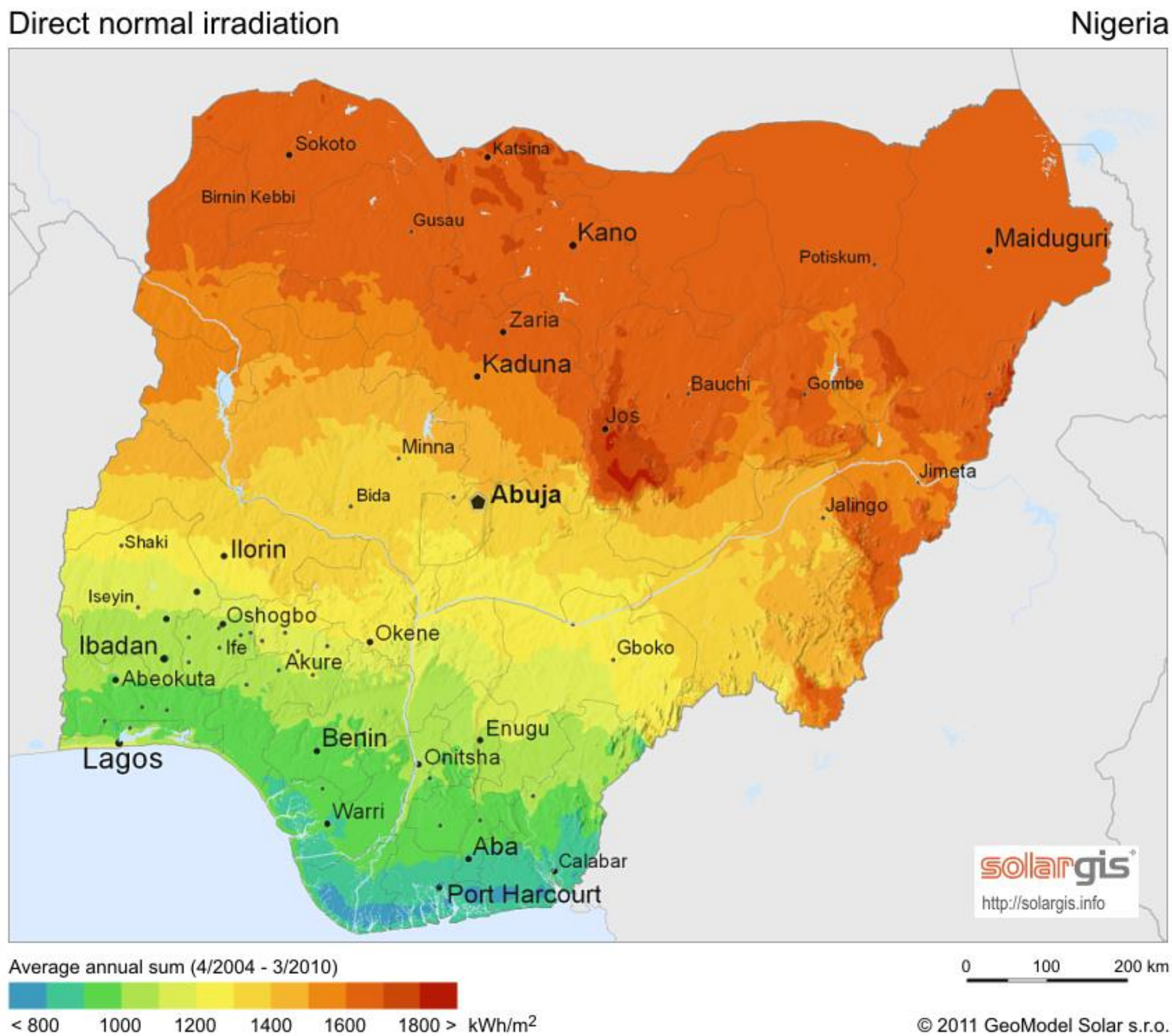

Figure 10 Nigeria's average Solar radiation map

The sun is the most readily and widely available renewable energy source capable of meeting the energy needs of whole world.[33] One of the greatest assets that Nigeria has that can facilitate solar energy generation in Nigeria is her geographical location, that is, the equatorial region which is full of large quantity of solar radiation. Solar radiation is fairly well distributed in Nigeria with average solar radiation of about 19.8 MJm^{-2} day^{-1} and average sunshine hours of 6 hours a day; ranging between about 3.5 hrs at the coastal areas and 9.0 hrs at the far northern

[33] The sun's power reaching the earth is typically about $1000W/m^2$. The total amount of energy that the earth receives daily is $1353W/m^2$.

boundary.[34] Nigeria lies within a high sunshine belt and thus has enormous solar energy potentials. If solar collectors or modules were used to cover 1% of Nigeria's land area, it would be possible to generate 1850 $\times 10^3$ GWh of solar electricity per year; this is over one hundred times the current grid electricity consumption level in the country.[35] Generally, the solar capacity for Nigeria ranges between **3.5kW/m/day – 7.0kW/m/day** and average sunshine daily of 4 – 7 hours.[36]

In Nigeria, more than 70% of the population are rural dwellers. Since the energy production level of any community dictates her pace of development, it is possible to alleviate poverty of the large community of Nigerians by providing alternative renewable energy (solar) for them. Several pilot projects, surveys and studies have been undertaken by the Sokoto Energy Research Center (SERC) and the National Center for Energy Research and Development (NCERD) under the supervision of the Energy Commission of Nigeria (ECN). Several PV-water pumping, electrification, and solar-thermal installations have been put in place. Such solar thermal applications include solar cooking, solar crop drying, solar incubators and solar chick brooding. Other areas of application of solar electricity include low and medium power application such as: water pumping, village electrification, rural clinic and schools power supply, vaccine refrigeration, traffic lighting and lighting of road signs.

