



## Renewable Energy in Sustainable Electricity and Economic Development: The Case of Nigeria

**Ekpobodo Raymond Ovwigho<sup>1</sup>, Yuri Chepurko<sup>2\*</sup>, Oleg Y. Kazenkov<sup>3</sup>, Dmitrii N. Ermakov<sup>4</sup>, Sinivie Progress Onini<sup>5</sup>, Bashir Aliyu Yauri<sup>6</sup>**

<sup>1</sup>Peoples' Friendship University of Russia (PFUR), Engineering Academy, Department of Engineering Business and Management/Space Technology, Moscow, 117198, Russia, <sup>2</sup>Polyus Research Institute of M.F. Stelmakh Joint Stock Company, Russia, <sup>3</sup>Polyus research institute of M.F. Stelmakh Joint Stock Company, Moscow, Russia, <sup>4</sup>Peoples' Friendship University of Russia (PFUR), Engineering Academy, Department of Engineering Business and Management/Space Technology, Moscow, 117198, Russia, <sup>5</sup>Peoples' Friendship University of Russia (PFUR), Economics Faculty, Department of Management, Moscow, 117198, Russia, <sup>6</sup>Peoples' Friendship University of Russia (PFUR), Faculty of Physical Mathematical and Natural Sciences, Department of Applied Informatics and Probability Theory, Moscow, 117198, Russia. \*Email: [chepurko@yandex.ru](mailto:chepurko@yandex.ru)

**Received:** 25 August 2019

**Accepted:** 11 November 2019

**DOI:** <https://doi.org/10.32479/ijeep.8836>

### ABSTRACT

The article is devoted to the potential role of renewable energy in the grid of the future electricity generation and economic development in Nigeria. The article further observed that it is also important to examine the economics of a variety of potentially competing technologies including market demand, flexible generation, and improved operational practices of electricity in Nigeria. In addition, while there are clear benefits of using energy storage to enable greater penetration of natural resources, it is important to consider the potential role of renewable energy in relation to the needs and demands of the electricity in Nigeria. Nigeria, which gained sovereignty since October 1, 1960 did not have its own stable electricity. Hence, the article is concentrated on renewable energy as a source of sustainable electricity and economic development. The authors were interested in renewable energy due to the huge demand of electricity in Nigeria and at large, in Africa. The natural resources have no limits to human environment or space (surface). Hence, the article attempts to find solution to the problem of electricity through renewable energy. The article further emphasizes on the important use of natural resources for building modern economy and technology advancement. The article discusses the importance of renewable energy and energy demand for electricity generation as a factor of diversification of national economy. Significant place is given to the interdependence of the renewable energy with the needs of sustainable electricity generation and economic development.

**Keywords:** Renewable Energy, Energy, Sustainable Electricity, Economic Development

**JEL Classifications:** O33, Q42, Q47, Q48

### 1. INTRODUCTION

The Federal Republic of Nigeria is the pearl of modern Africa. Nigeria in terms of population is comparable to Brazil; more than 200 million people live in Nigeria. The history of electricity supply in Nigeria can always be traced back to 1886 when two small generating sets were installed to serve the then Colony of Lagos. By an Act of Parliament in 1951, the Electricity Corporation

of Nigeria (ECN) was established, and in 1962, the Niger Dams Authority (NDA) was also established for the development of Hydro Electric Power. It was through the emergence of these two bodies in 1972 that the National Electric Power Authority (NEPA) was formed. As the resources of Electric Generation and Distribution in Nigeria declare the result of the power reform process in the year 2005 was the rename of NEPA into the Power Holding Company of Nigeria (PHCN). In quest of finding solution

to the problem of electricity in Nigeria, the Nigerian government has recently signed a six-year power deal with German energy giant Siemens Company in an attempt to fix the country's unreliable electricity grid. The power deal between Nigerian government and the German energy company is for production of at least 25,000 Megawatts of electricity by the year 2025. According to President Muhammadu Buhari, "today, in partnership with the German Government and Siemens AG, we are making an important move forward in addressing Nigeria's electricity challenge. As the DW Global Media Forum (2019) suggests to deliver more electricity to Nigerian businesses and homes". According to statistics released by the Washington Post (2012), nearly 25 percent of the population of all developing countries had no electricity. In Sub-Saharan Africa, seven out of ten people do not have access to electricity. Todd (2012) comparing other economies with Nigeria declares that 55% of Nigeria's population (people) do not have access to electricity.

