Bullion

Volume 42 | Number 2 Article 4

6-2018

Renewable energy consumption and economic growth in Nigeria: a co-integration and granger causality approach

Kingsley Imandojemu
Central Bank of Nigeria, kimandojemu@cbn.gov.ng

Akinlosotu Nathaniel Toyosi
NaTisolusions & Services

RENEWABLE ENERGY CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA: A CO-INTEGRATION AND GRANGER CAUSALITY APPROACH

IMANDOJEMU, KINGSLEY
Senior Supervisor
Central Bank of Nigeria

AKINLOSOTU NATHANIEL TOYOSI
Lead Consultant/Data Analyst
NATisolusions& Services

1.0 Introduction

The current world's population outburst, with venial desire for a better quality of life, and incremental demand for energy adds further expediency to the need for frameworks that can guarantee cost-effective, efficient, clean and renewable energy. Indisputably, the conventional way to meet energy needs in contemporary economies is to burn fossil. Presumably the share of energy production from alternative, cost effective and cleaner sources has increased slightly. Nonetheless, the usage of fossil fuels as an energy source remains predominant, supplying an estimated 85.0 percent of the world's energy production. The burning of fossil fuels, which results in greenhouse gas emissions, is the primary human activity affecting the amount and rate of climate change (World Bank, 2017).

Fossil fuels for energy contribute directly to global warming by emitting carbon dioxide to the atmosphere, as well as increasing deforestation and climate change. Economies dependent on fossil fuels increases greenhouse gas emissions causing drastic changes to our climatic systems. Therefore, the trade-offs between energy needs and the environmental consequences of increased energy consumption must be addressed through sustainable and clean energy sources. Providing the energy needed for growth while mitigating its effects on the world's climate is a global challenge. Goal 7 of the United Nations Development Programme (Sustainable Development Goals) – Affordable and clean energy – reaffirms the centrality of energy to development and wellbeing, and points to the policy deliverables that are required to ensure universal access to affordable electricity by 2030.

The International Energy Agency (2017) reports affirmed that one in five people across the globe lack access to electricity and, about 2.8 billion people still lack access to clean cooking. The expected switch to liquefied petroleum gas (LPG), natural gas and electricity remains unimpressive. One-third of the world's population –2.5 billion people – still rely on the traditional use of solid biomass while another120 million people cook with kerosene and 170 million with coal. Household air pollution from these sources is currently linked to 2.8 million premature deaths per year, and several billion hours are spent collecting firewood for cooking, mostly by women, that could be put to more productive uses (World Energy Outlook, 2017).

The inadequacy of electricity supply in Nigeria is one of the country's gigantic malaises. Installed generation capacity is 12,500 megawatts (MW), but only 3,500–5,000 MW current output is available and demand widely expected to dramatically outstrip available electricity generation capacity. The electricity supply is untrustworthy and not widespread (per capita electricity consumption in 2005 was 127 kWh, less than half that in Ghana (World Bank, 2008). The national electrical grid system is increasingly constrained due to its ageing infrastructure, vandalism, theft, bad maintenance culture, and a lack of proper monitoring. Unreliable electricity forces economic agents to install their own generators in their houses and businesses, at substantial cost. This is also a major contributor to carbon footprint.

Encouragingly, Nigeria can reverse this ugly trend with her endowed huge renewable resources which remain underutilised and largely untapped including solar, hydroelectric, wind in coastal areas and geothermal in the northern region. Nigeria occupies a position on the world solar map that allows the country access to 7.0 kWh/m2 (25.2MJ/m2 per-day) in the far north and about 3.5 kWh/m2 per day (12.6 MJ/m2 per-day) in the costal latitudes at 2500 sunshine hours per year.

