Global Journal of Engineering and Technology Advances
eISSN: 2582-5003
Cross Ref DOI: 10.30574/gjeta
Journal homepage: https://gjeta.com/

(REVIEW ARTICLE)

Check for updates

Electricity challenges in Nigeria: Renewable energy a way forward

Jelili Aremu Oyedokun [1,*], Emmanuel Taiwo Fasina [2], Bankole Adebanji [2] and Adewale Abe [2]

[1] *Department of Engineering and Scientific Services, National Centre for Agricultural Mechanization, Ilorin, Kwara State, Nigeria.*
[2] *Department of Electrical and Electronic Engineering, Ekiti State University, Ado-Ekiti, Nigeria.*

Global Journal of Engineering and Technology Advances, 2022, 11(03), 016–023

Publication history: Received on 18 April 2022; revised on 04 June 2022; accepted on 06 June 2022

Article DOI: https://doi.org/10.30574/gjeta.2022.11.3.0085

Abstract

The present crisis of electricity supply in Nigeria is adversely affecting its economy. The population is growing and life is getting more difficult for the citizens. Nigeria is rich in renewable energy sources, such as solar, biomass, thermal, wind, geothermal, tidal, hydro, biogas, wave, and ocean energy. However, less than 25% of the renewable energy potentials have been utilized. A critical investment in a renewable energy sector will not only solve electricity related problems but also help to achieve social-economy development in the country. In addition, renewable energy projects will help to provide jobs for the youth and create new investment opportunities for the people.

Keywords: Electricity Supply; Renewable Energy; Solar Energy; Wind; Biomass; Geothermal

1. Introduction

1.1. Electricity Deficit in Nigeria

Nigeria's electricity usage per capita is minimal in compared to neighboring nations, with 140 kWh in 2018. [1] Historically, the available power plants between 1970 and 2009 operated below capacities, and this coupled with the loss of a substantial amount of electricity in the transmission process. For instance, in 2001, electricity generation capacity stood at 5600 MW; while the actual power generated dropped to 1750 MW. When compared, the hydroelectric plants (Kainji, Shiroro, and Jebba) have greater power output than the gas-powered plants; this is understandable because the gas-powered plants are being faced with a lot of infrastructural and maintenance problems [1]. Between 1980 and 1996, there was a substantial difference in the amount of power generated and the amount of electricity billed in Nigeria. This confirms the loss of electricity during the process of transmission. Lack of adequate maintenance of electricity infrastructure, corruption and poor management are among factors that contribute to the loss of electricity in Nigeria [2],[3],

Currently, lack of stable power supply is the greatest challenge confronting medical institutions in Nigeria. The efficiency of hospitals in the area of medical research, training, and treatment are being challenged by erratic power supply. In [4], it is reported that the major challenge which the University College Hospital, Ibadan is facing is inadequate electricity supply. The hospital runs about seventy-five (75) generators to perform its operations.

1.2. Effect of Insufficient Electricity Supply in Nigeria

The problem of insufficient electricity supply in Nigeria has affected the socio-economic activities of the country. This has further compounded the difficulties being experienced by common citizens. A stable supply of electricity remains

* Corresponding author: Oyedokun JA
Engineering and Scientific Services Department, National Centre for Agricultural Mechanization, Ilorin, Kwara State, Nigeria.

the key determinant of the standard of living as it aids economic advancement, reduces hunger and crimes, and aids development. Adequate power supply remains a burning issue for all countries who desire sustainable growth and development all around the world [5].

In addition, the incessant increase in the prices of fuel has brought about an increase in the price of essential commodities as well as transport charges. The industrial usage of electricity has dropped from 78.7% in 1977 to 30.1% in 1987 and 53.3% in 2007 and 53% in 2010 [6]. Distributed generations (DGs) in instances when loads are far from the grid, have proven to be more cost-effective over time than grid energy or diesel generators. The dotted nature of rural load centers, as well as their low power demand levels, encourage the adoption of distributed generation. , In order to implement Distributed generation in remote areas that are unlikely to be grid-connected in the long run, deliberate policies and programs are required (15-20 years). This will necessitate collaboration between the government, private sector, and consumers.

Also, widespread use of fuel wood is responsible for growing environmental problems of soil erosion and desertification. To reduce the usage of fuel wood in the energy mix, the 1992 Presidential Taskforce on Alternatives to Fuel Wood proposed widespread use of biogas technology and solar cookers.

