Crimson Publishers
Wings to the Research

Mini Review

# Renewable Energy and Green Technology Adoption: A Viable Option for Efficient Energy Supply in Nigeria

**Stephen Enyinnaya Eluwa[1]*, Oluwaseun Kilanko[2], Eeda Ali N[3] and Amuda-Yusuf G[4]**

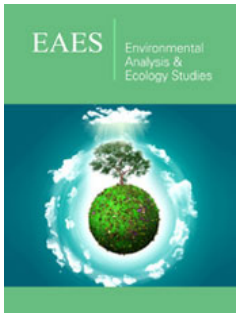
[1]Orient Concept, Nigeria

[2]Department of Mechanical Engineering, Nigeria

[3]Department of Built Environment Studies & Technology, Malaysia

[4]Department of Quantity Surveying, Faculty of Environmental Sciences, Nigeria

**ISSN: 2578-0336**




***Corresponding author:** Stephen Enyinnaya Eluwa, Orient Concept, Nigeria

**Submission:** July 27, 2021

**Published:** July 27, 2022

Volume 10 - Issue 1

**How to cite this article:** Stephen Enyinnaya Eluwa*, Oluwaseun Kilanko, Eeda Ali N, Amuda-Yusuf G. Renewable Energy and Green Technology Adoption: A Viable Option for Efficient Energy Supply in Nigeria. Environ Anal Eco stud. 000728. 10(1). 2022. DOI: 10.31031/EAES.2022.10.000728

**Copyright@** Stephen Enyinnaya Eluwa, This article is distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use and redistribution provided that the original author and source are credited.

## Abstract

Due to the historical bank of criticisms trailing electricity generation from fossil fuel in Nigeria over the years, and the need to diversify the energy mix through harnessing of abundant renewable energy resources in the country. This paper reviews the current development on renewable energy and green technology adoption in Nigeria. Systematic review through hybrid approach was adopted. Out of the three renewable energy sources (wind, solar, hydro) that studies have shown as having great potential in the country, only two (hydro and solar) have been developed and commercialized for public use. Among the 36 states in Nigeria, Lagos, Delta and Sokoto are leading in green technology adoption and renewable energy development, based on reported number of projects sited in them. The development and implementation of many renewable energy projects in Nigeria, are most times not in tandem with the provisions of National Energy Policy, which has led to sub-optimal performance.

**Keywords:** Renewable energy; Green technology; Nigeria

**Abbreviations:** MDGs: Millennium Development Goals; NERC: National Electricity Regulatory Commission; GHG: Greenhouse Gas Emissions; UNDESA: United Nations Conference on Environment and Development Agenda; FMWR: Federal Ministry of Water Resources; NDWC: Niger Delta Wetlands Centre; QCA: Qualitative Comparative Analysis

## Introduction

Energy is the foundation of modern day economy. Virtually everything done by humans today is dependent upon one form of energy or the other. This is critical to achieving almost all Millennium Development Goals (MDGs) [1], which can trigger economic activities and thus a prerequisite for human capital development [2]. Burgeoning population growth in the last five decades, with the attendant demands resulting from urbanization and industrialization has made the need for sustainable energy generation and distribution very important. In Nigeria, the energy sector is bedeviled with missed opportunities and wastage, due to lack of maintenance, poor regulation, and entrenched corruption. Transmission of electricity is a major challenge in Nigeria. The centralized grid system relies on large scale generation, and considerable amounts of energy are lost during transmission [3].