Oxymoronically, Nigeria remains beneath the comity of nations known for solar power utilization. This is in stark contrast to Germany, a country that is at the forefront of solar power and a world leader in photovoltaic (PV) installation, yet receives an average of only 3.3 sunshine hours per day. Nigeria's advantageous position means that renewable energy must be considered as a viable solution to the energy challenges that face the country, and in particular for communities in rural areas and informal settlements. In this regard, renewable energy technologies are capable of providing sustainable solution to Nigeria's energy access problems and support its economic development. Renewable energy technologies have the capability to be affordable, decentralised sources of electricity to those who are not connected to the national electrical grid. One of the things renewable energy technologies can help developing countries with, besides a diversified energy portfolio and increased energy security, is poverty reduction by providing affordable and accessible electricity to poverty stricken communities. Improving renewable and hybrid energy systems is key for rural communities, many of whom are still without a reliable connection to the national grid. However, cynics and critics of renewable energy affirm that electricity is required constantly in modern life today, so ideally there should be no breaks in energy transmission. This is one of the most common and a pervasive critique of renewable energy since it is often viewed as an intermittent energy source with disruptive cycles due to seasonal variations. The questions that remains resonate are what happen if some days the sun doesn't shine? There may be no wind, or there may be a drought, each of which inhibits the production of solar, wind and hydro-electricity, respectively. Nevertheless, this ubiquitous concern about renewable energy is slowly being answered. In 2014, there were notable improvements in the usage and creation of energy storage units which can store excess electricity to be used in times when renewable energy technologies cannot generate electricity (Renewable Energy Policy Network, 2015).

Importantly, past research has been inconclusive as to what type of relationship exists between renewable energy consumption and economic growth and there is few independent analysis of the Nigerian case. Hence, this work will empirically examine the relationship between renewable energy consumption and economic growth. It is increasingly becoming germane to understand the relationship between energy consumption, the environment, and the unrelenting pursuit of economic growth in the context of the Nigerian power sector with existing disequilibria between finite resources and infinite needs. This research work will attempt to further the understanding of this relationship in Nigeria.

2. Conceptual Review

The conceptual review of this paper was discussed under two major subheadings namely: renewable energy and economic growth

2.1 Renewable Energy:

Renewable energy can be broadly defined as any energy generated from natural processes including hydropower, geothermal, solar, tides, wind, biomass, and biofuels. Natural endowments are a rich source of adaptation, innovation and inspiration for numerous technologies for power generation. Renewable energy often displaces conventional fuels in four areas: electricity generation, hot water/space heating, transportation, and rural (off-grid) energy services (Renewable Energy Policy Network for the 21st Century, 2010).

Based on IEA (2017) report, by 2030, renewable energy sources power over 60 percent of new access, and off-grid and mini-grid systems provide the means for almost half of new access, underpinned by new business models using digital and mobile technologies. Since 2000, most new access has come from fossil fuels (45 percent coal, 19 percent natural gas and 7 percent oil). The technologies used to provide access however have started to shift, with renewable providing 34% of new connections since 2012, and off-grid and mini-grid systems accounting for 6 percent. Worldwide investments in renewable technologies amounted to more than US$286 billion in 2015, with countries like China and the United States heavily investing in wind, hydro, solar and biofuels (Renewable Energy Policy Network for the 21st Century, 2016). According to the UNEP 2015) renewable energy, excluding large hydroelectric projects, made up 53.6 percent of the total gigawatt capacity of all energy technologies installed in 2015 .Some places and at least two countries, Iceland and Norway generate all their electricity using renewable energy already, and many other countries have the set a goal to reach 100 percent renewable energy in the future. For example, in Denmark the government decided to switch the total energy supply (electricity, mobility and heating/cooling) to 100% renewable energy by 2050, (VadMathiesen, et. al., 2015).

Renewable Energy Policy Network for the 21st Century (2015) found that majority of developing countries have a natural advantage when it comes to renewable energy because of their abundant renewable energy resources. This makes a renewable solution to developing economies' energy problems even more competitive relative to the rising prices of more traditional energy sources (Renewable Energy Policy

Network for the 21st Century, 2015). There are invaluable sources of energy within developing countries that have thus far been largely unexploited. For example, according to Adusei (2011), Ethiopia and the Democratic Republic of Congo possess about 61 percent of Africa's untapped hydroelectric power potentials. Moreover, in 2014, Kenya added 1.1 gigawatts of geothermal energy which was the largest share of newly added geothermal energy in the world (Renewable Energy Policy Network for the 21st Century, 2015).

Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits. Globally, there are an estimated 7.7 million jobs associated with the renewable energy industries, with solar photovoltaics being the largest renewable employer. As of 2015 worldwide, more than half of all new electricity capacity installed was renewable (Renewable Energy Policy Network for the 21st Century, 2016). It is widely recognised that sustainable energy at low cost would contribute to poverty alleviation and arrest climate change. Renewable energy technologies have more benefits to developing countries than merely being environmentally friendly. They also can provide protection against future price increases in conventional fuels by diversifying the energy portfolio, aid in the balancing of both budget and trade deficits, and create new local economic opportunities which help support poverty reduction and promote economic growth (World watch, 2005 and Renewable Energy Policy Network for the 21st Century, 2015).