Nigeria is endowed with abundant renewable energy resources. Despite these natural resources which can be harnessed to provide a stable electricity supply, Nigerians still groan in the pain of epileptic electricity supply; most communities and businesses rely on the generator to carry on their activities. Therefore, exploring the vast resources of renewable energy will play a vital role in tackling the electricity challenges in the country.

2. Renewable energy sources in Nigeria

At the moment, the energy supply in Nigeria is mainly by fossil fuels and fuelwood. Due to an inability to harness alternative energy supplies, these two are becoming exhausted [7]. Despite having consistent access to both fossil and renewable energy sources, Nigeria has one of the lowest per capita electricity rates in Africa. Meanwhile, Power Demand Assessment has predicted a medium- to long-term electricity demand of 30,000MW and 192,000MW respectively. A significant improvement in the energy production and supply will be required to meet power demand in Nigeria [8]. As of 2014, the installed capacity of grid energy was over 6000MW, with roughly sixty-seven (67) percent of that being thermal and the rest being hydroelectric [9]. This emphasizes the urgent need to fully utilize Nigeria's renewable energy potential for the benefit of Nigerians and Africa as a whole.

Non-conventional renewable energy is a critical component of the Nigerian government's broader strategy for rapidly expanding access to power services. Aside from major hydropower, Nigeria's renewable energy contribution to the electrical industry is around 35MW, made up of 30MW small hydropower and 5MW solar PV. This amounts to around 0.06 percent of the country's overall electricity generating capacity [9]. According to the policy guideline, the country will rely on hydropower, solar PV, biomass, and wind energy for electricity production, based on the country's resource situation and technology basis [9]. Renewable energy must be introduced into Nigeria's electricity sector on a bigger scale to solve the country's present power supply problems. Nigeria's renewable energy potential is currently sufficient to supply all of the country's energy requirements. While biomass and solar energy are used infrequently, wind and geothermal energy are nearly obsolete in the country. Hydroelectric power output in Nigeria is remarkable, accounting about 13% of total electricity generation [10].

2.1. Hydropower Energy

Nigeria has a high potential for electricity generation through hydropower. About 29% of the overall electricity use in Nigeria is from hydropower plants. The first and largest hydropower supply station in Nigeria is in Kanji, on the Niger River, in Niger State; it has a capacity of 836 MW and may be expanded to 1,156 MW if necessary. The Shiroro and Ikom Rivers have a total capacity of 4,650 MW, while the second-largest hydroelectric facility is located in Jebba, Niger state. It can produce 540 MW. The Mambila Plateau Rivers have been estimated to have a capacity of 2,330MW [11]. Hydroelectricity is 38.5 percent of total grid power output in Nigeria. These includes hydropower plants in Kanji (760MW), Jebba (578MW), and Shiroro (600MW), as well as a small hydropower plant in Jos owned by NESCO (Nigerian Electricity Supply Company) with a capacity of 30MW [12]. The total hydropower potential in Nigeria is estimated to be 14,750 MW, with large hydropower accounting for 11,250 MW and Small Hydro accounting for 3,500 MW [1]. In addition, the Kashimbila Hydropower Station in south-eastern Nigeria has installed capacity of 40 MW [13].

2.2. Solar Energy

Nigeria, with a landmass of 9.24 x 10 5 km^2 and an annual average daily solar radiation of about 5.25 kW/m^2 /day at the coastal area and 7.0 kW/m^2 /day at the northern area. The country is naturally blessed with about 6.25 hours of annual average daily sunshine. An annual average daily solar radiation of about 5.25 kW/m^2 /day is obtainable at the coastal area, as a result, Nigeria receives around 4.851 × 1012 kWh of incident solar energy every day, or 1.804 x 1015 kWh on a yearly basis [14]. This annual solar energy is worth over 27 times the country's total conventional energy resources in energy units and more than 117,000 times the country's total electric power generation [15].

In Nigeria, solar energy is used as solar PV for rural electricity, solar crop dryers, solar cookers, solar water pumps, solar water heaters, and so on. Currently, Nigeria has a number of solar projects, including the 7.2kW Kwalkwalawa Village Electrification in Sokoto State, street lights in Ado Ekiti in Ekiti State, and the 5.0kW Iheakpu-Awka Village Electrification/TV Viewing in Enugu State [16].