2.2.1 Solar Power Technologies

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. The Renewable Electricity Action Program (REAP) of the Federal Ministry of Power and

[34] Renewable Energy Potentials of Nigeria; *Vincent-Akpu, Ijeoma, University of Stirling*
[35] Uzoma, C. C. ; Nnaji, C. E; Ibeto, C.N.; Okpara, C.G.; Nwoke, O.O.; Obi, I.O.; Unachukwu, G. O and Oparaku, O. U.(2011). Renewable Energy Penetration in Nigeria: A Study of the South-East Zone. Continental J. Environmental Sciences 5
[36] Nigeria Renewable Energy Master Plan (REMP), ECN & UNDP - November 2005

Steel (2006) published by the International Centre for Energy, Environment and Development in Nigeria did not cover this aspect of power generation.

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 the national grid.

Solar cells are also referred to as photovoltaic (PV) cells, which as the name implies (photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity. Panel stands for a group of modules are connected mechanically and electrically. A module is a group of cells connected electrically and packaged into a frame (more commonly known as a solar panel), which can then be grouped into larger solar arrays. Photovoltaic cells are made of special materials called semiconductors, such as silicon which is most commonly used. When light strikes the cell, a certain portion of it is absorbed within the semiconductor material and the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely.[37]

[37] PV cells also have one or more electric field that acts to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is the current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off for external use say, to power a calculator. This current, together with the cell's voltage (which is a result of its built-in electric fields), defines the power (or wattage) that the solar cell can produce. PV modules are integrated into systems designed for specific applications. The components added to the module constitute the "balance of system" or BOS. From: Renewable Electricity Action Program (REAP) 2006 *Federal Ministry of Power and Steel Nigeria*

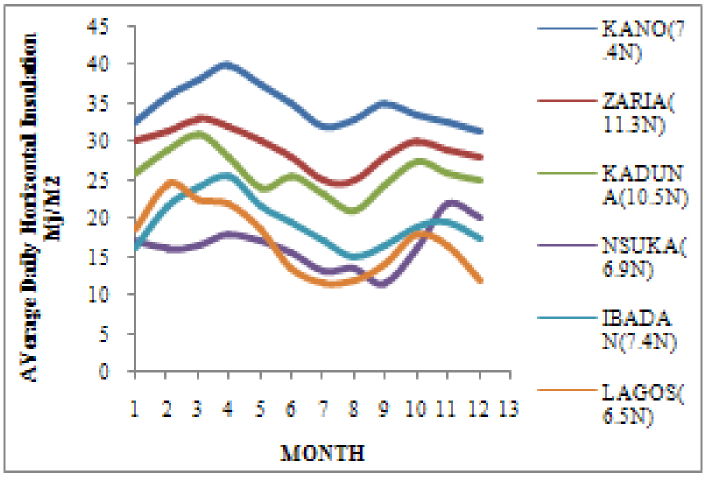

Figure 11: Average daily Horizontal Radiation

2.2.2 Estimated Resource Base

[38]The National Energy Policy Document states that "Nigeria lies within a high sunshine belt and, within the country; solar radiation is fairly well distributed. The annual average of total solar radiation is varies from about 12.6 MJ/m^2/day (3.5 kWh/m^2-day) in the coastal latitudes to about 25.2 MJ/m^2-day (7.0 kWh/m^2-day) in the far north." [39] Thus, over a whole year, an average of 6,372,613 PJ/year (≈1,770 thousand TWh/year) of solar energy falls on the entire land area of Nigeria. This is about 120 thousand times the total electrical energy generated by the National Electric Power Authority for the whole country for the year 2002. This then is an estimated potential solar thermal energy resource base.

Part of this resource falls on agricultural and forest lands and of course is useful for photosynthesis processes; others fall on developed areas, which could be harnessed for power generation through roof- and building-integrated designs. There could be immediate and widespread deployment of solar energy which could easily cover a large area of Nigeria, especially rural and riverine areas. For rural areas there are many advantages of solar energy over the present energy supply sources, especially a decentralized application. The decentralization of solar energy installation means individual acquisition, utilization and application of the system. No high or low tension transformer would be required, high or low tension wiring, equipment and logistic would be involved in the distribution of the energy, which means the solar PV panels could easily be carried, deployed and installed on individual establishment and premises in any part of the country at low cost within a very short period of time.

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[38] Yohanna J.K. et. al., *Solar Energy Potentials and Utilization in Nigeria, 2010*

[39] Annually, the above average solar intensity is 6898.5 MJ/m^2-year or 1934.5 kWh/m^2-year; a value that can be used to calculate the available solar energy. Assuming an arithmetic average of 18.9 MJ/ m^2-day (5.3 kWh/m^2-day), Nigeria has an estimated 17,459,215.2 million MJ/day (17.439 TJ/day) of solar energy falling on its 923,768 km^2 land area. The above arithmetic average may be interpreted as the application of each of the above radiation values to approximately half the area of the country, thus giving a total of (12.6 + 25.2) × (923,768/2) which gives the same value as before. From: Renewable Electricity Action Program (REAP) 2006 *Federal Ministry of Power and Steel Nigeria*

2.2.3 Problems Confronting Solar Installation in Nigeria

1. **Affordability**

Nigeria is still classified as underdeveloped country with high percentage of her population living under poverty level. This makes the ability to acquire solar energy devices, which are still considered expensive, difficult for both individuals and groups.

2. **Government Ignorance**

The people in government who make policy are very much unaware of the capacity of solar energy; many people assume that solar energy can power only small bulbs or at most television set. The print media also has not produced enough publicity on the subject matter. It is evident that the problems of solar energy in Nigeria, though enormous, but can be addressed within short period if government were to give proper attention to research, development, commercialization and installation of solar equipment through good policy evolution

3. **Component Failure**

Since the process of solar energy is very new in this part of the world, users get turned off if it does perform up to the years of guarantee which the equipment is rated. Equipment and component failure occurs mostly with components that do not carry a manufacturers address or guarantee.

4. **Cost of generation**

Comparing equipment and installation cost of solar energy with other energy supply sources, solar energy is more expensive in the short run. However, it is cheaper in the long run. The results show that the PV source is more expensive up to 4 years after installation. This is because solar energy components are very expensive and they are mostly imported except the cables and few accessories. Beyond 5 years, PV power becomes more attractive because of low running cost. A higher percentage of the population in Nigerian are low income earners and cannot afford or acquire solar power. However, higher income earners have access to other energy sources like petrol/diesel generators apart from the grid.