Epileptic electricity supply to homes and industries due to inadequate power generation and transmission, limited access to national grid, and high dependent on petrol and diesel powered generators are persistent problems for nearly every Nigerian. The country is blessed with vast oil and gas reserves, abundant sunlight all year round, and significant hydropower potential. Despite all these resources, energy crisis still persist in Nigeria. The major sources of electricity in Nigeria are the natural gas and hydro, with the former accounting for 70% and

latter 30% [4]. The 23 power grids connected to generating plants in Nigeria have installed capacity of 10,396MW, while about 6,056MW is available. Out of the 6,056MM available, 4,996MW (82.5%) is from thermal base (gas generating plants) while the rest 1,060MW is hydro [5]. With a human population over 200 million [6], it is obvious that energy per-capita of Nigeria is very low compared to what is obtained in most developing and developed nations. The average power consumption in Nigeria is estimated at 143 kWh/year per capita. The grid electricity supply in Nigeria lagged behind that of similar emerging economies. The major reason that explains this low per capita power consumption, is that more than 50% of electrical energy consumed in the country is estimated to be currently off-grid by petrol and diesel powered generators of all sizes and shapes [7]. Due to insufficient and erratic supply of grid electricity, most homes and business owners rely heavily on diesel and petrol powered generators for their electricity supply. According to estimates from the National Electricity Regulatory Commission (NERC), Nigerians spend up to N769.4 billion (USD 89.5 million) annually in fueling generators. Of this amount, N540.9 billion (USD 69.2 million) was spent on diesel while N255.5 billion (USD 32.7 million) was spent on petrol [8]. About 60 million petrol/diesel powered generating sets are used for electricity generation in Nigeria (The Vanguard Newspaper. Jan 26, 2009). The over reliance on fossil fuels in the energy supply mix, experts have warned has debilitating effect on the and human health.

Coming to terms with these realities and rethinking how we can live, work, and prosper in a rapidly evolving global order, intensifies the need for a shift from over dependence on gas powered turbines and use of petrol/diesel powered generators for electricity generation in Nigeria, to adoption of more environmentally friendly and reliable renewables- wind, solar, and hydro. The current electricity generation and consumption patterns in Nigeria is environmentally unsustainable. During the United Nations Rio+20 Conference on Sustainable Development, heads of states around the world acknowledged that change from unsustainable to sustainable patterns of production and consumption is sine-qua-non for sustainable development. They emphasized that 'green economy' in the context of sustainable development is one of the major tools available for attaining sustainable development. The energy sector accounts for over 70% of carbon dioxide and other Greenhouse Gas Emissions (GHG). Ensuring reliable, sufficient, and environmentally responsible supplies and distribution of energy is a major challenge for nations [9]. According to Cecily Davis, construction partner and Co-Head Fieldfisher's Africa Group ''it is unfortunate that a number of African countries particularly in North and West Africa, have become so reliant on oil and gas that they find themselves in a bind when it comes to investing in renewable energy projects''. Thus, this paper presents a systematic literature review of renewable energy resources and green technology adoption in Nigeria. The aim of the review is to examine level of investment/development on renewable energy resources, and green technology adoption in Nigeria.

## Concept of Green Technology

### Technology

Before delving into the concept of green technology, it is necessary to know what 'technology' means. Technology refers to collection of skills, techniques, processes and methods used in the production of goods or services or in achieving some set objectives [10]. It is a system created by 'humans which uses knowledge and organization to produce objects and techniques for the attainment of specific goals" [11]. Li- Hua (2009) opined that "technology represents the combination of human understanding of natural laws and phenomena accumulated since ancient times to produce things that fulfill our needs and desires or that perform certain functions".

### Green technology

There exists no commonly universally agreed definition of green technology. However, one important point that dominates whatever definition being given to green technology is ''environmental sustainability". Green technology can be defined as technology that has the ability or potential to significantly enhance environmental performance relative to other technology. This definition has its premise from the "environmentally sound technology", a term adopted under the United Nations Conference on Environment and Development Agenda 21 [12]. Agenda 21 of the UN states that environmentally sound technologies are geared towards protecting the environment with less pollution, sustainable use of resources, recycle more wastes and products and handle the residue from the wastes in a more acceptable manner than the technologies for which they were substituted (Low Carbon Green Growth Roadmap for Asia and the Pacific-Fact sheet, 2012). It is a type of technology that is considered environmentally friendly as a result of processes involved in its production or supply chain. It could also be referred as clean energy production that involves the use of alternative fuels and technologies that have less harmful effect to the environment than fossil fuels [13]. Long [14] noted that green technology concentrates on sustainable innovation that takes into consideration short-term and long-term environmental effects. Green technology is not only used to promote reduction in greenhouse gas emission and sustainability, but also proffer answers to climate change [15]. Green technology involves development and application of products, equipment and systems that conserve resources and minimize negative environmental impact of human actives [10]. According to the authors, green technology satisfies the following criteria:

