

# **SUSTAINABILITY IN RENEWABLE ENERGY PRODUCTION IN NIGERIA; A MATERIALS ENGINEERING PERSPECTIVE**

**Author:** Okereke Oscar

## **Abstract**

Satisfying the ever-growing demand for energy in a sustainable, eco-friendly and economical way has been a major challenge of the 21st century. Trends have shown that sustainability, economy and eco-friendliness depends on the deployment of materials which thanks to continued technological innovation, evolves continually. As such, materials, therefore, play a very important role in the quest for this development unequivocal to the fact that the features of our modern industrialization are our escalating extravagance of materials. Globally, the world's primary energy production is; oil, coal and gas as a major source of environmental pollution not ruling out its short life-span. As such it is imperative for a developing country like Nigeria in the bid to conform to global practice on pollution and secure the future of the energy sector to embark on the quest for sustainable energy. This paper attempts to render the interrelationship between materials and the quest for sustainable energy while highlighting how a country like Nigeria can tap into it as both a solution to current power issues and as recourse for future energy development.

**Keywords:** Materials; Engineering; Technology; Energy; Sustainability; Advancement.

**List of Abbreviations:**

<b>CPV</b>	-	Concentrating photovoltaic
<b>CSP</b>	-	Concentrating solar power
<b>EGS</b>	-	Enhanced geothermal system
<b>IEA</b>	-	International Energy Agency
<b>Li-ion</b>	-	Lithium ion
<b>Mteo</b>	-	Millions of tons of oil equivalent
<b>Mw</b>	-	Megawatt
<b>NESTEC</b>	-	National engineering science and technology
<b>PV</b>	-	Photovoltaic
<b>R&amp;D</b>	-	Research and Development
<b>TEM</b>	-	Transitional stage electricity market

## **1.0 Introduction**

Energy is a constant concern to a nation's economic and standard of living, its effect plays a very pivotal role in the nation's growth. With a flashback in time, evolutions in materials have always influenced energy generation, storage and transmission. Conversely, the influence of energy on the lives of people is glaring. Industrial/ technological revolution, modern communication, lifestyle, social interaction to mention but a few have been directly influenced by the development of energy via materials. Thus for a developing country like Nigeria, the onus for sustainability is greater than ever seen before. It is pertinent to point out that the availability of energy is pivotal to the standard of living, affluence, and personality of a country. Nigeria's energy status is at the fracture point. So it is with this advancement of technology we can, therefore, regain our elasticity or rather our energy. The role of materials advancement to energy cannot be overemphasized, in that without materials, there is no energy. Therefore, it is at this horizon lies the aim of this essay "materials for energy". Materials role to the nation's energy sector is not the only solution to her headache, but such as a journey of a thousand miles begins with a single step, the journey of our energy breakthrough could also begin with just a look into the roles of materials to our energy sector. With these we could as well answer the questions in our minds and mouths: has all been done to efface Nigeria's energy backdrop? Is there a way out for or country? What are the missing pieces to the puzzle, and how do we apply them?

Before we begin to discuss the reasons why Nigerians are in these positions, let us examine how deep this might have burrowed into our nation by having an overview of our energy sector and then discuss how we can improve for the future.

## **2.0 The Nigerian energy sector: The Status Quo**

Analysis has shown that the power sector is key to economic development. According to a World Bank report on the availability of electricity, out of 189 countries studied, Nigeria ranked 187 while it takes about 260 days to access permanent electricity connection in a commercial city like Lagos, Nigeria [WB;

2014: b]. Commercial cities like Lagos. As such the major hindrance even when connected is erratic nature of the supply. A 2011 World Bank survey shows that over 83% manager's survey points towards power outages as the main constraint to business development in Nigeria. General average power outages of about eight hours daily were observed to lead to hammering sales of over 4%. [World Bank (WB); 2011] The fundamental effect of this negativity facing the progress as to supply of electricity in Nigeria is paramount. This has therefore vetoed the investment of nationalized power sector in the 1990s, with regression in budgets upholding with no competence addition. Privatization of the electricity sector was done in 2013 with the focus on improving electricity supply reliability (fig 1). However, to have an effective reliability of the system, it is therefore expedient for restructuring.