The global use of renewable energy options has expanded rapidly over the past two decades as their energy demand, reliability and cost-effectiveness has been successfully demonstrated in several niche markets. Given the high cost of supplying electricity to isolated rural communities and villages in Nigeria, decentralized renewable energy options often can compete on cost with inter-states supply options such as grid extension. Despite her abundance of natural resources, Nigeria remains almost completely dependent on fossil fuels and gas for meeting her energy needs. Improving access to electricity has been made a priority among Nigeria's States, where approximately 70% (60%, excluding States capital and Federal Capital, Abuja) of the population lacks access to electricity. This poses an enormous challenge to foreign investors and citizens to invest in businesses where most of Nigerian states have no electricity.

The energy challenges, which has engulfed Nigeria for almost two decades, has been enormous and largely contributed to the incidence of poor power supply by paralyzing industrial, technological and commercial activities during this period. The Council for Renewable Energy, Nigeria (CREN, 2009) noticed that power outages brought about a loss of 126 billion Naira (US\$984.38 million) annually. Apart from the huge income loss, it has also resulted in health hazards due to exposure to carbon emission caused by constant use of 'backyard generators' by different households and business enterprises, unemployment and high cost of living leading to deteriorating living conditions in Nigeria.

Building upon renewable energy resources for sustainable electricity and economic development is dramatically increasing along with improvements in the quality of life, industrialization and increased investment. Hence, today, the world is well advanced in meeting that challenge, while also testing the practical limits of doing so from natural resources (variable renewable energy). To this end, Nigeria's dependence on oil for energy is depriving her from utilizing the abundant renewable energy resources, which are environmentally friendly in terms of global warming.

This article is to determine the development and optimization of renewable energy resources to improve the technological, sustainable electricity and economic development of Nigeria.

The article is also aimed at conducting energy consumption and economic evaluation of renewable energy in other countries. This research employs the use of System Analysis Method in order to present to the renewable energy regulator; the Council for Renewable Energy, Nigeria (CREN) as a complex and multi-functional organ with a special system of connections and values. The Structural Analysis Method can be applied when studying the state of Nigerian renewable energy. Methods of Comparatives and Situational Analysis were used when comparing the national consumption of renewable energy in Nigeria with other countries in Africa, as well as in western countries. Quantitative methods can be used in assessing the level of energy consumption and demand in Nigeria.

## 2. RESEARCH BACKGROUND

The renewable energy of a country is a mirror image of the sustainable electricity and the economy. Understanding the specifics of the Nigerian renewable energy resources are impossible without an analysis of the specific features of her electrification and economic development. In 1960, Nigeria gained independence from the United Kingdom (UK). However, the country's economy did not switch to an innovative development path: along with the rapidly developing commodity sector, oil and agriculture still play an important role. The industrial sector of Nigeria is represented by the dominant extractive industries, primarily oil production, which provides 90% of export revenues and more than 80% of revenues to the national budget. Nigeria is ranked first in oil production in Africa and seventh position in the world. However, the influence of the United States and the leading Western states, possess the necessary technological and financial resources, use the creative labor potential of Nigeria is quite large. With the vast exploration and reserve of oil and gas in the country, Nigeria installed about 6000 Megawatts (MW) of electricity, of which barely 4500MW is generated for use because of her poor facilities maintenance and inability to invest on renewable energy resources (lack of diversification of energy sources). Its electricity demand is more than 15000MW. In industrialized nations, uninterrupted electricity is critical to economic stability and security, as well as to technology advancement. Hence, many industrialized countries are highly dependent on renewable energy resources, as well as other countries for their energy and their economies are dependent on the willingness of other countries to supply it. However, there is a functional relationship between renewable energy and sustainable development in the Nigeria economy. According to Hui (1997), renewable energy has an important role to play in meeting the future energy needs in both rural and urban areas. This is why Nigeria needs to seize the opportunities presented by renewable energy resources in sustainable electricity development to establish renewable energy markets with renewable energy technologies for economic development.