According to estimates, the solar potential deposit for the entire country of roughly 923,768 km2 regions rises to 4,849, 782 kWh/mb2 days [17].

According to the findings, there are no grid-connected solar projects in Nigeria [18]. The bulk of solar system installations are either off-grid or stand-alone mini-grid applications. There is no comprehensive database of solar energy applications and projects in Nigeria [19]. However, solar thermal power plants have recently gained popularity on the global scene, with several governments investing in the technology due to its advantages [20].

Solar integration projects approved by the Nigerian Electricity Regulatory Commission provide the most trustworthy and best data (NERC). The Nigerian Energy Support Programme first disclosed this data in 2014, and it is provided in Table 1. (NESP). Some projects should have been implemented according to the period assigned to each project, but there is no evidence to support this assumption and provide a credible proof.

Nigeria's solar energy goals are mostly for the generation of power. The goals of solar power in the electricity sector are summarized in Tables 2 and 3. By 2015, 2020, and 2030, Nigeria plans to generate 9.74 percent, 18 percent, and 20 percent of its used electricity from renewable sources, respectively. By 2015, 2020, and 2030, solar energy is anticipated to produce 1.26 percent, 6.92 percent, and 15.27 percent of the power consumed in Nigeria, respectively. Solar energy is predicted to provide 76.36 percent of total electricity utilized in the long run. Other goals for solar energy usage were set. Table 3 [20] summarizes the findings.

The majority of solar technology and scientific undertakings in Nigeria are low-energy. Solar freezers, street lighting, solar-powered water pumps, and solar-powered chargers for various electronics are among the items on the list. Over 100 streets in Abuja (Nigeria's federal capital city) are powered by solar street lighting installations, according to a report [21]. The Energy Commission of Nigeria (ECN) also supports 58 solar projects, 50 of which are aimed at rural electrification [22]. In the Nigerian state of Zamfara, a total of 22 isolated settlements now have access to solar power. The Rural Electrification Agency (REA) established in 2005 to coordinate rural electrification (maintaining and harvesting rural renewable energy sources) claim that over 600 solar projects for Nigerian farmers have been erected, but no specifics regarding these projects are provided [23].

Table 1 Proposed Nigeria solar energy project details as of 2014 [21]

S/No	Licensee	Capacity (MW)	State
1	Rook Solar Investment Limited	50	Osun
2	Quaint Global Nigeria Limited	50	Kaduna
3	Nigeria Solar Capital Partners	100	Bauchi
4	Anjeed Kafanchan Solar Limited	10	Kaduna
5	Lloyd and Baxter LP	50	Abuja
6	KVK Power Pvt Limited	50	Sokoto
7	Pan-African Solar	54	Kastina

Table 2 Nigeria solar energy electricity target summary [20]

S/No	Activity/Item	Year		
		2015	2020	2030
1	Solar PV home systems (SHS)	5	10	15
2	Solar PV water pumping	50	1,000	5,000
3	Solar PV community services	45	500	3,000
4	Solar PV refrigerator	20	500	2,000
5	Solar PV Street and traffic lighting	100	1,000	10,000
6	Solar PV large-scale PV plants (1 MW capacity)	80	990	9990
7	Solar thermal electricity (1 MW capacity)	300	2136	18127

Table 3 Nigeria solar energy application future target summary [20]

S/No	Application	Year		
		2015	2020	2030
1	Solar water heaters	4,000	60,000	150,000
2	Solar cookers	2,000	50,000	150,000
3	Solar dryers	150	2,000	60,000
4	Solar stills	100	3,000	2,000
5	Solar pasteurizers	300	4,000	10,000

2.3. Wind Energy

Wind energy requires various technology, which have been tested in the northern parts of the country throughout the years, mostly for water pumping from open wells in several secondary schools in northern part of Nigeria Other "possible applications" of wind energy conversion systems in Nigeria include green power generation for rural communities and integration into the national grid system [24].

Wind speeds in Nigeria range from 1.4-3.0 meters per second in the south to 4.0-5.12 meters per second in the north. Except for offshore places and coastal regions, wind speeds in the southern section of the country are generally weak [25]. According to preliminary research, total derivable wind energy reserves at 10m height can range from 8MWh/yr in Yola to 51MWh/yr in the mountainous sections of the Jos Plateau, and up to 97MWh/yr in Sokoto [25].