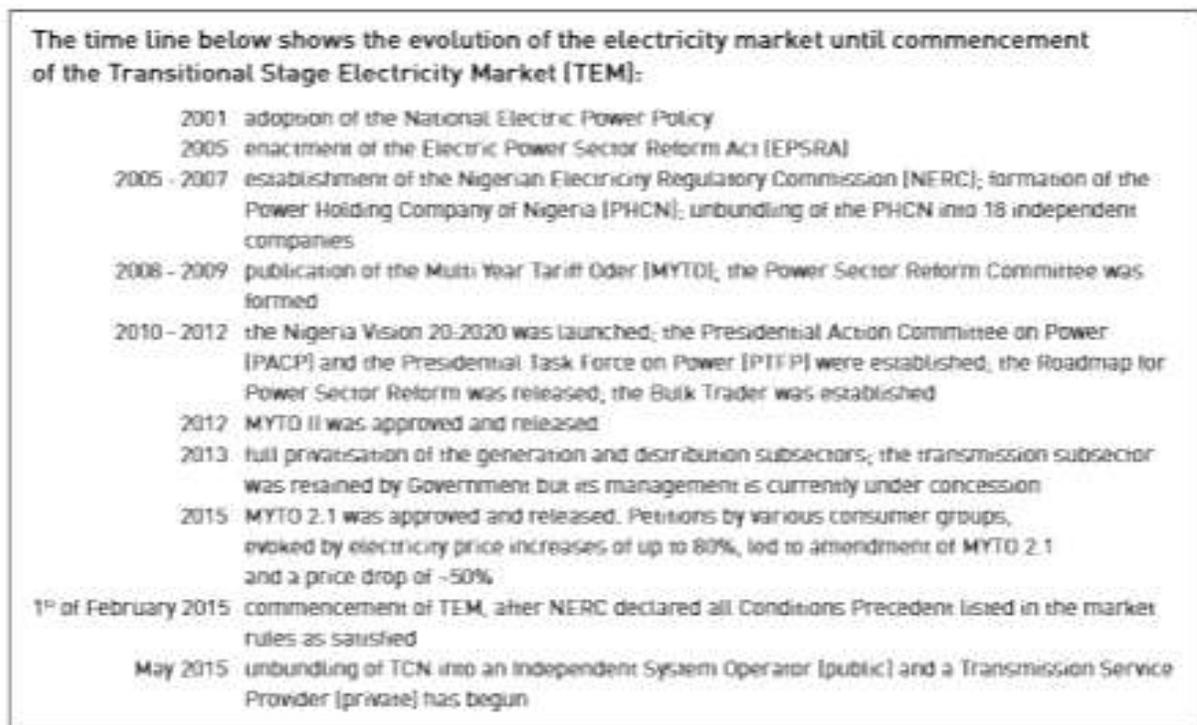


Figure 1: Evolution of electricity until the transmission stage. (Source: The Nigerian Energy Sector, 2015).

Chemical source of energy like biofuels and wastes accounts for about 85% of the energy consumed in Nigeria which is approximately 99.3Mtoe annually, comes from biofuels and waste (figure 2). However

residential areas take up almost 90% of the produced energy of which majority goes into cooking operation. Conventional sources like a generation from reimported fuels only give about 13%. In all, electricity accounts for only 1.9% showing the level of availability of power from electric sources. With the growing rural population, the environmental impact of the use of chemical sources of energy generation will be compounded. Comparing the power generation trend of Nigeria and other developing countries as shown in figure 3 below, it can be seen that the performance of Nigeria over a 20years timeline is below 100% as compared to countries like Indonesia (372%), Bangladesh (451%) and Brazil. Bangladesh in 2012 alone generated 2x electrical energy as Nigeria. As such the quest for sustainability looks almost unachievable. Nonetheless, it is pertinent to point out that the major birth of electrical energy in Nigeria is hydro and thermal plants as compared to other countries that have diversified into the use of solar, wind and nuclear power as means of improving the power demand. But the link between these lies on the material to be used. Though blessed with lands and extended periods of sunshine, solar collectors, wind turbines, nuclear reactors all require state of art materials for both generation and storage of energy; facilities that are not common in Nigeria.

Having given a quick view on the power situation in the energy sector, we can now look into the various ways materials can improve the energy sector, this implies us proffering the various renewable sources of energy and ways it would affect our growth – which includes solar, hydro, geothermal, nuclear energy etc.