Most importantly, energy consumption shows a strong correlation with national income, so that countries with higher income are also those with higher energy consumption. The impact of renewable energy on economic growth create employment and raises incomes. Basically, most economic activities would not be possible without energy as critical input, and these include the

Small and Medium-Scale Enterprises (SMEs) that constitute the primary source of new jobs for the lower strata of the teeming population. Hence, the type of economic growth and development that create jobs and raises incomes depends on greater and more efficient use of energy and Nigeria should not be exempted. Today, there is an increasing demand for renewable energy in Nigeria due to the increased electricity demand and economic development for civilization.

Energy is essential to human way of life (Mitchel, 1983). It provides human-being with comfort, transportation, and the ability to produce food and material goods. According to Adeyemo (2001), energy consumption has been directly related to the gross national product, which is a measure of the market value of the total national output of goods and services. Hence, the interaction between the growing population and energy demand is the most important determinant with the level of economic activity and its structure would be measured by the total gross domestic product (GDP) alongside the various sectors and sub-sectors of the Nigerian economy.

Population projection of Nigeria was expected to grow from 181.18 million in 2015 to 281.81 million by 2030 at an average annual rate of 2.86% between 2015 and 2030. The increase in the energy demand is due to the high level of economic activities expected in Nigeria as measured by the total GDP. The total projected energy demand in million tons of oil equivalent (MTOE) in Nigeria can be seen in Table 1.

Sunday Olayinka Oyedepo (2012) found the trends of the projected energy demand are going to be high in the nearest future as it is shown in Table 1. By 2020, the total energy demand will base on 10% GDP growth rate revealed that the household segment would have the largest share of all sectors in Nigeria. The electricity demand (extracted from the total energy demand) shows an increasing trend from the base year 2020 to 2030 in the four adopted growth scenarios, indicating a high economic growth rate leading to substantial increase in the electricity demand.

In accordance with Nigerian Energy Support Program (NESP), the total energy consumption by economic sectors for Nigeria, Brazil and South Africa, which for the remainder of this research article will serve as a peer group comparison. This is illustrated in Figure 1.

It shows in Figure 1 that residential sector accounts for most of the final energy consumption in Nigeria with a share of about 78% followed by industrial use, whereby the latter only amounts to approximate 9%, followed by the rapidly expanding transport sector.

**Table 1: Total projected energy demand (MTOE) in Nigeria**

Scenario	2020	2025	2030
Reference (7%)	118.14	169.18	245.19
High Growth (10%)	190.73	259.19	414.52
Optimistic (11.5%)	245.97	331.32	553.26
Optimistic (13%)	312.61	429.11	715.7

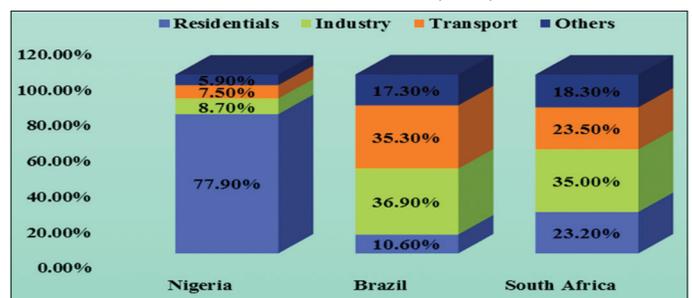
Source: Adopted from Energy Commission of Nigeria (ECN, 2006)

The peer-group comparison reveals that in percentage terms energy consumption in Nigeria is slanted firmly towards the residential sector. While, other countries shown a much lower share of residential energy consumption. In addition, the two other countries shown much interest on industry sectors account for most of the final energy consumption. The problem of unstable electricity has affected the Nigerian industry, as residential energy consumption outstrips that for industry by a factor of almost nine. Considered the substantial proportion of the population that lives in Nigeria, electricity generation through renewable energy to drive industrialization and electrification are both policy imperatives for economic development.