5. **Political Problems**

The politics behind acquisition and installation of solar energy at both the governmental and technical level in Nigeria are not encouraging. On the government's part, there is no clear cut legislation backing the utilization of renewable energy. The government has not at any time embarked on giant step by installing or acquiring large solar power plants.

6. **Identification of good geographical location**

The problem of geography can be solved by integrating the most relevant and important aspects of solar energy installation and generation into the curriculum of the professional training schools, such as the civil and surveying, who are the first contact point for proponents and users of solar energy.

Communiqué reached in the 2007 National Energy Forum (NASEF), among others, identified additional challenges to solar energy development in Nigeria as: cultural restriction on land use, lack of appropriate institutional framework, low level of technical expertise, vandalization and theft of system components and lack of local manufacturing of system component-PV.

2.3 BIOMASS POTENTIAL (VINCENT-AKPU, IJEOMA)

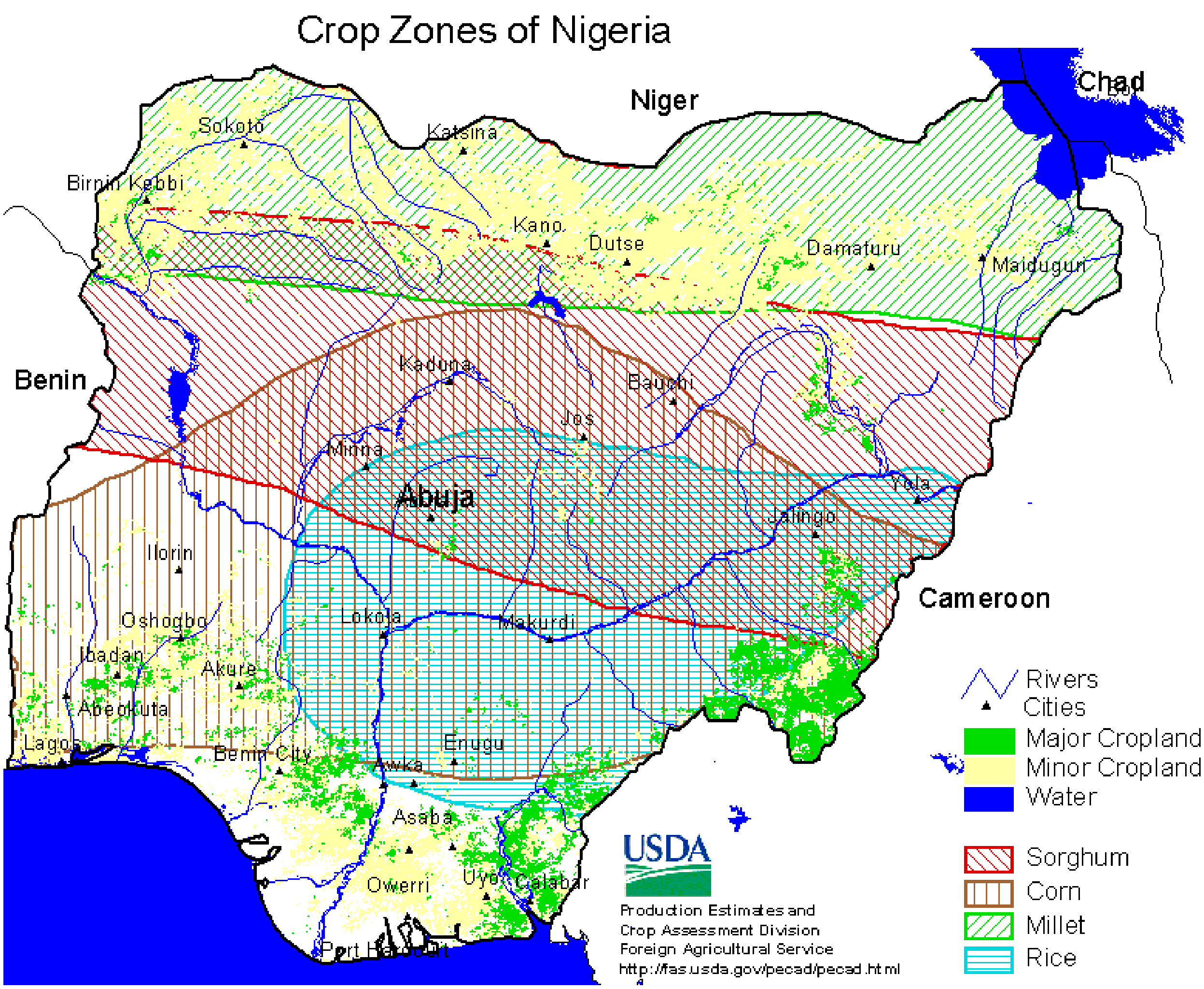

Figure 12: Crop Zones of Nigeria

Biomass is plant derived from matter. The biomass resources of Nigeria are crops, forage grasses and shrubs, animal wastes and waste arising from forestry, agriculture, municipal and industrial activities, as well as, aquatic biomass.[40] Crops such sweet sorghum, maize, sugarcane are the most promising feedstock for biofuel production. Plant biomass can be utilized as fuel for small-scale industries. It could also be fermented by anaerobic bacteria to produce a cheap fuel gas (biogases). Biogas production from agricultural residues, industrial, and municipal waste

[40] Uzoma, C. C. ; Nnaji, C. E; Ibeto, C.N.; Okpara, C.G.; Nwoke, O.O.; Obi, I.O.; Unachukwu, G. O. and Oparaku, O. U.(2011). Renewable Energy Penetration in Nigeria: A Study of The South-East Zone. Continental J. Environmental Sciences 5

does not compete for land, water and fertilizers with food crops like is the case with bioethanol and biodiesel production and, will reduce the menaces posed by these wastes. In Nigeria, feedstock substrates for economically feasible biogas production include water lettuce, water hyacinth, dung, cassava leaves and processing waste, urban refuse, solid (including industrial) waste, agricultural residues and sewage.[41]