A multi-billion-naira wind mill project in Katsina State's Rimi Local Government Area (L.G.A) promises reliable power to residents in the area as well as additional power to the Nigerian national grid. The Federal Government of Nigeria has stated that when the 10MW Wind Farm power project now under development in Katsina State is completed, the state and its environs will have enough electricity [26]. This project would be Nigeria's first wind-powered electricity plant, adding 10 megawatts to the national grid. The Japanese International Cooperation Agency has generously supported and, most importantly, sponsored the initiative [27]. The 5kW aero generator, which primarily supplies electricity to Sayya Gidan Gada Village in Sokoto State is the country's only operational wind power system [12].

2.4. Biomass Energy

The Nigeria biomass energy resources includes crops, wood, charcoal, grasses and shrubs, residues and wastes (agricultural, forestry, municipal, and industrial), and aquatic biomass [28]. In Nigeria, biomass used for energy production accounts for 34% of total biomass production. For 2008 and 2010, a fuel-wood supply shortage of roughly 22% and 28% was predicted, respectively. Biomass and garbage make up about 78 percent of the primary energy supply; agricultural biomass harvests account for 0 percent, electricity for 0 percent, and heat for 50 percent. All

agricultural biomass harvest is most likely used for heat. On farms, a large quantity of maize husks, paddy husks, shells, and other materials are left to degrade. A reasonable estimate without any credible study data would be 50%. However, losses in biomass availability are predicted due to land area loss due to sea level rise and flooding in the south, as well as droughts in the north. In the end, a net increase in biomass seems unlikely; but low penetration and use of energy-efficient biomass technology may jeopardize any net gain [8].

Ebonyi State is collaborating with the United Nations Industrial Development Organization (UNIDO) on a five-megawatt biomass gas turbine project that will cost $15 million (about N2.3 billion). The mill husks will be used to generate power for the gas turbine, which will contribute to the state's rapid development. The five megawatts generated will be surplus, as the mills will use two megawatts and the Oferekpe water scheme will use 1.5 megawatts, with the remainder going to the surrounding areas [29].

Following the project's inception, the United Nations Industrial Development Organization (UNIDO) conducted study on the Abakaliki Rice Mill's environmental impact. "It was discovered that numerous lives were lost due to burns caused by the heat of the rice husk, as people excavating rice inside the husk were unwittingly burned." The government was subsequently notified by UNIDO that utilizing biomass turbine technology, it was possible to turn the husk into electricity; the plant is located at Ikwo, near one of the modern rice mills opened in Nigeria's Ebonyi state. The mill husks will be used in the gas turbine to generate electricity and energy [29], [30].

2.5. Biogas Energy

Nigeria is projected to produce around 227,500 tons of fresh animal manure every day. Water lettuce, water hyacinth, manure, cassava leaves, municipal garbage, solid (including industrial) waste, agricultural wastes, and sewage have all been recognized as feedstock substrate for an economically viable biogas operation. Nigeria can produce roughly 6.8 million m3 of biogas every day, based on the fact that 1 kg of fresh animal waste produces about 0.03 m3 of gas. Furthermore, the country is anticipated to generate 20 kg of municipal solid waste (MSW) per capita each year. The total generated MSW will be at least 1.77 million tonnes per year, based on the 1991 census figure of around 88.5 million people. Nigeria, which has a population of 162,47 million people as of 2011 [31], will generate about 2 x 1.77 million tonnes of MSW (about 3.54 million tonnes) every year. The annual MSW output will continue to rise as urbanization and industrialization continue unabated [32]. As a result, biogas generation could be a cost-effective way to reduce or even eliminate the threat and annoyance of urban garbage in many communities by recycling it for sustainable energy production and consumption.

2.6. Geothermal Energy

Nigeria has a high occurrence of geothermal manifestations on a broad scale due to the wide area of application as well as ease of exploitation. The Ikogosi Warm Springs in Ekiti State and the Wikki Warm Springs in Bauchi State are the two known geothermal resource regions (KGRAs) in the country. The passage of water to significant depths through faults in the area's basement complex rocks causes these surgical effusions. High geothermal gradient trends can generally be found inside sedimentary areas, such as the Lagos sub-basin, the Okitipupa ridge, the Auchi-Agbede section of the Benin flank/hinge line, and the Abakaliki anticlinorium. The Niger delta's deeper Cretaceous and Tertiary cycles are geo-pressured geothermal horizons. Several magmatic intrusions emplaced during the Late Cretaceous along the axis of the Benue trough in the Benue fold-belt, stretching from the Abakaliki anti-ciborium to the Keana anticline and the Zambuk ridge. Positive Bouguer gravity anomalies also run parallel to this trough, implying a shallow mantle. The Ikom, Jos plateau, Bauchi plateau, and Adamawa portions of this belt underwent Cenozoic volcanism and magmatism.