**TOTAL ENERGY CONSUMPTION BY RESOURCES IN 2012**

Total energy consumption: 116.5 Mtoe

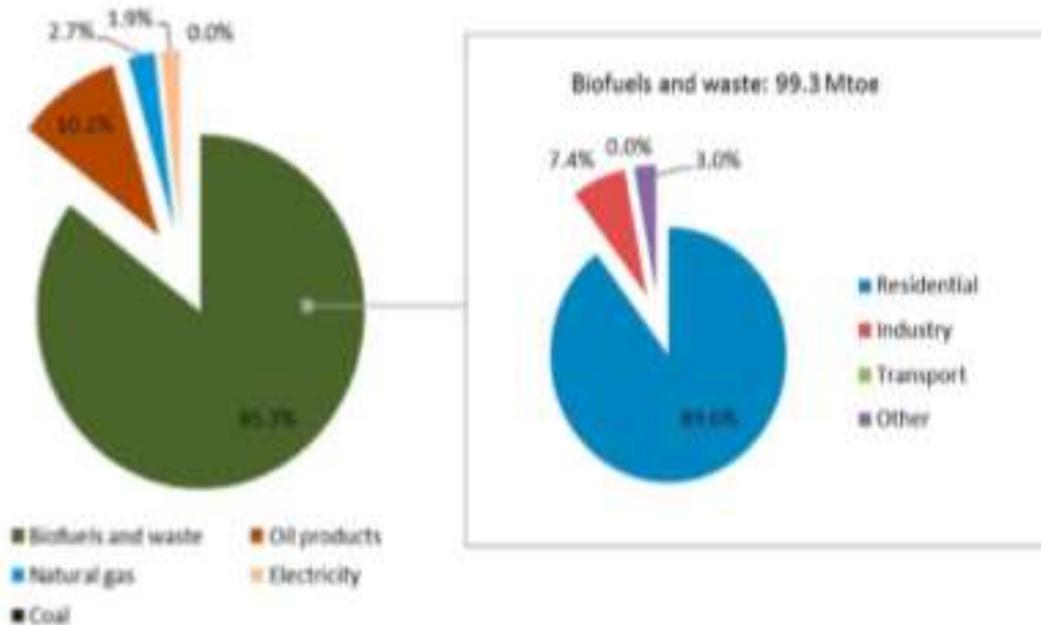


Figure 2: Total energy consumption based on source (Copied from IEA, 2019)

**ELECTRICITY GENERATION (GWH) IN NIGERIA AND PEER COUNTRIES SINCE 1992**

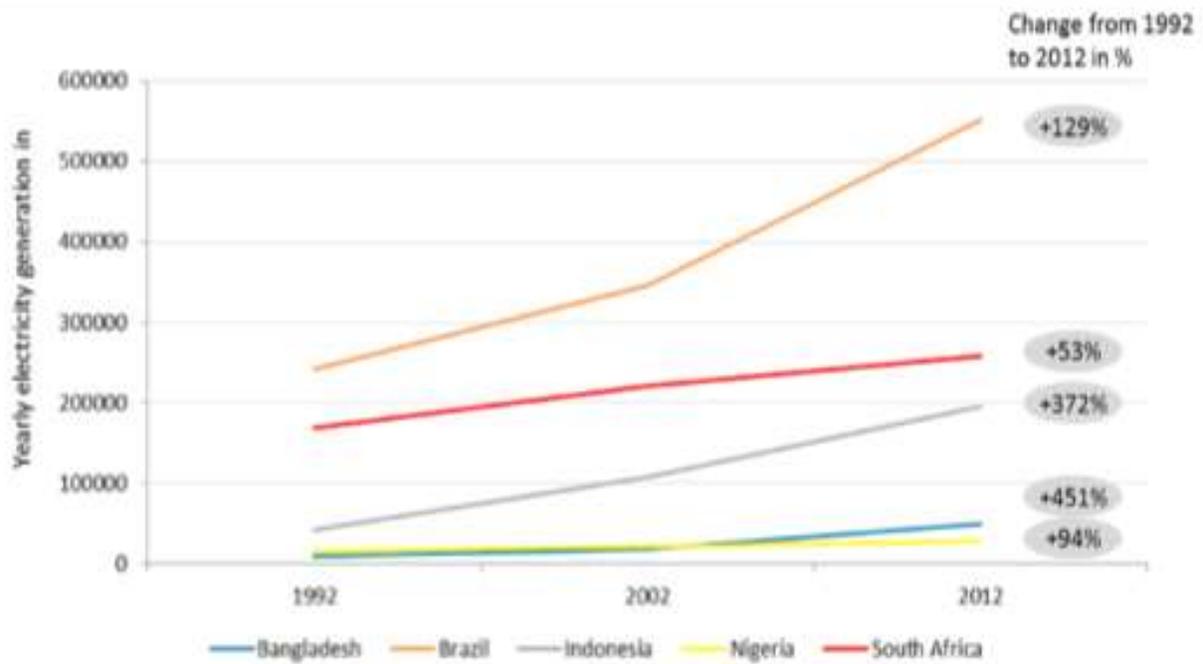


Figure 3: Comparison of energy generation in Nigeria and peer countries (Copied from IEA, 2019)