i. It minimizes environmental degradation

ii. Zero or low Greenhouse Gas (GHG) emissions

iii. Conserves energy use and natural resources

iv. Promotes the use of renewable resources

Green technology encompasses a broad range of production and consumption technologies that minimize damage to the


Copyright © Stephen Enyinnaya Eluwa

environment and improve the condition of ecosystems (UNEP 2003). In terms of pollution arising from energy generation and consumption, green technology involves both process and product technologies that generate little or no waste and increase energy efficiency. Green technology does not only refer to individual technologies but also systems. The systems include: procedures, know-how, equipment, goods and services, as well as managerial and organization procedures (UNEP 2003). Combining the aforementioned view points, green technology is any innovation, production process or procedure that promotes energy efficiency and environmental sustainability. It has four pillars-environment, social, economic and energy as shown in (Figure 1).

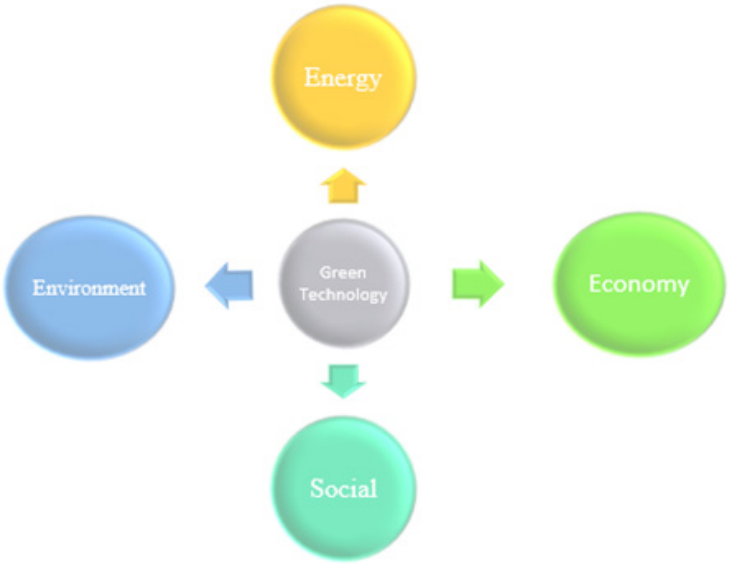



**Figure 1:** Four pillars of green technology.

## Renewable energy and green technology adoption in Nigeria

### Hydropower

The adoption of renewables have a relatively short history in Nigeria, especially in the public view. However, this perception may not be true as renewable energy from hydropower has actually been at the centre of Nigeria's grid electricity production since the 1960s. Until very recently, the Kanji and Jebba Dams (1300MW) accounted for about half of Nigeria's power sources (Newsom, 2012). However, the situation changed when the country started building gas powered stations for electricity generation, whose role continues to be constrained by poor management, corruption and unstable gas supplies. Out of the 23 operational power plants in Nigeria, as at 2015, only three are hydro plants, the rest are gas plants. The last hydropower plant in Nigeria was built 38 years ago. However, as climate change debate continues and the need for nations to reduce their carbon emissions, the Federal Government of Nigeria, through its agencies have started diversifying to renewables in meeting the energy need of the people. One of such initiatives is the setting up of new large scale hydropower plants in parts of the country identified as having hydro potentials for electricity generation. The Federal Ministry of Water Resources (FMWR) has identified and conducted studies on some of the completed and on-going dam projects for hydropower. The dams include: Gurara, Oyan, Ikere Gorge, Bakolori, Dadin Kowa, Tiga, Kiri, Jibiya, Challawa Gorge, Owena, Doma, Waya, Mgowo, Zobe, Kampe, Kashimbilla, Ogwashiku, Zungeru and Mambilla [7].