However, there are limitations that bedevil the use of renewable energy. Despite the fact that as renewable energy technology improves, its downsides will continue to decrease and it will become even more competitive with fossil fuels. There are still aspects of renewable energy technologies which have put countries off from implementing it earlier or in larger quantities. For instance, the initial investment cost is high, much larger than conventional energy sources, which does not favor developing countries (International Renewable Energy Agency, 2015). But while conventional energy sources have lower capital costs, they tend to have significant operating costs whereas the operating costs of renewable energy systems offset their high initial capital costs over time (World watch Institute, 2005).

2.2 Economic Growth:

Economic growth is the increase in the inflation-adjusted market value of the goods and services produced by an economy over time. It is conventionally measured as the percent rate of increase in real gross domestic product (real GDP). Economic growth is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. It can be measured in nominal or real terms, the latter of which is adjusted for inflation. Traditionally, aggregate economic growth is measured in terms of gross national product (GNP) or gross domestic product (GDP).

Economic growth is an important macro-economic objective because it enables increased living standards, improved tax revenues and helps to create new jobs. Economic growth is accepted and desirable. It is the major cause of changes in living standard, with growth, each generation can expect, on the average, to be substantially better off than all proceeding generations.

However, growth is not without its costs, industrialisation, unless very carefully managed, causes deterioration of the environment. Nevertheless, most people would probably agree that the gains from growth were worth the economic costs incurred by those who lose it. Since growth doubles average living standards over 20 to 30 years. It is clearly possible by suitable redistributive policies to make everyone better off as a result of growth. The theory of economic growth is a long-run theory. It ignores short-run fluctuations of actual national income around potential income and concentrates on the effects of investment on raising potential income.

2.3. Theoretical and Empirical Review

There are four causality scenarios which have led to the creation of the following hypotheses regarding the relationship between renewable energy consumption and GDP. First, if an increase in renewable energy consumption causes an increase in GDP then this is evidence of the growth hypothesis. The growth hypothesis connotes unidirectional causality running from energy consumption to GDP whereby energy acts as a complement to labour and capital in the production process (Payne, 2010). The growth hypothesis interprets energy as a driver of economic growth such that energy conservation policies, perhaps to reduce emissions for example, may result in a decrease in GDP. The second scenario is the antithesis of the growth hypothesis. As such, the conservation hypothesis posits that there is unidirectional causality from GDP to energy consumption.

The conservation hypothesis implies that energy conservation policies such as emission reductions or energy efficiency improvements will not adversely affect economic growth (Payne, 2010). The third scenario suggests the existence of an interdependent relationship whereby energy consumption and GDP affect each other simultaneously (Payne, 2010). This scenario is described as the feedback hypothesis and is supported by evidence of bidirectional causality between energy consumption and GDP. Finally, the neutrality hypothesis sees energy consumption as a relatively small component of GDP and thus should not have a significant impact on economic growth (Payne, 2010). Consequently, the neutrality hypothesis is supported by the non-existence of a causal relationship between energy consumption and GDP.

Sustainable energy sources are germane to socio-economic development in the global space. The empirical literature studying the relationship between renewable energy consumption and economic growth has expanded considerably in the last decade. The current research spans a wide variety of countries and regions and encompasses both developed to developing economies. Similar to the energy consumption economic growth literature, the research findings also vary between countries and within regions. Many studies have been conducted on the causal relationship between economic growth and renewable energy consumption but have found mixed results (Apergis, Chang, Gupta and Ziramba, 2016). Amri (2017) examines the relationship between economic growth and energy consumption under two categories- renewable and non-renewable energy consumption. The findings from the ARDL model supported a long-run relationship between economic growth and non-renewable energy consumption but no co-integration was found between renewable energy consumption and economic growth. The results posited bi-directional causality between non-renewable energy consumption and economic growth both in the short-run and long-run. Furthermore, the results revealed a unidirectional causality flowing from renewable energy consumption to economic growth in the long- run.