### 3.0 Solar power

Light from the sun is an essential carbon-neutral energy source to mankind and is constantly growing to an express rate. The sun provides about 13 terawatts of energy on an hourly basis; an amount which is less than the man's annual consumption rate. To tap this enormous energy from the sun, there is a need for scientists and engineers to provide resourceful solutions to efficiently capture the free and free energy from sunlight and quench our energy thirst. The prospective to effectively raise the amount of electricity gotten from the sun's energy is what the material science, and engineering offers. Compensation of electrical power from sunlight include; limitless, at no cost and renewable energy source, production of the greatest energy during the days of the greatest demand, energy reimbursement in less than three years, a low trace of carbon content, with no loss in materials. Technologies such as PV, CPV, CSP and Solar Thermal, can be used effectively to arrest the sun's energy. PV converts sun-rays to useful electrical energy. The growth PV technology over the years was over 40% yearly to be precise, reducing its costs of electricity. This current growth has been motivated owing toward improved effectiveness, principally in the growth of silicon-based PV materials; and natural elastic molecular, polymeric or nanoparticle-based cells. Challenges involved in such technologies involve the need to constantly boost solar cell capacity by refining the compositions of materials used, and the cell's architecture. Alternatively, materials with rich qualities, nontoxic, low-cost developed in nanoscale to reduce surface reflection and to arrest the full intensity of light-rays from the sun, solving materials aging issues by extending the life-span, low-cost of production with proficient solar system materials recycling methods, filling the gap between commercial and research cell efficiency to reduce power cost from modules will bring to fruition the challenges involved.

### **3.1 The opportunity:**

To alter the efficiency of solar energy and creating eco-friendly plastic solar cells that can be mounted on both flat and curved faces, with the convergence of nanotechnology and PV technologies will be a great opportunity, platform-driven with the thoughts of a materials scientist for our future energy.

### **4.0 Nuclear energy**

Majorly established emission-free electricity creation technologies with short trace carbon content are ever said to be the nuclear form of energy. Established in Nigeria 2004, is a research plant located on the prestigious University in Zaria, with a plan to create about 4000MWe of nuclear power by 2030 with the involvement of international agencies. Construction of such established plans was supposed to start in 2011 to start energy generation from nuclear power by 2017-2020. Plans of this establishment have not been cancelled as construction will soon begin. More recently, is the deliberation with the Rosatom of Russia to develop blueprint, creation and functioning of four nuclear reactors for energy generation by 2015(Wikipedia, 2016). Recent nuclear power plants hold the solution to the nation's energy independence and with energy's goal to the purest form and therefore a vehicle for employment. These plants are expected to possess unreceptive systems for safety measures, proficient use of nuclear fuel resources, generating a lesser volume of nuclear waste, including operations involving elevated temperature/radiation fields. Sophisticated materials proffer's to containing this challenge with the solutions to waste clearance. With the involvement of computational modelling, artificial intelligence tools used in the development of this materials, provision of more consistent performance involving elevated temperatures/radiation fields, in highly corrosive environments and for a longer period will be achieved. With such development, a new module of materials and advanced coating system for fuels, components for reactors and as much will be generated. Benefits attracted to this type of energy are numerous such as, creation of over a thousand job during construction with up to 400 high paying jobs when in operation. Nuclear power plants contribute just about 400 million naira to the local economy,

virtually 29 billion in sales in the local community and over a billion in labour income (estimate based upon 4 nuclear power plant if established).