It has been estimated that Nigeria produces about **227,500 tons** of fresh animal waste daily. Since 1kg of fresh animal waste produces about 0.03m^3 of biogas, Nigeria can potentially produce about **6.8 million m^3** of biogas every day from animal waste only. Although biogas technology is not common in Nigeria, various research works on the technology and policy aspects of biogas production have been carried by scientists in the country. Some significant research has been done on a reactor design that would lead to the development of anaerobic digesters.[42]

Sawdust and wood wastes are other important biomass resources associated with the lumber industry. Small particle biomass stoves already exist for burning sawdust and wood shaving. Biomass utilization as energy resources is currently limited to thermal application as fuel for cooking and crop drying. Hoogwijk *et al*., conducted a comparative analysis of the bio-energy potentials, reported in the literature, and examined the main factors influencing biomass availability.[43] Their estimated range of global bio-energy potentials for the year 2050 is between 32 EJ/year and about 1130 EJ/year, which is rather wide.[44] There is, however, insufficient analysis on the influence of competing use of land and biomass in the estimates for bio-energy potentials. The ability to exploit the global energy potential depends on technological progress, economic–incentives, and institutional development related actions. Such actions include minimizing associated environmental impacts, development of dedicated fuel supply systems, avoiding conflicts with food production, biomaterials production and other land uses, solving logistics-of-supply problems, particularly those related to transport of feed stock.

[41] Akinbami, J.F.K. (2001). Renewable Energy Resources and Technologies in Nigeria: Present Situation, Future Prospects and Policy Framework. Mitigation and Adaptation Strategies for Global Change

[42] Akinbami, J.F.K. (2001). Renewable Energy Resources and Technologies in Nigeria: Present Situation, Future Prospects and Policy Framework. Mitigation and Adaptation Strategies for Global Change

[43] Hoogwijk, M., Faaij A., van den Broek R., Berndes G., Gieten, D., Turkenberg W., (2003): Exploration of the ranges of the global potential of biomass for energy, Biomass and Energy, Vol. 25 No. 2; 119 – 133.

[44] Prof. Thomas Okpo Kimble Audu and Prof. Emmanuel O. Aluyor, *The Potential of Bioenergy and Biofuels Tech. Development in Nigeria.*

Increasing the share of energy carriers from biomass in the global energy supply requires a reliable, sustainable and cost-effective chain of production, transport and conversion of the biomass feed stock. Also, the technologies that allow the conversion of biomass into high quality energy carriers should be cost effective, efficient, environmentally sound and flexible. Biomass gasification offers a considerable potential and can act as a key enabling technology for the development of integrated and flexible bio-energy strategies. It permits the production or co-production of electricity, Fisher-Tropsch liquids and hydrogen.

2.3.1 Resource Base

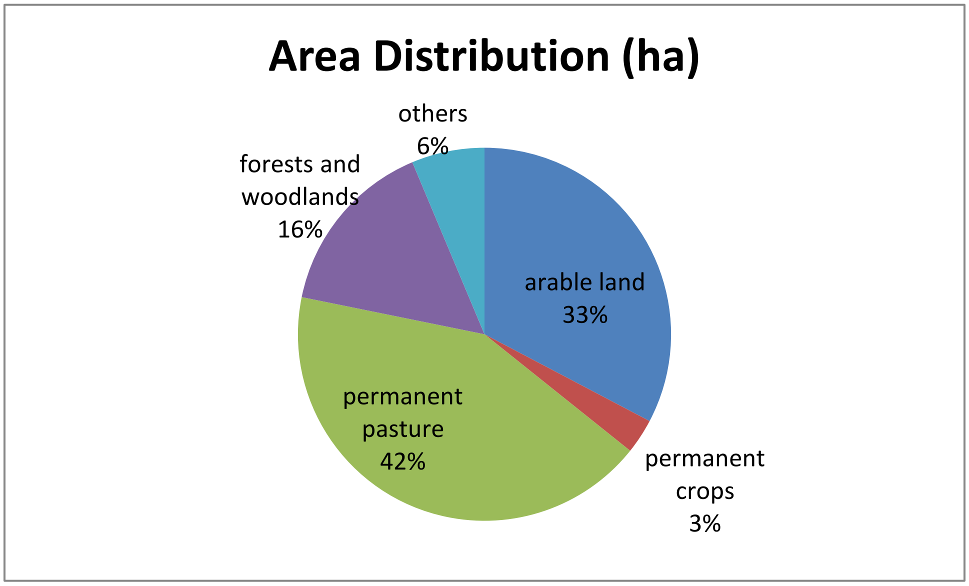

Figure 13 Nigeria's Land Area Distribution

There is no doubt that Nigeria has adequate potential for biomass production. Biomass, as a source of energy, has been, and remains, a principal method for cooking, drying and heating in Nigeria. Through adequate funding and research, the biomass resources can be used to supply clean energy and materials. Consider, for example, that 10% of the arable land, (that is, 3,020,000 ha) is used for energy production. For an estimated yield of 10 tons of total solids per ha, 30,200,000 tons of total solids will be produced. The High Heating Value (HHV) of wood is said to be 19.73 + 0.98MJ/kg, with an allowance for a loss of 1.4MJ/kg as latent heat of vaporization of the produced water.[45] In the present circumstances, for an HHV of 18MJ/kg total

[45] Prof. Thomas Okpo Kimble Audu and Prof. Emmanuel O. Aluyor; *The Potential of Bioenergy and Biofuels Tech. Development in Nigeria.*

solids the 10% of the arable land would yield 574 PJ of energy or 12.8 Mtoe (million tonnes oil equivalent).

Although the priority of the agricultural policy of Nigeria is food production, the need for power generation cannot be over emphasized. Biomass agriculture can have a very significant, positive influence on the national economy. Energy crops represent the largest potential source of bio-energy feed stocks, whether as whole biomass or as wastes, or residues. The availability of dedicated land is, however, a pre-condition for the potential to be realized. Fertilizer and other inputs have a major impact on the sustainability of the energy crops. Ligno-celulosics require lower amounts of such inputs. Biomass is one potential source for the conversion of plant material into a suitable form of energy or as fuel for an internal combustion engine.
Land utilization and management for bio-energy production are extremely critical in assessing the total energy and environment life cycle sustainability of bio-based renewable fuels.