### Solar

Among the renewable energy sources in Nigeria, solar seems to have gained prominence in terms of investment and adoption. Nigeria is endowed with huge solar potential by virtue of her location around the equator, within a high sunshine belt where solar radiation is fairly distributed [16]. The annual daily average of total solar radiation in Nigeria varies from about 12.6MJ/$m^2$/day (3.5kWh/$m^2$/day) in the southern coastal regions to about 25.2MJ/$m^2$/day (7.0kWh/$m^2$/day) in the far north [17]. Solar resources are highest in the northern Nigeria, because it is an arid region with high temperature and low rain fall. The southern Nigeria has less potential for solar energy as it is often cloudy and has longer rainy season [18]. The production of solar energy system is heavily dependent on the amount of incoming solar energy, referred to as solar irradiation or more generally as solar resource. The high potential of solar resource in the country makes it an attractive pathway for renewable energy supply and reduction in carbon emissions [19]. Nigeria is endowed with huge solar resource, however, there is no existing large scale commercial solar project [7].

### Wind

Wind power seems to be the least well-understood source of renewable energy in Nigeria. Until recently, Nigeria was thought of by both local and international policymakers as 'not a windy country' but this conclusion is based on a very limited dataset. The assertion that Nigeria is 'not a windy country' is mainly


Copyright © Stephen Enyinnaya Eluwa

due to lack of accurate data to support or contradict it (Nesom, 2012). Studies have suggested that the northern part of Nigeria is endowed with more wind resources than the southern part [20,21]. The development of wind and other renewable energy sources in Nigeria have not experienced much progress in recent years due to some inherent problems that have impeded growth of the industry. Nigeria has coastal line of about 853km which has potential for the generation of electricity via the use of offshore wind turbines. However, technical investigation to evaluate the exact wind energy resources that abound in the shores of the country has not been carried out [22]. Wind energy has not really been utilized in Nigeria. Most of the studies conducted are either pilot in nature or mere use of time series data obtained from some agencies or organizations by researchers to model , predict or analyse wind potentials that abound in the country [23-26]. Ayodele et al. [27] through a cross regional analysis of the six geo-political zones in Nigeria, examined the wind resources at 10m height by employing the Weibull distribution functions. Findings from the study revealed that only Kano and Jos out of the fifteen sites considered produced the most excellent wind energy potentials that is cost effective and could be connected to grid systems. Unlike solar energy that its utilization for electricity generation by households is currently being commercialized, wind as alternative renewable energy source is still at the exploratory stage in Nigeria.

## Green technology adoption (Solar Photo Voltaic)

The early stages of green technology adoption in Nigeria started with solar powered boreholes since the mid-1990s. Boreholes especially in rural areas rely on generators which are expensive to maintain. For example, the Niger Delta Wetlands Centre (NDWC) has been experimenting with solar-powered water boreholes since the 90s. Due to the cloudy nature of the region, people thought that solar powered boreholes may not work. However, NDWC has been able to demonstrate model water boreholes around several key principles and provide direct evidence to disentangle the "too cloudy hypothesis" (Newsom, 2012). Over 50% of Nigeria's population lack access to grid electricity [28] and it is even erratic (Newsom, 2012). In order to fill this deficit in electricity supply, there is an ongoing transition within the energy sector in Nigeria [29]. The current transition from heavy reliant on fossil fuels for electricity generation to adoption of solar has open a new chapter in Nigeria's energy history. Some of the factors that triggered the shift include: (i) Nigeria's energy system which depends heavily on fossil fuels has functioned limitedly over the years, trigging the demand for alternative sources of energy and (ii) The central government has not been the major driver of the shift towards adoption of renewable energy, rather state governments, private corporations and community initiatives [29]. One of the arguments for failure of the energy sector in Nigeria, is centralization of generation and transmission. The sub-nationals (state governments) have not been given opportunity to fully participate in the generation and transmission of electricity in Nigeria. However, the current transition within the energy sector in Nigeria, affords private organizations, Local Governments, State Governments and individuals the opportunity to actively participate. The adoption solar PV in Nigeria has gained prominence over the last five years. For example, Baru et al. [30] in their study reported that 60% of solar energy adopters in Kano city, Nigeria installed their solar system between 2015 and 2016, which reveals that there is increase in adoption of solar PV by Kano residents. According to SEFAA 2016 [7] report, efficient lighting will be used by 40% of households in Nigeria by 2020 and 100% by 2030.