## **5.0 Wind power**

Materials role to wind power is unequivocal. Nowadays, blades made of polymer-matrix composite reinforced with fibreglass or carbon is used in wind turbines. The electrical generators in the turbines consist of magnets created with rare earth materials. The rotations of these blades drive an electric generator via a gearbox, having alloys of a special constituent to contain the ample variety of the wind speeds. As the growth of off-shore installations, the birth of elevated stresses and unsympathetic conditions that can defy the durability of materials is introduced. Therefore, these blades must possess enough stiffness to avert failure due to buckling and deflection, requiring long-term fatigue life in callous situations. R&D continues to attempt these vital problems. Though challenges in this area are abounded such as, smart materials in the construction of the blades which will automatically adjust its pitches to contain wind speed variations, and also avert corrosion and fatigue, sensor induced turbine blade to continually monitor damages due to fatigue and signal the need for servicing. Our goal, therefore, is the installation of the wind turbine should be raised to a factor of 10-20x spread to suitable sites in Nigeria to generate over 20% of electricity in the future.▶

## **6.0 Geothermal power**

The energy gotten from the conversion of warmth that is held on within the earth crust to usable electricity through the employment of heated water pumped up into and out of a deep well with the help of a turbine or in a fluid heat exchanger is thought because of the heat variety of energy. Styles of heat with nice potential for world energy use square measure various. The energy provided through this type is claimed to be consistent and accessible. Recent generations of **ESG** don't need naturally predicament resources instead; highly pressured water is pumped up into the well through associate injection rock. As water travel through this rock fractures, the warmth of the rock is captured up-till a definite level then

forced out through a second borehole as prevalent water, this predicament is employed to drive a rotary engine that produces electricity. Subtle technologies square measure needed for **ESG**. Work on this kind of energy is. However, to be established in Nigeria will be seen in countries like the U.S. wherever it 1st application has begun, employing a production well at an advert geothermic website. Geologically, the structure and history in Nigeria influence such exploration at intervals every earth science space. The product of magnetic and volcanic activities, as an example, square measure various at intervals the Benue trough. **Biu** upland has over eighty volcanoes and **Jos** upland with intensive volcanic rock flows (Grant et al., 1972; Turner, 1978). With materials R&D, we will solve the challenges concerned during this project likes, the creation laborious drilling materials for geothermic wells, novel materials for piping systems that may resist corrosion thanks to the extreme temperatures of fluid.

## **7.0 Fossil energy**

Over two-thirds of the recent and projected energy generation is from fossil fuels. Listing how important this energy source is. In 2014, the consumption rate in total was about 19.04% as reported from a recognized source, according to the World Bank collection of development indicators. Advancement in materials has enabled various developments of energy efficiency gotten from fossil fuel to converting systems. Over the years, momentous efforts have resulted in the sophisticated use of materials for fossil fuel converting systems. Elevated working temperatures have been introduced due to the type of coatings applied to hot turbine components wherefore, increasing its efficiency. Advanced materials have, therefore, yielded a considerable improvement in the overall effectiveness of converting fuel to energy. Companies producing advanced materials and boilermakers have worked along to develop new materials to be used in critical boilers. These new materials, and therefore, the new power cycles have allowed efficiencies of coal discharged power plants to be augmented to forty-second. Through this event, new materials coating systems has grown, subsidized fuel consumption Associated in the Nursing connected drop in inexperienced house gas with different variety of waste discharge brought to fruition.

## **8.0 Biofuels**

The use of biofuel offers the chance to interchange up to half-hour of Nigerians transportation fuels, decreasing the economic drain annually that leaves the shores of Nigeria to the getting off foreign oil and elevating the protection of our energy offer. The Breaking down of cellulose, the chemical unmanageable building blocks of plants, needs belligerent materials that speed up reaction rate as well as improving the life-span which will accommodate the corrosive nature of the constituent. The membrane alga possesses is rich towards raw materials production of crude diesel oil and gas chains; they, however, want a routine that will chemically alter the properties of material during conversion. Several of these processes occur naturally. Sophisticated materials with analytical tooling systems need to know the perspective of this crude production of fuel, and therefore, develop a simulated algorithm that unswervingly and with efficiency manufacture the required finish product.

## **9.0 Lithium ion Batteries**

Batteries- rechargeable and non-rechargeable, has been said by the various analyst to be the most proficient, trusted means for energy storage. The Li-ion rechargeable batteries are paving ways for more advancement in energy storage, with the proper structuring of this type of battery, energy storage will be more effective. Many emerging Li-ion batteries require better materials to enhance their workability. Thus, materials R&D will need to structure advanced materials in nanoscale with a defined cell integrity composition. More recently, the progress of this type of storage has increased, from its improvement in the alteration of the electrode's chemical composition to the development in electrodes design. This, therefore, proffers opportunities in the future generational Li-ion battery commercialization for energy storage.