2.3.2 Bio-Based Renewable Fuels

Bio-fuels are biomass-based fuels. They exist in the three states of aggregation: solids, liquids and gases, and are classified as Combustible Renewable and Waste (CRW).

1. Solid bio-fuel

- Wood, wood waste, twigs, leaves, grasses, purpose – grown energy crops, woody materials generated by wood and paper industry or by forestry shavings, chips as well as straw, nut shells, rice husks, fibrous wastes and poultry litter, that are directly burned or converted into a low quality gas in small low technology anaerobic tank digesters or fixed bed *gasifiers*.
- Charcoal which is the solid residue of the destructive distillation and pyrolysis of wood and other vegetable matter.[46]

2. Liquid bio-fuel:

Liquid bio-fuel is either bio-alcohol such as ethanol fuel or oil such as biodiesel or straight vegetable oil (SVO). Biodiesel (alkyl ester) can be used as fuel in modern diesel vehicles. Its use results in the reduction in net CO_2 emissions. It can be made from waste and virgin vegetable and animal oils and fats, otherwise known as lipids. Some energy crops such as, corn, corn stalks,

[46] According to an analysis on energy use in developing countries undertaken by the International Energy Agency (IEA), 2.4 billion people rely on biomass for cooking and heating. It accounts for more than 80% of their total residential energy requirements.

sugar cane are grown specifically for the production of ethanol, a liquid that can be used in internal combustion engines. In the U.S.A. ethanol is being phased into the energy infrastructure as an E85, that is, a fuel consisting of 85% ethanol and 15% gasoline as transport fuel. Brazil is already using E100, that is, 100% alcohol to drive some of their vehicles. Bio-butanol is currently being developed as an alternative to bio-ethanol.

Liquid bio-fuels are classified into two main groups – oxygenates and hydrocarbons:

- Oxygenates: examples include; methanol, ethanol, butanol and mixed alcohols,
- Hydrocarbons: examples include; Bio-diesel, synthetic diesel or green diesel, and synthetic gasoline.

Liquid bio-fuels are also categorized as per the feedstock, and or, the simplicity or otherwise, of the conversion process.

2.4 HYDRO-POWER POTENTIAL

Figure 14 The Niger river - Africa's 3rd largest river

Hydropower is derived from the potential energy available from water due to the height difference between its storage level and the tail water to which it is discharged. Power is generated by mechanical conversion of the energy into electricity through a turbine, at a usually high efficiency rate. Depending on the volume of water discharged and height of fall (or head), hydropower can be large or small.

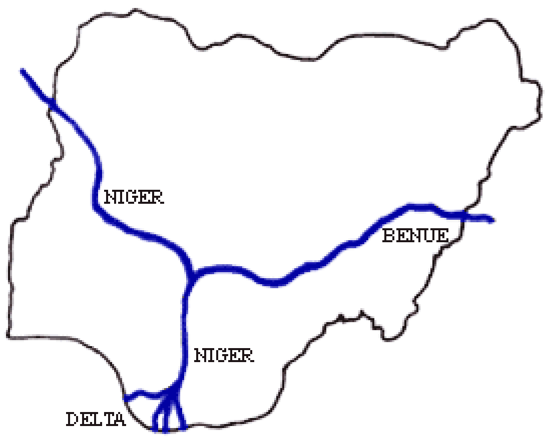

Figure 15 Nigeria's map showing major tributaries

About two-third of Nigeria lies in the watershed of the Niger River, which empties into the Atlantic at the Niger Delta, with its major tributaries; The Benue in the Northeast, the Kaduna in the North Central, the Sokoto in the Northwest, and the Anambra in the Southeast. The Niger is African's third longest river and fifth largest in term of discharge.

Several rivers of the watershed flows directly into the Atlantic notably the Cross river in Southeastern Nigeria and the Ogun, Osun and Oyan in the Southwest. Several rivers of Northeastern Nigeria, including the Komadugu Gana and its tributaries, flow into Lake Chad. The lake rests in the centre of a major drainage basin at the point where Nigeria, Niger, Chad and Cameroon meet. Kainji Lake created in the late 1960s by the construction of the Kainji Dam on the Niger River in Nigeria. The country's topography ranges from lowlands a1ong the coast and in the lower Niger valley to high plateau in the North and mountain along the eastern border, most part of the country is linked with productive rivers which are scatted virtually all over the country. In Nigeria, electricity is seen as an essential infrastructure in the same category as roads, telecommunication and water. In fact it is the life-blood of our national development and industrial growth. Nigerian's hydro potential is high and hydropower currently accounts for about 19% of the total installed commercial electric power capacity. The overall large scale potential (exploitable) is in excess of 18,600 MW. Unfortunately, only about 19% is currently tapped.[47]

2.4.1 Hydro Resource Situation

Nigeria is endowed with abundant water resources. Annual rainfall decreases from a high of 3400mm depth in the south central shores of the Niger Delta to 500mm over the northern

[47] Ismaila Haliru Zarma, *Hydro Power Resources in Nigeria, ECN, 2006*

boundaries of the country, with a perched increase to 1400mm over central Jos Plateau region.[48] Similarly, the eastern ranges of Adamawa and Cameroon boundaries experience elevated precipitation as high as 2,000mm relative to contiguous low areas of the country.

Nigeria has considerable hydro potential exemplified by her large rivers, small rivers and stream and the various river basins being developed. Nigerian rivers distributed all over the country with potential sites for hydropower scheme which can serve the urban, rural and isolated communities. An estimation of river Kaduna, Benue and Cross River (at Shiroro, Makurdi and Ikom respectively) indicated that total capacity of about 4,650MW is available, while the estimate for the river Mambilla plateau is put at 2,330MW.[49] Hydropower is the most exploited renewable energy source in Nigeria, dating back to 1968 when the eight units were commissioned with a generation capacity of 760MW. Although there may not be any international consensus on the definition of small hydropower, an upper limit of 30 MW has been considered. Thus, 30 MW has been adopted as the maximum rating under this dispensation.[50] Small hydro can further be sub-divided into mini hydro (<1MW) and micro hydro (<100KW). Thus both mini and micro hydro schemes are subunits of the SHP classification.