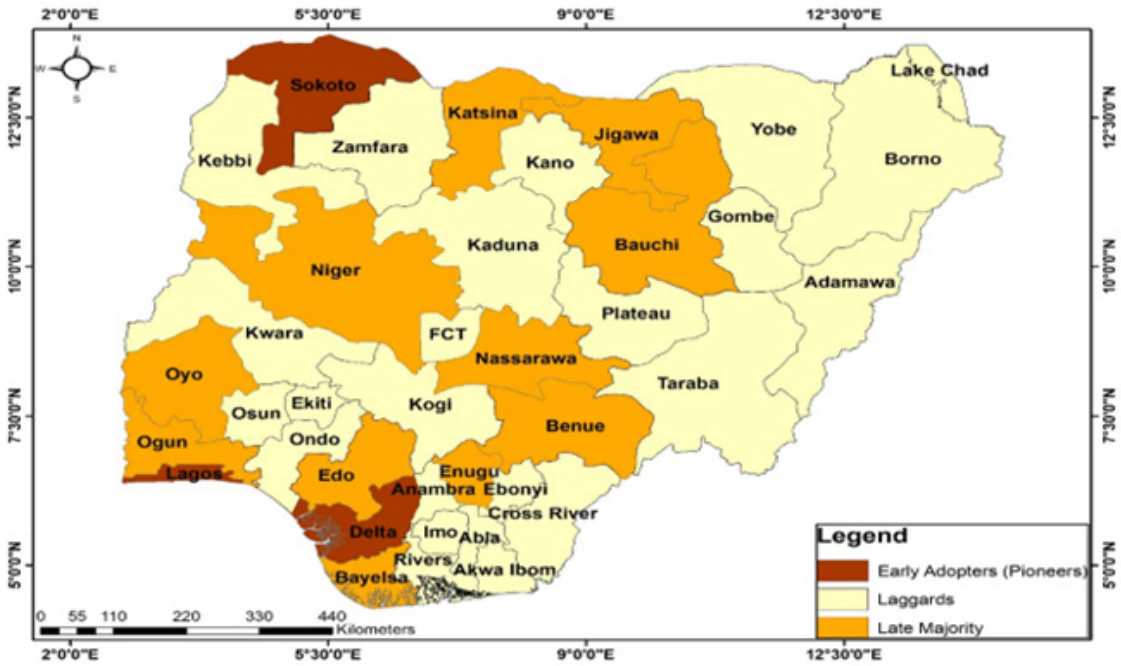



**Figure 2:** Adoption/development of renewable and green technology among the states in Nigeria.


Copyright © Stephen Enyinnaya Eluwa

In their study in Kano, one of the mega cities in Nigeria, Barau et al. [30], reported that over 50% of respondents that have adopted solar PV were resident in unplanned neighbourhoods of the city. The implication of this according to the authors is that areas of the city that are planned have relatively stable grid electricity supply compared to those that are unplanned. Similarly, majority of adopters in the study area, changed their high energy consuming appliances to more efficient ones after their installation of solar PV. In another seminal study, Osunmuyiwa & Kalfagianni [29], examined the conditions for adoption and development of renewables and green technology in Nigeria. In this study, adoption/diffusion of solar, wind and biofuel among the 36 states in Nigeria was examined. The authors applied method of Qualitative Comparative Analysis (QCA) to analyze three different cases of adoption/diffusion of renewable energy in Nigeria. Thus, the states were categorized as: i) Pioneer states in renewable energy development, (ii) Semi-laggard states and (iii) Laggards. A state is considered a pioneer when it has a threshold of installed capacity of 1000kw or more. It is considered a semi-laggard when it has a threshold of installed capacity between 1000kW and 100kW. Finally, a state is a laggard when it has a threshold of 99kW–5kW of installed capacity. The threshold used for this study according to the authors was the share of installed capacity rather than energy per capita due to lack of verifiable data on annual electrical use of the state in KW hours. Their findings revealed that there is a variation in renewable energy adoption/diffusion in Nigerian states on the basis of type of technology and installed capacity in KW per state. Based on their findings, Lagos, Sokoto and Delta are pioneers (early adopters); Enugu, Oyo and Bauchi are semi-laggard States (late majority) while Nasarawa, Niger, Edo, Ogun, Jigawa, Bayelsa, Katsina and Benue are laggard states (Figure 2).

## Conclusion

Nigeria has abundant renewable energy resources that could promote reduction in carbon dioxide emissions arising from heavy reliance on fossil fuels. Currently, over 70% of grid electricity generated in the country is from gas powered stations. In the country's quest to increase share of renewables in her energy mix, green technology or innovation is needed for proper harnessing and efficient use of these renewable energy resources. The major feature of green technology is that it promotes or facilitates a reduction in greenhouse gas emissions relative to status quo. This reduction can be through energy generation process (wind, solar, hydro) or through the use of energy efficient home appliances [31]. Similarly, development of renewable energy potentials in Nigeria will help in creating direct and indirect job for the teeming unemployed youths [32,33]. It will also provide electricity access to majority of the Nigerian population living in rural areas, including more sustainable provision for household's cooking.