Apergis et.al, (2016) investigates the long-run relationship between hydroelectricity consumption and economic growth for the 10 largest hydroelectricity consuming countries (Brazil, Canada, China, France, India, Japan, Norway, Sweden, Turkey and the USA). The study used annual data for the period 1965 to 2012. The results from the Bai and Perron (2003) tests of co-integration suggested an existence of a long-run relationship between economic growth and hydroelectricity consumption. The results from a non-linear panel smooth transition vector error correction model were divided based on the three structural breaks, 1988, 2000 and 2009. A one-way causality from economic growth to hydroelectricity consumption was established in the long-run and short-run for the period before 1988. For the period after 1988, a feedback hypothesis was realised between economic growth and hydroelectricity consumption in the long-run and short- run.

Khobai (2017) investigates the causal relationship between renewable energy consumption and economic growth in South Africa. It incorporates carbon dioxide emissions, capital formation and trade openness as additional variables to form a multivariate framework. Quarterly data is used for the period 1990 – 2014 and is tested for stationarity using the Augmented Dickey Fuller (ADF), Dickey Fuller Generalised Least Squares (DF-GLS) and Phillips and Perron (PP) unit root tests. The study employs the Autoregressive Distributed Lag (ARDL) model to examine the long run relationship among the variables. The results validated an existence of a long-run relationship between the variables. Moreover, a unidirectional causality flowing from renewable energy consumption to economic growth was established in the long-run. The short-run results suggested a unidirectional causality flowing from economic growth to renewable energy consumption. The findings of the study suggest that an appropriate and effective public policy is required in the long-run, while considering sustainable economic growth and development.

Omri, Mabrouk and Sassi-Tmar (2015) examines the causal link between energy consumption (nuclear energy and renewable energy) and economic growth for 17 developed and developing countries covering the period between 1991 and 2011. Mixed results were found for nuclear energy and renewable energy. Commencing with nuclear energy, their findings validated a one-way causality flowing from nuclear energy consumption to economic growth in Spain and Belgium, a unidirectional causality flowing from economic growth to nuclear energy consumption was established in Sweden, Netherlands, Canada and Bulgaria and bidirectional causality between nuclear energy and economic growth was found for Argentina, Brazil, France, Pakistan, and the USA. No causality was established for Finland, Hungary, India, Japan, Switzerland and the UK. The results for renewable energy and economic growth suggested a unidirectional causality from renewable energy consumption to economic growth in Hungary, India, Japan, Netherlands, and Sweden. A unidirectional causality from economic growth to renewable energy consumption was evident in

Argentina, Spain and Switzerland whereas bidirectional causality was found for Belgium, Bulgaria, Canada, France, Pakistan and the USA. No causality was found for Brazil and Finland. A feedback hypothesis between nuclear energy consumption and economic growth was realised for the panel while a conservation hypothesis was established between renewable energy consumption and economic growth.

The study by Halkos and Tzemes (2014) investigates the link between electricity consumption from renewable sources and economic growth for 36 countries covering the period between 1990 and 2011. The study used a non-parametric methodological technique. The study analysed the entire sample of countries and then grouped the countries into sub-samples. The results for the entire sample of countries established that the relationship increases only up to a certain level of economic growth. A highly non-linear relationship was realised for emerging and developing countries while for developed countries, an increasing non-linear relationship was observed.

Sebri and Ben-Salha (2014) studies the relationship between economic growth, renewable energy consumption, carbon dioxide emissions and trade openness for the Brics countries. The study was taken over a period 1970 to 2010, using the ARDL bounds testing approach and the vector error correction model (VECM) technique. The results suggested an existence of a long-run relationship between economic growth, renewable energy consumption, carbon dioxide emission and trade openness. The VECM model results supported bi-directional causality flowing between renewable energy consumption and economic growth. Apergis and Payne (2014) investigates the relationship between renewable energy consumption, output, carbon dioxide emissions and fossil fuel prices for seven Central America countries for the period between 1980 and 2010. The results affirmed a long run relationship between renewable energy consumption, output, carbon dioxide emissions, coal prices and oil prices. The results further showed that these variables are positively and significantly related.

Ohlers and Fetters (2014) examines the causal linkage between electricity generated from different forms of renewables for the 20 OECD countries covering the period between 1990 and 2008. Their findings from the Pedroni panel co-integration test confirmed that electricity generated from the renewables and economic growth has a long-run relationship. Furthermore, they established a feedback hypothesis between economic growth and hydroelectricity in the short-run. Zirimba (2013) examines the relationship between economic growth and hydroelectricity consumption for Algeria, Egypt and South Africa for the period 1980 – 2009. The findings from the Toda and Yamamoto technique suggested a feedback link between hydroelectricity consumption and economic growth in Algeria. Moreover, it was established that economic growth Granger-causes hydroelectricity in South Africa while no causality was observed for Egypt.