[48] Renewable Electricity Action Program (REAP) 2006 *Federal Ministry of Power and Steel Nigeria*
[49] Ismaila Haliru Zarma, *Hydro Power Resources in Nigeria, ECN, 2006*
[50] Renewable Electricity Action Program (REAP) 2006 *Federal Ministry of Power and Steel Nigeria*

2.4.2 SMALL HYDRO POWER (SHP) POTENTIALS IN NIGERIA

In recent studies, hydropower potential sites are distributed in 12 States and in the river basin. However, SHP potential sites exist in virtually all parts of Nigeria. There are over 278 unexploited sites with total potentials of 734.3 MW.[51]

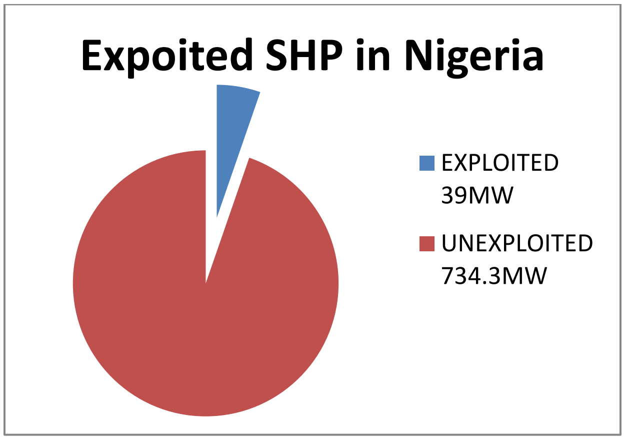

Figure 16: Exploited SHP in Nigeria

So far about eight SHP stations with aggregate capacity of 39.0 MW have been installed in Nigeria by private company and the government.[52] Some around Jos Plateau, where there is 2MW Station at Kwall fall on N'Gell river (river Kaduna) and 8MW station at Kurra fall, which was developed by a private company (NESCO) more than 75 years ago.

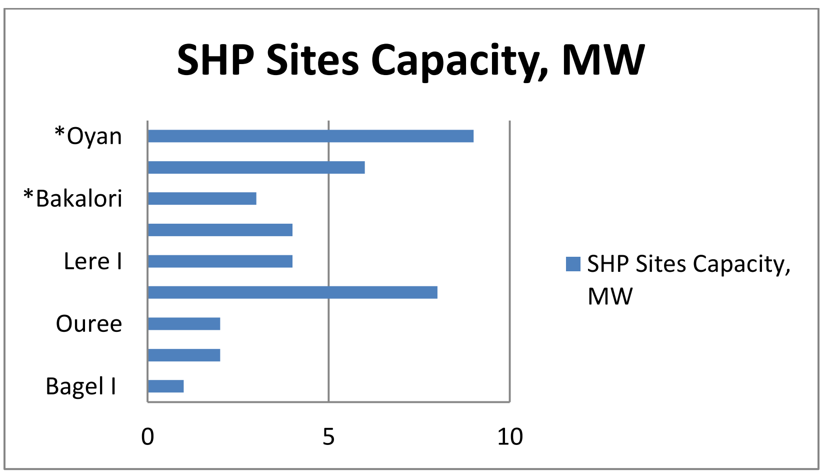

Figure 17: SHP Sites Potential Generating Capacity

[51] Esan , A.A ., Preparedness on Development Green Energy for Rural Income Generation-Nigeria's Country Paper
[52] Ismaila Haliru Zarma, *Hydro Power Resources in Nigeria, ECN, 2006*

2.4.3 Small Hydro Power (SHP) Development Program

Since Energy Commission of Nigeria (ECN) signed the MoU with United Nations Industrials Organization - International Centre on Small Hydro Power (UNIDO-IC-SHP) in 2002, one of the activities of the SHP development Programme is awareness creation, both at local government and state government levels. Some state governments have indicated their desire to develop some small hydropower potential sites to ECN. The technically exploitable small hydro capability in Nigeria is high but under-utilized. The SHP development programme in the last year has been able to assess potential sites for developments as shown in the table below.

2.4.4 Potential SHP Sites for Development

Analysis of data indicated there to be about 90% difference in volumes of water at the Northern part (close to the Niger River) of Nigeria than in other locations within the country. Hence, the graphs are grouped into the Low and High Water Volume Discharge. It should be noted that during the wet season, water volumes could increase by a factor as high as 50%.