## References


1. Nishimoto S (2004) United Nations Development Programme Energy for Development Conference. Netherlands.
2. World Bank (2006) Development Report. Equity and Development. Open Knowledge Repository.
3. Shaad B, Wilson E (2009) Access to sustainable energy: What role for international oil and gas companies? Focus on Nigeria. p. 1-46.
4. Oyebanji IJ, Adeniyi B, Khobai H, Roux P (2017) Green growth and environmental sustainability in Nigeria. International Journal of Energy Economics and Policy 7(4): 216-223.
5. Nigerian Electricity regulatory Commission (NERC) (2021) Power Generation in Nigeria.
6. Sasu DD (2021) Demographics of Nigeria-Statistics and facts. Statista.
7. Sustainable Energy For All Action Agenda (SEFAA) (2016) Inter-Ministerial Committee on Renewable Energy And Energy Efficiency (ICREEE). Federal Republic of Nigeria.
8. GEF-UNDP (2011) Promoting energy efficiency in residential and public sectors in Nigeria. GEF-UNDP Energy Efficiency Programme, Energy Commission of Nigeria.
9. United Nations (2013) Innovation Policy for Green Technologies. A Guide for Policy Makers in the Transition Economies of Europe and Central Asia. United Nations Commission for Europe, p. 1-35.
10. Bhardwaj M, Neelam (2015) The advantages and disadvantages of green technology. Journal of Basic and Applied Engineering Research 2(22): 1957-1960.
11. Volti R (2009) Society and technological change. 7th (Edn), Worth Publishers, USA, pp. 1-488.
12. United Nations (1992) Department of Economic and Social Affairs, Earth Summit Agenda 21: The United Nations Programme of Action from Rio, Brazil.
13. Kenton W (2020) What is Green Tech?.
14. Long M (2019) What is green technology and examples of its benefits.
15. Onyia CJ, Chime CO, Agbata OB, Ekenechukwu NL, Enekwenchi K, et al. (2017) Green technology: A contribution to sustainable development in Nigeria. CJAST 22(6): 1-6.
16. Energy Commission of Nigeria (ECN) (2003) National Energy Policy. Federal Republic of Nigeria, Nigeria.
17. Ohunakin O, Adaramola MS, Oyewole OM, Fagbenle RO (2014) Solar energy application and development in Nigeria: Drivers and barriers. Renewable And Sustainable Energy Reviews 32: 294-301.
18. Nigerian Energy Support Programme GIZ-EU (2015) The Nigerian Energy Sector- An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification. 2nd (Edn), Germany, pp. 1-152.
19. Arup & Design Genre (2016) Building Energy Efficiency Guideline for Nigeria. Federal Ministry of Power, Works and Housing.
20. Adaramola MS, Oyewola OM (2011) On wind speed pattern and energy potential in Nigeria. Energy Policy 39(5): 2501-2506.