Steam would be encountered at a depth of around 6,000 feet (1,800 meters) in the Lagos and Auchi-Agbede sectors, and at about 4,250 feet (1,300 meters) in the Abakaliki area, according to geothermal gradients. The determination of geothermal gradients in undrilled resource areas and depths to Curie isogeotherms (about 570°C, 1,058°F) in the basement complex and intrusive areas from thermal attenuation of the remanent magnetic field would be based on a combination of heat-flow measurements and analysis of existing aeromagnetic data. The use of a combination of gravity analysis, electrical, refraction-seismic, electromagnetic, and telluric methods to accurately delineate and evaluate Nigeria's known and suspected geothermal resource areas for future detailed investigations and possible exploitation for sustainable energy production and consumption would be beneficial [33].

2.7. Ocean Energy

Some oceans in Nigeria are warmed, while the depths are cold, to the point where there is a small temperature difference on each side of the equator, allowing for Ocean Thermal Energy Conversion (OTEC) within around 25 degrees [34]. Using a low boiling point fluid like ammonia, which is a gas at normal air temperatures of 7000F (2400C), colder water

from the deep ocean can be pumped to condense the ammonia and then let it warm up and expand to gas. The consequent impact of the gas pressure can be used to turn a generator using a turbine. The plant, however, would have to be large and anchored in the vast open ocean or on a ship, all of which would be vulnerable to storms and corrosion, and the quantity of water intensity that would have to be transferred would be tremendous due to the low effect. The challenge of storing and delivering the generated electricity would also be significant. Although OTEC has a limited number of significant energy sources, the final output is electricity [35]. This energy resource is abundant and exciting in Nigeria if properly handled and used [36].

2.8. Tidal Energy

A valuable tidal power site requires a unique configuration, as well as a high tide along a coastline and a narrow estuary that can be dammed. Damming estuaries allows for significant environmental impact, as evidenced by their abundance in Nigeria. For a long time, most places in the country's south were thought to be ideal tidal power sites [3]. Managing and improving them would not harm fisheries or other sea-related commercial operations, but it will be a hindrance to the habitats of millions of birds who use such areas as part of their migration routes for everyday living and survival. Although tidal power has not been established as a source of energy, the final product is electricity [35] [36].

2.9. Wave Energy

Various types and types of installations have been attempted to generate energy from this source, with mixed results. Piston arrangements, which are moved up and down by waves, move turbines connected to electricity generators [3]. This has been put to the test in the Netherlands. Though the waves in Nigeria's marine locations are neither consistent nor predictable, if correctly harnessed, the final outcome is energy production. In Nigeria, producing considerable amounts of power from waves appears to be a distant and minor prospect [36].

3. Discussion

Findings according to the literature showed that Nigeria has a huge potential for renewable energy resources that are grossly underutilized despite their availability in reasonable quantities. Renewable energy penetration in Nigeria is still in its infancy; hydropower and biomass are the only sources of renewable energy in the country that are used, though their utilization is lower than their potentials, while wind, biogas, and solar energy have only been used in small amounts.

The energy from solar and wind are almost available throughout the year, especially in the Northern part of the country and if the two energies are been utilize very well it will proffer solution to the country electricity challenges. In Literature findings, the available renewable energy in the country will not just proffer solution to electricity challenges but also create an eco-friendly and sustainable environment which will lead to rapid growth in the country's economy, creation of jobs for youths, reduce the unemployment rate as well increase the leaving standard of the citizen, financing and market potential. Electricity challenges can be adequately addressed by harnessing the available renewable energy potentials. Politics and poor publicity are the two key hurdles acting against solar energy growth and production in Nigeria. Most renewable energy programs have been implemented in an ineffective manner due to insecure governance. This is demonstrated by the misuse and mismanagement of funds allocated to these programs. Nigeria may learn from countries such as Germany, Spain, the United States, and China by adopting some of their practices. In Nigeria's renewable energy sector, there are targets and policies in place, however there is no data to show that the 2015 solar energy electricity generation target was met. Moreso, the development of solar and renewable energy technology has been hampered by a lack of public awareness about renewable energy policies [10]. More focus should be paid to renewable energy development. This would aid in the resolution of Nigeria's electricity generation problems and the reduction of the country's energy poverty. Renewable energy policy should be widely advertised, and the general public's energy literacy should be enhanced. Renewable energy policies should be reviewed on a regular basis to track their progress and implementation [7].