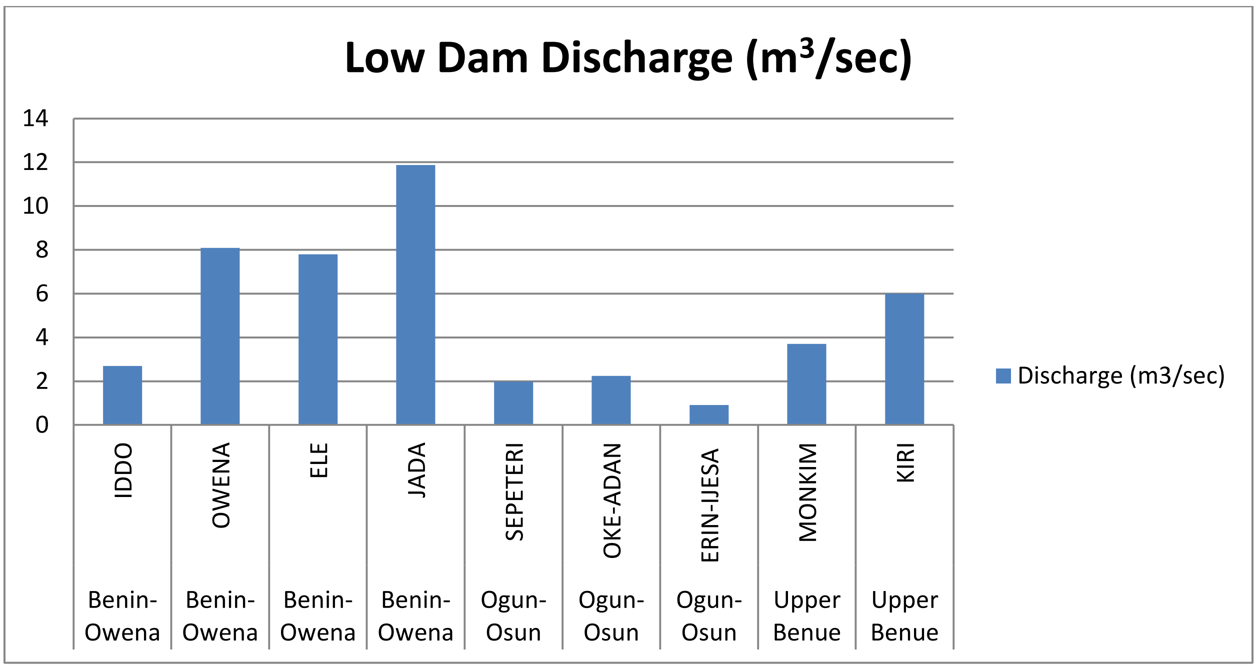

Figure 18: Low Dam Discharge volume/sec

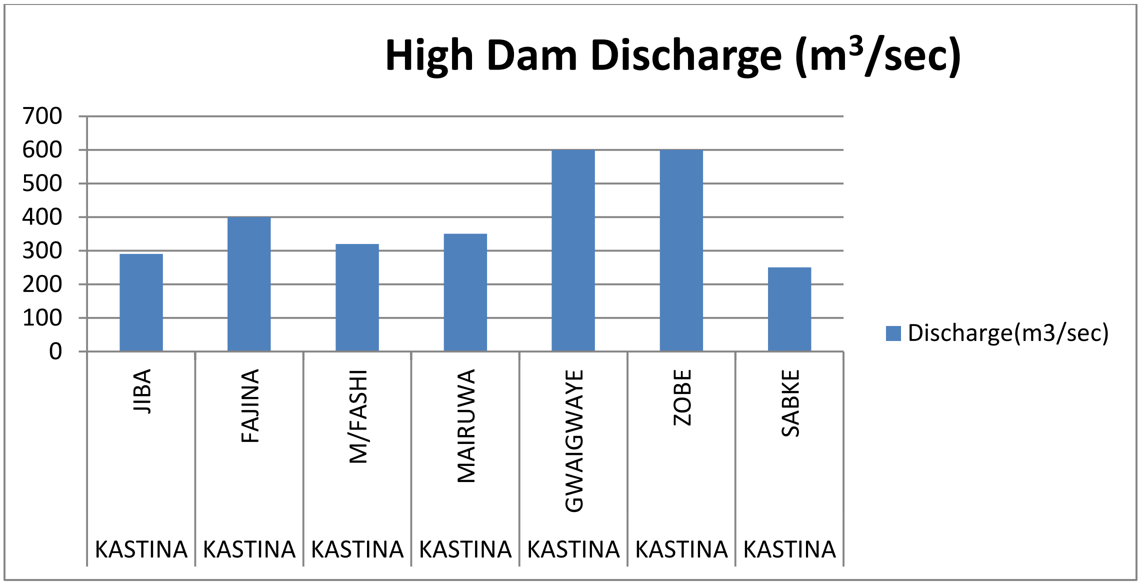

Figure 19: High Dam Discharge volume/sec

Challenges for Hydropower

1. **Huge financial investments**

The very expensive equipment and overhead cost in undertaking hydropower scheme, especially on dam construction penstock, turbine and generator amongst others, is a great challenge considering the nation's status as a developing country.

2. **Poor revenue collection**

Based on the fact that the majority of Nigerians are in rural areas (about 70% of the country's population), it is always hard to get people to pay their tariff regularly. With the interrupted nature of power supply in the country, this results in poor revenue collection.

3. **Significant environment damage**

Major problems in Nigeria include desertification, deforestation, erosion, massive water impoundment, poaching and settlements within the potential areas. Constructing more hydroelectric dams could contribute significantly to environmental damage in the country.

3 RECOMMENDATIONS

3.1 Wind Energy Recommendations

In addition to the aforementioned suggestions to overcoming the various identified challenges, there are other strategies/suggestions which if implemented could move the nation forward in the drive to utilizing wind for energy development. **These include amending the Land Use Act of 1979 to encourage wind farm establishment.** This invariably would involve the activities of town planning and rural development authorities so that policies that favor wind farm development would be entrenched in such a way that it will be difficult to alter in future. Investors willing to embark on WET through establishment of wind farms across the country will need enough land to do so, and such land should necessarily be inexpensive. Also, areas marked for wind farms would need to be devoid of wind breaks, so, the nation's planning authorities would need to develop appropriate standards for establishing wind farms. **There is also a need to integrate WET into the Independent Power Project of Nigeria.** This should be done in such a way that encourages people and industries to own their standalone wind energy applications and enables avenues for linking excess generation with the national grid. **Another very important step is integrating WET into the rural development plan.** While planning for the development of rural areas in order to encourage rural-urban integration, the concerned authorities must take note of the advantages of wind energy for power generation and how such can be used to power communities not connected to national grid. Thus, it would be very good if wind-for-power could be considered as complementary standalone energy sources for rural development. Other strategies that could also be embraced include leveling the playing field in the energy market between nonrenewable and renewable energy sources, focusing on the developments of wind farms and technologies, creating sustainable markets for the sale of wind energy within the country and developing a suitable wind map for the nation to serve as information resource for the public and willing wind energy investors.

3.2 Solar Energy Recommendations

For effective and efficient utilization of solar electricity in Nigeria, the following recommendations will be useful:

1. Encourage research in the techno-economies involving the initial and subsequent costs of solar plants and their power efficiencies.