In order to optimize costs and improve efficiency, Nigeria's renewable energy uses market mechanisms and decentralization measures. According to Alam (2006), energy is the indispensable force driving all economic activities. Therefore, we fully agree that energy interaction and its role show that renewable energy as a sphere of life activity will affect almost all aspects of the quality of human life. This implies that, the greater the energy consumption, the more the electricity generation and economic activities in the nation and as a result a greater economy emerges. The modern trends in development of the global energy market formulated key areas for the development of Nigeria in the field of international innovation cooperation in the power sector. According to Stern (1997a), all economic processes must require energy; this therefore, makes energy always an essential factor of production.

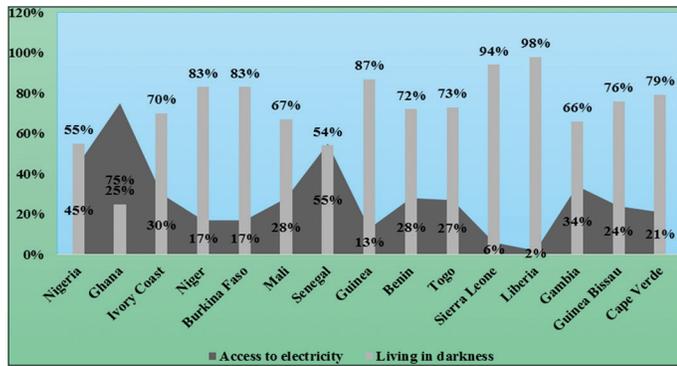
The power sector in Nigeria has been unproductive and hence the need for restructuring processes aiming to improve the efficiency of the electricity market. This implies privatization of power activities by which market competition is introduced in the production and supply of electricity in Nigeria. In the process of developing the power sector, it is necessary that the interests of preserving the environment for future generations are equally important as economic development and renewable energy interest of today's generations. To this end, the authors acknowledge or see renewable energy resources as corner stone of power diversification for sustainable electricity and economic development. Efficient and well-developed renewable energy from natural resources will not only boost the economy with competitiveness of the national economy, but it will as well affect the improvement of living standard of the population and development of the society. Subsequently, the basic task of the global free energy is to ensure

**Figure 1: Total energy consumption by economic sectors for Nigeria, Brazil and South Africa (2012)**



Source: IEA

**Figure 2:** ECOWAS, seven out of ten people do not have access to electricity



Source: The Washington Post, 2012

quality and stable delivery of electricity to consumers, as well as to secure and reliable security with optimal price of electricity and acceptable dynamics of delivery.

### 3. METHODOLOGY AND DATA

To improve the situation of renewable energy resources for sustainable electricity and economic development, the government and power sector should cooperate in solving the above problems. According to March (1991), to be innovative, an organization or community must be adept in using existing knowledge, as well as in learning new ways of producing knowledge. The Russian Decree 449 “Renewable Energy Source Development Measures” expressed the view that to develop and support usage of renewable energy depends on a detailed innovation knowledge of the past in order to avoid electricity challenges that led to the need to improve renewable energy resources in Nigeria.

In the preparation of further policy documents, it is advisable to form acts and by-laws that cover rural electrification in the organization of the preparation process. For example, for the direction of “Innovation in technical systems” these could be engineering and technical disciplines in the national innovation system and so on. This approach would allow to build a structure for the consistent study and research of renewable energy resources in Nigeria. In addition, such an organization of the energy research makes it easy to create an innovation of competencies.

The difference in their preparation is the difference in finding solutions and the amount of energy needed to produce. In this regard, the authors offer a structural-functional model of the energy needed in Nigeria, after seeing the current state of electricity generation in ECOWAS countries by percentages (Figure 2).