Apergis and Payne (2012) investigates the linkage between renewable energy consumption, non-renewable energy consumption and economic growth for 80 countries for the period 1990 – 2007. The study employed the Pedroni heterogeneous panel co-integration test and panel error correction model. Their findings confirmed an existence of a long run relationship between economic growth, renewable energy consumption and non-renewable energy consumption, capital formation and labor. The results further supported a feedback link between renewable energy consumption and non-renewable energy consumption and economic growth in the long run and short run.

Apergis and Payne (2011) studies the link between renewable energy consumption and economic growth in six Central American countries covering the period from 1980 to 2016. The study employed the heterogeneous panel co-integration model and panel error correction model. Their findings confirmed an existence of co-integration between economic growth, renewable energy consumption, labor force and gross fixed capital formation. Furthermore, it was observed that there is a feedback relationship between renewable energy consumption and economic growth both in the long-run and short-run. Aminu and Aminu (2015) set out to re-examine the causal relationship between energy consumption and economic growth using Nigeria's data from 1980 to 2011 in a multivariate framework by including labour and capital in the causality analysis. Applying Granger causality test, impulse response and variance decomposition analysis; the results of the causality test reported absence of causality and that of variance decomposition found that capital and labour are more important in affecting output growth compared to energy consumption.

Odularu and Okonkwo (2009) investigates the relationship between energy consumption and the Nigerian economy from the period of 1970 to 2005. The energy sources used to test for this relationship were crude oil, electricity and coal. By applying the cointegration technique, the results derived infer that there exists a positive relationship between current period energy consumption and economic growth. With the exception of coal which was positive, a negative relationship was noted for lagged values of energy consumption and economic growth. The implication of the study is that increased energy consumption is a strong determinant of economic growth having an implicit effect in lagged periods and both an implicit and explicit effect on the present period in Nigeria.

Ogundipe and Apata (2013) examines the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique based on the Cobb-Douglas growth model covering the period 1980-2008. The study also conducted the Vector Error Correction Modelling and the Pairwise Granger Causality test in order to empirically ascertain the error correction adjustment and direction of causality between electricity consumption and economic growth. The study found the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth. Also, the study shows an evidence of bi-directional causal relationship between electricity consumption and economic growth.

3.1. Model Specification

This study is aimed at establishing the causal relationship between renewable energy consumption (RENC) and economic growth proxied by real gross domestic product (RGDP) in Nigeria over the years (1990-2017). The Mao Lin Cheng and Yun Han (2013) modified Cobb-Douglas production model which conjure that changes in the factor of production are responsible for economic growth and development is the foundation of the model.

The modified Cobb–Douglas production function is given thus:

$$Y = AX_1^{\beta 1} X_2^{\beta 2} \ldots X_m^{\beta m} e^{p1D1+p2D2+\cdots p_r D_r} \ldots\ldots [1]$$

Through differential computation, we get

$$dY = \frac{Y}{A}dA + \beta_1 \frac{Y}{X_1}dX_1 + \beta_2 \frac{Y}{X_2}dX_2 + \cdots + \beta_m \frac{Y}{X_m}dX_m. \qquad \ldots\ldots [2]$$

Assume that the economic vector $(A, X_1, X_2, ..., X_m, Y)$ changes from the tth year $(A^{(t)}, X_1^{(t)}, X_2^{(t)}, \ldots, X_m^{(t)}, Y^{(t)})$ to the $(t+1)$st year $(A^{(t+1)}, X_1^{(t+1)}, X_2^{(t+1)}, \ldots, X_m^{(t+1)}, Y^{(t+1)})$ in accordance with a certain continuous curve; then

$$\Delta Y = \int_{L(t)} dY = \int_{L(t)} \frac{Y}{A} dA + \int_{L(t)} \beta_1 \frac{Y}{X_1} dX_1 + \int_{L(t)} \beta_2 \frac{Y}{X_2} dX_2 + \cdots + \int_{L(t)} \beta_m \frac{Y}{X_m} dX_m. \ldots\ldots [3]$$