2. The government should subsidize the cost of importation of Renewable Energy Technologies (RET), most especially solar PV to bring down high costs.
3. Private individuals and organizations should be encouraged by appropriate authorities to invest in solar technologies.
4. The wide chasm between research bodies (universities, polytechnics and research institutes) and manufacturing industries must be bridged.
5. The government should create more awareness about the advantages of Renewable Energy Technologies (RET), such as solar technologies.
6. The government can also consider placing restrictions on the importation of diesel and petrol engine generators because of their adverse effects on the environment.
7. Funding of solar technology researches and development initiatives in Nigerian Universities, Polytechnics and Research Institutes to develop solar PVs with greater efficiency and which are adaptable to our environment is advocated. Such pilot schemes are seriously undertaken at the National Agency for Science and Engineering Infrastructure, NASENI, FCT Abuja and the Prototype Engineering Development Institute Ilesa, Osun State. The National Energy Research Centres at the University of Nigeria, Nsukka, the Obafemi Awolowo University, Ile-Ife and Usmanu Danfodiyo University, Sokoto, also provide a valuable source of solar radiation and other climatic information. Less consistently collected are data from some tertiary institutions nationwide, where individual energy researchers' work on various energy projects.

Thus, it will be very good if solar-for-power could be considered as complementary standalone energy sources for rural development rather than the present state of some no power rural communities.

3.3 Hydro Power Recommendations

1. **Industrial and economic development**

There is a historically positive relationship in Nigeria between power availability and industrial and economic development, shown in the decline or stagnation of the manufacturing sector in Nigeria after the late 1980s. A faster pace of industrial development is expected when IPP begins producing and supplying additional cheap power. Normally 40% of power generated goes to industrial development. In rural areas, agro-based SME are most likely to develop.

Nearly 200,000 employees get direct employment and the same number get indirect employment. Similarly converting the SHP sites for tourism development and fish farming can create employment opportunity, allowing more people to benefit from these projects.

2. Clean power development

Nigeria will suffer if its sustainable hydropower potential is not tapped, since hydropower is its only easily harnessed indigenous power source. It is also one of the very few competitive advantages for the country, since land, labor and other inputs to industrial development are costlier in Nigeria compared to other countries. The development of SHP projects reduces the usage of diesel and kerosene for generating electricity in off-grid areas for the high-income group. This will also reduce transportation costs of transporting fuel from cities to rural areas.

Another aspect to be noted is the destruction of trees from forested areas for lighting and cooking. The SHP projects can be developed as multipurpose projects, being used for flood control, drinking water purpose, irrigation, fish farming and for tourism development.

3. Improved availability and quality of the power supply

Reliable and adequate electric power will reduce the costs and losses currently suffered as a result of inadequate power by increasing productivity, effectiveness and the quality of outputs while reducing hardships, inconveniences and disrupted services due to power interruptions, as well as the expenditures made by businesses and households to compensate for inadequate power. Since Nigeria faces a power shortage during the peak hours, this additional capacity will help in improving the voltage in the distribution network.

4. Economic growth and employment

Poverty is clearly related to unemployment. The lack of electricity is an important constraint that works against employment, contributing to the under-utilization of human and natural resources, resulting in widespread unemployment and poverty.

Although the poor generally do not qualify for new jobs in the industrial and manufacturing sectors, they can benefit from the effects of economic growth, such as new construction and increased expenditure in the informal sector. These types of unskilled jobs, however, tend to be low-paid, temporary and/or insecure. This has been demonstrated from experience, where income from the Gulf countries facilitated the increase of wage rates, not only in the construction sector, but also in agriculture because of linkages in the labor market.

The availability of power would also enhance public services and infrastructure facilities such as communications, which are necessary for the growth of industries and activities in the service sector.

5. Public services

Continuous power is a necessary condition for the full operation of a range of public services, from health and medical services and facilities, street lighting, schools and communications to water systems. All these services have major impacts on the quality of life through health, sanitation, education, safety and security, information and recreation.

They provide essential services to those with limited incomes, who cannot afford the alternatives like the affluent in the country.

6. Accessibility

More than sixty percent of total households in Nigeria do not have access to electricity. Availability of electricity is critical for household work. Sufficient power throughout the day and evening will allow women to complete their domestic tasks more easily, quickly and effectively, and to become involved in other income generating additional activities. If we are adding 732.0 MW from SHP, a major portion nearly 39 MW will go to domestic consumers, thereby providing electricity for additional 3,700 new consumers.

4 CONCLUSION

Nigeria just recently privatized her power sector. This implies that over the next decade new power plants can be expected to spring up as highlighted in the privatization documents. This creates a perfect position for Nigeria to invest and build large scale power plants from any or combined renewable sources highlighted above. Though initial cost of installation of RE devices is high, the long-term cost is competitive with conventional energy sources. The government will have to ensure that fiscal and non-fiscal incentives are put in place for private investors that are willing to invest. The government itself must be ready to invest intensely in yearly RE development before she can achieve 100% renewable energy. The development of RE services should be linked to many other sectors such as agriculture, small scale industrial enterprises or the Millennium Development Goals. They will have greater likelihood of success if implemented in line with these activities to ensure sufficient demand for the energy services providers and may attract funding.

Experience has shown that most renewable energy technologies (especially those that can be locally manufactured) require subsidies only in the initial stages, and can become financially sustainable in the short- to medium-term after a certain level of technology dissemination has been attained. Nigeria now has a published energy policy which emphasizes the development RE. However, an integrated policy and vigorous implementation strategy are needed to facilitate rapid diffusion of RE in the nation's energy mix.

As the current flow of information on RE technologies is inadequate, demonstration projects on various energy forms should be established widely so that the performance and efficiency with which services are delivered is exhibited. This will sensitize the public as well as assist in the creation of markets for RE system. The need for capacity building both at institutional and personnel level for acquiring technical, organizational, and managerial skills required for increased development of renewable energy should be identified. Activities such as entrepreneurship and managerial skills development training programs and technical courses in RE technologies with a view of developing energy service companies for providing services to rural areas need to be introduced. The existing research and development centers and technology development institutions should be adequately strengthened to support the shift towards increased renewable energy utilization.

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