The authors reviewed and applied the work of Gbadebo and Chinedu (2009), indicating that additional models in natural resource consumption can be used to evaluate, monitor and improve the effect of energy on the economy. There is a certain approach in calculating the dynamics of forecasting the role of renewable energy in the economy of Nigeria. The model is represented by the following formula:

$$Y = F(K, L, E) \quad (1.1)$$

Where;  $Y = \text{RGDP} = \text{aggregate real output (aggregate real gross domestic product)}$ ;  $K = \text{Gfcf} = \text{Gross fixed Capital formation}$ ;  $L = \text{Labf} = \text{Labour force}$ ;  $E = \text{Total Energy Consumption}$ .

Let's energy ( $E$ ) in the model is disaggregated into four energy types, which includes: Solar, wind, hydro and biogas. Splitting the energy into four types, the model could be rewrite as follows:

$$\text{RGDP} = f(\text{Gfcf}, \text{Laf}, \text{SE}, \text{WE}, \text{HE}, \text{BIOGE}) \quad (1.2)$$

Where;  $\text{SE} = \text{Solar energy}$ ;  $\text{WE} = \text{Wind energy}$ ;  $\text{HE} = \text{Hydro energy}$ ;  $\text{BIOGE} = \text{Biogas energy}$ .

For purpose of estimation we rewrite equation (1.2) above in the linear form, as:

$$\text{RGDP}_t = \alpha_0 + \alpha_1 \text{Gfcf}_t + \alpha_2 \text{Laf}_t + \alpha_3 \text{SE}_t + \alpha_4 \text{WE}_t + \alpha_5 \text{HE}_t + \alpha_6 \text{BIOGE}_t + U1_t \quad (1.3)$$

$\alpha_1$  to  $\alpha_3$  represent the slope coefficients

$\alpha_0$  is the intercept

$U1_t$  Is the stochastic term or the error term at time (t).

The priori expectations are as follows:

$$\alpha_1 > 0, \alpha_2 > 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_5 > 0, \alpha_6 > 0$$

In the non-linear form we also estimated

$$\ln \text{RGDP}_t = \beta_0 + \beta_1 \ln \text{GFCF}_t + \beta_2 \ln \text{LAF}_t + \beta_3 \ln \text{SE}_t + \beta_4 \ln \text{WE}_t + \beta_5 \ln \text{HE}_t + \beta_6 \ln \text{BIOGE}_t + U2_t$$

Where;

$\beta_1$  to  $\beta_6$  are elasticities and  $\beta_0$  is the intercept

$U2_t$  Is the error term.

### 4. RESULTS AND DISCUSSION

It is noted that the low productivity and human empowerment in Nigeria is due to poor electricity generation over a period of time (t), especially in the industrial sector. The influence of renewable energy on the effectiveness of electricity generation is significant and it plays an important role in improving the national economy. If the Nigerian renewable energy sector wants to use its potential in any field of technology advancement for the benefit of the national economy, as well as train technical specialists of the energy improvement, they need to introduce a new specialist model, ways to assess their level of training, and also take it on themselves responsibility for risks from cooperation with industry and energy business. In this case, government, industry and energy business will be interested in cooperation. Then, individuals and the society at large will benefit from such collaboration, as the research results would translate into energy market-ready innovations. In the context of the large-scale development of the Nigerian renewable energy resources, the prospects for improving energy to increase the efficiency of the Nigerian electricity and economic development are highly relevant. The effective and

efficient development of renewable energy is an essential part of the electricity generation for modern global industrial economy, which is responsible for creating jobs that guarantee a living wage.

The practical significance of renewable energy is a holistic process of forming and directing the development of technology, monitoring the state of the electricity generation, security, communication, transportation and infrastructural development.

At present, it is difficult to overestimate the role of renewable energy resources in ensuring the competitiveness of the national economy of Nigeria. The research resulted in that fact that Nigeria has quiet number of problems that affect the quality of electricity generation, which include:

- Poor organized workshops training and practical training of specialists;
- Undeveloped innovation technology of renewable energy;
- Problem of insecurity;
- Poor technical knowledge;
- Insufficient electrical equipment;
- Delayed payment of employees' salaries;
- Imperfect policy and management;
- Religious sects and the constant incensement of electricity bills;
- Market failures assessing public benefits from renewable energy resources.