4. Conclusion

To summarize, Nigeria, as a country in the belt of high renewable energy potentials, has a tremendous potential for solar energy, wind energy, and other available renewable energy in the country, all of which can be used to supplement the country's epileptic conventional electricity. The country had a lot of renewable energy drivers, thus harnessing their potential to incorporate renewable energy into the country's electrical grid was a huge opportunity.

Compliance with ethical standards

Acknowledgments

We acknowledge our indebtedness and deepest sense of gratitude to all members of staff, Faculty of Engineering, Ekiti State University, Ado Ekiti and National Center for Agricultural Mechanization, Ilorin, Kwara State, Nigeria.

Disclosure of conflict of interest

We hereby declared there is no conflict of interest.

References

[1] Energy Commission of Nigeria, 2009. Renewable Energy Electricity in Nigeria - Way Forward. http://www.energy.gov.ng

[2] Oseni (2011-12-01). "An analysis of the power sector performance in Nigeria". Renewable and Sustainable Energy Reviews. 15 (9): 4765–4774. doi:10.1016/j.rser.2011.07.075. ISSN 1364-0321.

[3] Fasina E.T., Hassan A.S., Cipcigan L.M. , "Impact of localised energy resources on electric power distribution systems. 2015 50th International University Power Engineering Conference, pp. 1–5, 2015, doi: 10.1109/UPEC.2015.7339793

[4] Jesse Abiodun Otegbayo , Chief Medical Director University College Hospital Ibadan (Punch Newspaper March 3 2020, page 40)

[5] Oyedepo, Energy and sustainable development in Nigeria: the way forward. Energy, Sustainability and Society 2012 2:15.

[6] Bamikole, O. O. (2012). The Impact of Capacity Utilization on Manufacturing Productivity Growth in Nigeria Using Co-Integration Analysis (1975-2007). doi.org/10.2139/ssrn.2066174

[7] Olusola Bamisile, Mustafa Dagbasi, Akinola Babatunde and Oluwaseun Ayodele (2017) A review of renewable energy potential in Nigeria; solar power development over the years Energy Systems Engineering Department, Cyprus International University, Haspolt-Lefkosa, Mersin 10, Turkey

[8] Obioh I., Fagbenle R.O., (2009). Energy Systems: Vulnerability – Adaptation – Resilience (VAR). Hello International. www.heliointernational.org/VARNigeria.

[9] Federal Ministry of Power and Steel, Federal Republic of Nigeria, Renewable Electricity Action Program (REAP), International centre for Energy, Environment and Development, December 2006. www.iceednigeria.org.

[10] Iloeje, O. C. (2002). Renewable Energy Development in Nigeria: Status and Prospects. In: Ewah, O. E. (Ed) (2002). Proceedings of a National Workshop on "Emerging Rural Transformation in Nigeria: Sealing up Electricity Access and Renewable Energy."

[11] Aliyu, U.O and Elegba, S. B. (1990). Prospect for Small Hydropower Development for Rural Applications in Nigeria. Journal of Renewable Energy Vol. 1, pp. 74-86.

[12] Sambo, A. S. (2006). Paper Presented at the Renewable Electricity Policy Conference ''Renewable Energy Electricity in Nigeria; the Way Forward'' 11th - 12th December 2006.

[13] Aurecongroup.com 2014. A photo of Kashimbila Hydropower Station.www.aurecongroup.com

[14] Chendo, M. A. C (2002). Factors Militating Against the Growth of the Solar-PV Industry in Nigeria and their Removal. Nigerian Journal of Renewable Energy Vol. 10, Nos. 1&2 pp. 151-158.

[15] Osueke C. O., Ezugwu C.A.K. (2011) "Study of Nigeria Energy Resources and Its Consumption" International Journal of Scientific & Engineering Research, Volume 2 (12):121-130.

[16] Awogbemi, O., Komolafe. C.A., (2011) "Potential for Sustainable Renewable Energy Development in Nigeria" Pacific Journal of Science and Technology 12(1): 161-169.