Let

$$\Delta Y = \int_{L(t)} \frac{Y}{A} dA, \qquad \Delta Y_{Xi} \int_{L(t)} \beta_1 \frac{Y}{X_i} dX_i (i = 1, 2, \ldots, m) \ldots\ldots [4]$$

Then

$$\Delta Y = \Delta Y_A + \Delta Y_1 + \Delta Y_2 + \cdots + \Delta Y_{X_m}. \ldots\ldots [5]$$

Since

$$\frac{\partial Y}{\partial A} = \frac{Y}{A}, \qquad \frac{\partial Y}{\partial X_i} = \beta_i \frac{Y}{X_i} (i = 1, 2, \ldots, m), \ldots\ldots [6]$$

It follows that

$$\Delta Y = \int_{L(t)} \frac{\partial Y}{\partial A} dA, \qquad \Delta Y_{Xi} = \int_{L(t)} \frac{\partial Y}{\partial X_i} dX_i (i = 1, 2, \ldots, m) \ldots\ldots [7]$$

Obviously, ΔY_A denotes the absolute influence value of the economic growth which is caused by technical progress; ΔY_{X_i} denotes the absolute influence value of the economic growth which is caused by the *ith* factor. Hence, the contribution rate of the *ith* input factor to the economic growth (Wickens, 1970; Chand and Kaul, 1986; Pendharkar, Rodger, & Subramanian, 2008; Kiselev and Orlov, 2010) is

$$\frac{\Delta Y_{X_i}}{\Delta Y} \quad [8$$

The method of residual is used to calculate the contribution rate of technical progress. Since

$$\frac{\Delta Y_A}{\Delta Y} + \frac{\Delta Y_{X_1}}{\Delta Y} + \cdots + \frac{\Delta Y_{X_m}}{\Delta Y} = 1, \quad [9]$$

the contribution rate of technical progress is expressed as

$$\frac{\Delta Y_A}{\Delta Y} = 1 \quad \frac{\Delta Y_{X_1}}{\Delta Y} \quad \cdots \quad \frac{\Delta Y_{X_m}}{\Delta Y} \quad [10]$$

At present, it is difficult to determine the form of the $L^{(t)}$d curve due to the very complicated change process of the economic variables. However, with regard to the practical problem, some change curves can be used for fitting, such as the straight line, exponential curve and the power-function curve, etc. In the short term, such as within a year, the power-function curve has stronger adaptability to the growth pattern of the economic variables. Here, the condition of Nigerian economic growth is given; in order to discuss the growth pattern and calculate the contribution rate of the input factor to economic growth, the paper selects GDP (Y) as the comprehensive representative index of the economic growth, and takes the number of practitioners (L), the fixed asset investment (K) and the total energy consumption (E) as three economic forces or factors to make analysis. This procedure establishes the model in equation [11].

$$Y = AL^{\beta_1}K^{\beta_2}E^{\beta_3}e^{p_1D_1+p_2D_2+\cdots+p_rD_r} \quad [11]$$

Considering the position of the coordinate origin, $L^{(t)}$ is expressed as

$$\begin{cases} L = L_i + (L_{i+1} - L_i)t^b, \\ K = K_i + (K_{i+1} - K_i)t^b, \\ E = E_i + (E_{i+1} - E_i)t^b, \\ A = A_i + (A_{i+1} - A_i)t^b, \\ Y = Y_i + (Y_{i+1} - Y_i)t^b, \end{cases}$$

and then

$$\Delta Y_L = \int_{L(t)} \beta_1 \frac{Y}{L} dL = \int_0^1 \beta_1 \frac{Y_i + \Delta Y_i t^b}{L_i + \Delta L_i t^b} \Delta L_i dt^b \quad [12]$$

$$x=t^b \int_0^1 \beta_1 \frac{Y_i + \Delta Y_i x}{L_i + \Delta L_i x} \Delta L_i dx \quad [13]$$

$$= \frac{\beta_1 (Y_i \Delta L_i - Y_i \Delta L_i}{\Delta L_i} \ 1n \left(\frac{L_i + \Delta L_i}{Li}\right) + \beta_1 \Delta Y_i \quad [14]$$

Hence, the labour contribution rate is expressed as

$$\frac{\Delta Y_L}{\Delta Y} = \beta_1\left(\frac{1}{y} - \frac{1}{l}\right) 1n\,(1 + l) + \beta_1 \ldots\ldots\ldots \qquad [15]$$