## 5. CONCLUSION

Renewable energy in Nigeria is characterized by both electrification and technological lag, so the transition to the energy formation of a national innovation system is advisable. It will allow for positive changes not only in the power sector, but also in other sectors of the Nigerian economy, through the activation of competition, technology advancement, the restoration of core industries, the strengthening of overall socio-economic stability and stimulation of the energy formation of innovative processes.

It is advisable to form an integrated system of renewable energy resources focused on training young people in the field of energy innovation for sustainable electricity and economic development. The first stage is represented by general energy innovation specialized training programs, workshops and schools and the second stage is represented by technical colleges, research institutes and universities. Without failure, government must include this in the educational curriculum in collaboration with the industries. The third stage is represented by legislators. Law makers should implement policies that encourage citizens to have the ability to generate electricity and to also patronize domestic electricity production.

It is extremely important for Nigeria to partner with leading foreign energy countries, such as Russia and Germany

to improve her electricity generation. Investments in renewable energy resources do not only pay off, but also, subsequently, lead to the appearance of innovative products, technology advancements, human empowerment and significant capitalization of the country. The organization and implementation of renewable energy researches and practices seems to be important. It assists to address the environmental concerns that emerged due to greenhouse gas emission such as carbon dioxide (CO<sub>2</sub>), oxides of nitrogen (NO<sub>x</sub>), oxides of sulfur (SO<sub>x</sub>), and particulate matters as a result of power generation from bio energy.

## REFERENCES

- Adeyemo, S.B. (2001), Energy Potentials of Organic Wastes. Proceedings of the First National Conference. p55-61.
- Alam, M.S. (2006), Economic Growth with Energy. Available from: <https://www.u-picardie.fr/eastwest/fichiers/art79.pdf>. [Last retrieved on 2019 Jul 30].
- Energy Commission of Nigeria. (2006), National Energy Policy. Abuja: Federal Republic of Nigeria.
- Gbadebo, O.O., Chinedu, O. (2009), Does energy consumption contribute to economic performance? Empirical evidence from Nigeria. *Journal of Economics and Business*, 7(2), 43-47.
- Hui, S.C.M. (1997), From renewable energy to sustainability: The challenge for Hong Kong. *Hong Kong Institution of Engineers*, 1997, 351-358.
- March, J.G. (1991), Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71-87.
- Mitchel, J.W. (1983), *Energy Engineering*. New York: John Wiley and Sons.
- NEPA. (1995), *Thermal Power Stations in Nigeria*. Lagos: NEPA Headquarters, Marina. p38-40.
- Oyedepo, S.O. (2012), Energy and sustainable development in Nigeria: The way forward. *Energy Sustainability and Society*, 2(10), 15.
- Stern, D.I. (1997a), Limits to substitution and irreversibility in production and consumption: A neoclassical interpretation of ecological economics. *Ecological Economics*, 21, 197-215.
- The DW Global Media Forum. (2019), Can Siemens Save Nigeria's Chaotic Power Sector? The Nigerian Government has Agreed to a Deal with the German Energy Company in an Attempt to Fix the Country's Unreliable Electricity Grid. Available from: <https://www.dw.com/en/can-siemens-save-nigerias-chaotic-power-sector/a-49719128>.
- The Electricity Generation and Distribution in Nigeria: Technical Issues and Solutions. Available from [https://www.researchgate.net/publication/267029542\\_Electricity\\_Generation\\_and\\_Distribution\\_in\\_Nigeria\\_Technical\\_Issues\\_and\\_Solutions](https://www.researchgate.net/publication/267029542_Electricity_Generation_and_Distribution_in_Nigeria_Technical_Issues_and_Solutions).
- The Nigerian Energy Support Programme. (NESP). Available from: <https://www.giz.de/en/downloads/giz2015-en-nigerian-energy-sector.pdf>.
- The Washington Post. (2012), 1.3 Billion are Living in the Dark. Available from: <https://www.washingtonpost.com/graphics/world/world-without-power/>. [Last Retrieved on 2019 Aug 02].
- Todd, L. (2012), Around the World, 1.3 Billion People Lack Access to Electricity. Available from: <https://www.washingtonpost.com/graphics/world/world-without-power/>.