[17] Oladeji, J. T. 2013. Harnessing Energy from the Sun. Report and Opinion 2013;5(6), http://www.sciencepub.net/report

[18] Ozoegwu CG, Mgbemene CA, Ozor PA. The status of solar energy integration and policy in Nigeria. Renewable Sustainable Energy Review. 2017;70:457-71.

[19] Tian Y, Zhao CY. A review of solar collectors and thermal energy storage in solar thermal applications. Applied Energy. 2013;104:538-53

[20] Energy Commission of Nigeria. Draft of national renewable energy and energy efficiency policy (Internet). 2014 March (cited 2015 Dec 8). Available from: http://www.energy.gov.ng/

[21] REN21. Renewables 2015 global status report. Paris: REN21 Secretariat; 2015.

[22] Energy Commission of Nigeria (Internet). (cited 2016 Dec 16). Available from: http://www.energy.gov.ng

[23] Muhammad U. Rural solar electrification in Nigeria: renewable energy potentials and distribution for development. The World Renewable Energy Forum; 2012 May 15; Colorado, USA. p. 1-8.

[24] Idris N. A, Lamin, H.S. Ladan, M.J. Yusuf, B.H Nigeria's Wind Energy Potentials: the Path to a Diversified Electricity Generation-Mix, International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol.2, Issue.4, July-Aug. 2012 pp-2434-2437

[25] Fasina E.T., (2021) Investigation of the Nigerian power network with solar PV system. International Journal of Latest Research in Engineering & Technology (IJLTRET) 7(3) 01-09.

[26] www.punchng.com/wind-farm-to-add-10mw-to-nationalgrid

[27] Edirin. B. A., Nosa. A. O., A Comprehensive Review of Biomass Resources and Biofuel Production Potential in Nigeria, Research Journal in Engineering and Applied Sciences 1(3) 149-155, Emerging Academy Resources (2012), ww.emergingresource.org

[28] Energymixreport.com/News/Alternative and Renewable Energy/Ebonyi biomass turbine project

[29] Sweet Crude Reports (2014), A Review of The Nigerian Energy Industry, sweetcrudereports.com/power/Ebonyi biomass turbine project. Thursday, January 9th, 2014.

[30] Akinbami, J-F.K. Ilori, M.O. Oyebisi, T.O. Akinwumi, I.O. Adeoti, O. Biogas energy use in Nigeria: current status, future prospects and policy implications. Renewable and Sustainable Energy Reviews 5 (2001) 97–112. www.elsevier.com/locate/rser

[31] Abdullahi, D. Suresh, S. Renukappa S. and Oloke, D. Key Barriers to the Implementation of Solar Energy in Nigeria: A Critical Analysis, 2nd International Conference on Green Energy Technology (ICGET 2017) IOP Publishing IOP Conf. Series: Earth and Environmental Science 83 (2017) 012015 do i :10.1088/1755-1315/83/1/012015

[32] Olufemi Oladapo Babalola, High-Potential Geothermal Energy Resource Areas of Nigeria and Their Geologic and Geophysical Assessmen Volume: 68 (1984), Issue: 4. (April), pp 450, Copyright 1997 American Association of Petroleum Geologists (AAPG), archives.datapages.com

[33] Leye M. Amoo and R. Layi Fagbenle, Hydrogen energy's key contributions to the sustainable energy mix of a low-carbon future in Nigeria. International Journal of Sustainable Energy, 2014, Vol. 33, No. 4, 742–765, Taylor and Francis Group

[34] Gerald Scholz. Modern Energy Services and the MDGs in East Africa. In: Renewable Energy for Development: Stockholm Environmental Institute-Newsletter of the Energy Programme, 2nd Edition, Vol 19. No. 2., 2006

[35] Aliyu Ibrahim Kankara, Energy Environment Interactions: Potentials and Problems of Renewable Energy in Nigeria. Advance in Electronic and Electric Engineering. Volume 3, Number 1 (2013), pp.25-30. Research India Publication http://www.ripublication.com/aeee.htm

[36] Fasina E. T., Oliyide R. O., and Cipcigan L. M., "Localised energy systems in Nigerian power network", in Proceedings - 2017 IEEE 15th International Conference on Industrial Informatics, INDIN 2017, 2017, pp. 456–461, doi: 10.1109/INDIN.2017.8104815.