## **10.0 Efficient energy for transportation**

Evolution in materials science has been the key to unlocking our fashionable lifestyle, count personal transportation, and mass transportation of individuals and product. As an example, refined rubber

composites have stunningly extended the lifetime of tires, and application of the latest steels has a diode to exhaust systems that usually endure for the lifetime of the vehicle. Similarly, the expansion of corrosion-resistant coatings has currently exaggerated the period of the structure and improved the physical look. Next people challenges are going to be somewhat completely different; however, these challenges are going to be overcome through the expansion and application of latest or increased materials. The world's rising reliance on restricted oil resources together with considerations connected to climate conditions, and gas emissions demand the enlargement and exploitation of vehicles with decrease consumption in fossil oil. At the same time, client wants demand that the solutions be non heritable at cheap, and sooner with none deviation in performance, traveler safety or convenience. The longer term wants are going to be met through a mix of exaggerated fuel potency, use of alternate fuels or energy sources, and curtailment. Materials R&D can play polar role all told of those areas, and can contribute for the most part to the technological wants of future vehicles.

### **10.1 Energy efficient buildings**

Statistics shows that developed countries accounts for four-hundredth of primary energy consumption, seventieth of electricity use and four-hundredth of atmospherical emissions (greater than that of energy related to transportation). A nations building sector is a crucial sector of its economy. In spite of those numbers, exceptional progress has been created in energy potency throughout the last 20 years as a result of growth in materials resulting in new anti-green materials, low emissivity windows and dense fluorescent illumination. There square measure ample places in an exceedingly building wherever materials have an effect on energy potency however they need to work along to possess most profit. Integrated building systems, therefore, square measure essential to energy economical and net-zero buildings. These building systems utilize new materials and integrated style approaches, however need a amendment in culture to bring designers, contractors, utilities and end-users along within the method. At present, net-zero buildings square measure technologically doable however square measure a significant challenge.

Achieving price effective net-zero building systems needs lower price multifunctional materials, additional economical solid state lighting materials, additional corrosion resistant metals and improved producing processes.

## **10.2 R&D: The way forward**

While it seems to be a perturbed task for our energy sustainability, it is necessarily a priority for the R&D to look into various ways of developing technologies that can take our energy sustainability to a high level. Tech student has a big part to this in that in this quest for sustainability ideas will surface through student competitions and research development. The role of the government cannot be enough for the progress of this sustainability, availability of resources is therefore needed for this sustainability to suffice. Engineering and technology research institute could also be founded to take up matters of such which will as well solve our energy issues. Also, implementations of advanced materials to the Nigeria energy sector will welcome more sustainable advancement.

## **10.3 Sustainability**

Materials science has a right away and direct affiliation to sustainability through economical use of energy-intensive materials that we tend to use each day, without affecting the flexibility of the next generational wants, the headache is therefore contained. Recycling metal, steel, plastic, and glass yield monumental energy savings

## 11.0 Conclusion

To take the electricity seen bull by the horns and emerge victorious, Nigeria should refrain from burying her head within the sand. This essay has drawn on an upscale body of empirical and theoretical literature to detail ingenious solutions to efface this scene. Materials developments are typically invisible to the users of technology; however they're at the Guts of numerous necessary advances. The conclusion of the past took time and patient investment within the folks and therefore, the infrastructure for research project. Developments of materials square measure the sole. Thanks to advance the prosperous and property energy future can. This implies finance within the leading-edge analysis and educating ensuing generations of scientists and engineers required to secure our country's technological leadership.

## References:

Advanced Materials for Our Energy Future. (29/09.2019). pp.1-24.

African Economic Outlook. *Country Notes – Nigeria* Retrieved October 1, 2019 from  
nigeriaeconomicoutlook.org

Burite. J. "*Nigeria's deliberation with Russia's Rosatom for Nuclear Reactor*". Retrieved September 16,  
2019, from <http://bloomberg.com>.

Grant N. K., Rex D (1972). "*Geothermal areas in Nigeria*" *Mining*. 35, 277- 292.

P.H.C.N.(2009). "Electricity privatization" Retrieved October 2, 2019 from  
nigeriaelectricityprivatisation.ng

Turner D. C. (1978). *Volcanoes in Nigeria*. *Geology and Mining*, 50-65.

World Bank . *Data Nigeria*. Retrieved August 29, 2019 from [worldbank.org](http://worldbank.org)

Global Energy Council. *Effectiveness and Challenges in Nigeria's Energy Demand*. Retrieved September  
2019 from <http://congresspapers.com>

World Nuclear Association. (2007). "*Emerging Nuclear Energy Countries*". Retrieved September 17,  
2019

Yahoo News. "*Two nuclear power plant sites selection in Nigeria*", Retrieved September 17, 2019