21. Aririguzo JC, Ekwe EB (2019) Weibull distribution analysis of wind energy prospect for Umudike, Nigeria for power generation. Robot Comput Integr Manuf 55: 160-163.
22. Attabo AA, Ajayi OO, Oyedepo SO (2019) Wind energy generation from Nigeria continental shelf: A Review. IOP Conf Series: Earth and Environmental Science 331: 1-16.
23. Ajayi OO, Fagbenle RO, Katende J ( 2011) Assessment of wind power potential and wind electricity generation using WECS of two sites in south west, Nigeria. International Journal of Energy Science 1(2): 78-92.
24. Ohunakin SO (2011) Assessment of wind energy resources for electricity generation using WECS in north-central region. Nigeria J Renewable and Sustainable Energy Reviews 15(4): 1968-1976.
25. Oyedepo SO, Adaramola MS, Paul SS (2012) Analysis of wind speed data and wind energy potential in three selected locations in South-East



Copyright © Stephen Enyinnaya Eluwa

Nigeria. International Journal of Energy and Environmental Engineering 3: 1-11.

26. Abdulkarim A, Abdelkader SM, Morrow DJ, Falade AJ, Adediran YA (2017) Statistical analysis of wind speed for electrical power generation in some selected sites in northern Nigeria. Nigerian Journal of Technology 34(4): 1249-1257.

27. Ayodele TR, Ogunjuyigbe ASO, Amusan TO (2016) Wind power utilization assessment and economic analysis of wind turbines across fifteen locations in the six geographical zones of Nigeria. J Clean Prod 129: 341-349.

28. Ley K, Gaines DJ, Ghatikar A (2014) The Nigerian energy sector-An overview with a special emphasis on a special emphasis on renewable energy, Energy Efficiency and Rural Electrification. 2nd (Edn), German Society for International Cooperation (GIZ) GmbH, Bad Homburg v.d.H., Germany.

29. Osunmuyiwa O, Kalfagiannib A (2017) Transitions in unlikely places: Exploring the conditions for renewable energy adoption in Nigeria. Environmental Innovation and Societal Transitions 22: 26-40.

30. Barau AS, Abubakar AH, Kiyawa AI (2020) Not there yet: Mapping inhibitions to solar energy utilisation by households in African informal urban neighbourhoods. Sustainability 12(3): 1-14.

31. Allan C, Jaffe AB, Sin I (2014) Diffusion of green technology: A survey. Motu Working Paper 14-04 . Motu Economic and Public Policy Research, p. 1-34.

32. Richard L (2009) Definitions of technology. In: Friss IKBO, Pedersen SA, and Hendricks VF (Eds), A Companion to the Philosophy of Technology. Wiley-Blackwell, US, pp. 18-22.

33. (2021) Low Carbon Green Growth Roadmap for Asia and the Pacific: Turning resource constraints and the climate crisis into economic growth opportunities.


*Copyright © Stephen Enyinnaya Eluwa*