Similarly, the obtained capital contribution rate is

$$\frac{\Delta Y_K}{\Delta Y} = \beta_2\left(\frac{1}{y} - \frac{1}{k}\right) 1n\,(1 + k) + \beta_2; \ldots\ldots\ldots \qquad [16]$$

the energy contribution rate is

$$\frac{\Delta Y_E}{\Delta Y} = \beta_3\left(\frac{1}{y} - \frac{1}{e}\right) 1n\,(1 + e) + \beta_3; \ldots\ldots\ldots \qquad [17]$$

Further, the contribution rate of technical progress is

$$\frac{\Delta Y_A}{\Delta Y} = 1 - (\beta_1 + \beta_2 + \beta_3) - \beta_1\left(\frac{1}{y} - \frac{1}{l}\right) 1n\,(1 + l) - \beta_2\left(\frac{1}{y} - \frac{1}{k}\right) 1n\,(1 + k) \ldots\ldots\ldots \qquad [18]$$

$$-\beta_3\left(\frac{1}{y} - \frac{1}{e}\right) 1n\,(1 + e)$$

In the above formula, k, l, e denote the growth rates of capital, labour and energy, respectively; and y denotes the economic growth rate. Obviously, when k, l, e are small, then

$$1n(1 + l) \approx l, \qquad 1n(1 + k) \approx k, \qquad 1n(1 + e) \approx e. \qquad \ldots\ldots\ldots [19]$$

From equation [15], [16] and [17], the contribution rate of each factor (labour, capital and energy contribution) is derived as shown in equation [19], [20] and [21] respectively.

$$\frac{\Delta Y_L}{\Delta Y} = \beta_1 \frac{l}{y}, \qquad \ldots\ldots\ldots \qquad [20]$$

$$\frac{\Delta Y_k}{\Delta Y} = \beta_2 \frac{k}{y}, \qquad \ldots\ldots\ldots \qquad [21]$$

$$\frac{\Delta Y_E}{\Delta Y} = \beta_3 \frac{e}{y}, \qquad \ldots\ldots\ldots \qquad [22]$$

$$\frac{\Delta Y_A}{\Delta Y} = 1 - \beta_1 \frac{l}{y} - \beta_2 \frac{k}{y} - \beta_3 \frac{e}{y} \ldots\ldots\ldots \qquad [23]$$

Equation [23], is also consistent with the calculation result which is achieved by Solow's growth rate equation (Wu, 2006 and Yuan et.al, 2009).

Since the focal emphasis of this study is on the impact of renewable energy consumption on economic growth. We dropped the independent variable (energy) and replaced it with a more suitable vector of variable which is renewable energy consumption. Also our study is time series in nature, this makes us to remove i from the model which represents cross-sectional component. The theoretical propositions embodied in these relationships are verified and the estimation of the variables involved which are measured with econometric model is undertaken.

The equation of this study is specified in a production function form as:

RGDP = f (RENC, LFE, GFCF, COE, EXCR) .... [24]

$$RGDP = \alpha_0 + \alpha_1 RENC + \alpha_2 LFE + \alpha_3 GFCF + \alpha_4 COE + \alpha_5 EXCR + e_i \quad [25]$$

By adopting a log-linear specification and taking the natural logarithm of both sides of the equation and assuming linearity among the variables, equations [24] and [25] gives:

$$logRGDP = \alpha_0 + \alpha_1 logRENC + \alpha_2 logLFE + \alpha_3 logGFCF + \alpha_4 logCOE + \alpha_5 logEXCR + e_i \quad [26]$$

$$\alpha_0 > 0,\ \alpha_1 > 0,\quad \alpha_2 > 0 \quad \alpha_3 > 0 \quad \alpha_4 > 0 \quad \alpha_5 > 0$$

Where:

RGDP = Real gross domestic product

RENC = Renewable energy consumption

LFE = Labour force employed

GFCF=Gross Fixed capital formation

COE = CO2 emission per capita

EXCR = Official exchange rate

α_0 = Constant

$\alpha_1, \alpha_2, \alpha_3, \alpha_4$ and α_5 are parameters to be estimated

e_i = error

Causality Model Specification

The pair-wise bivariate causality model is as present below:

$$RGDP_t = \sum_{i=1}^{n} \alpha_0 RGDP_{t-i} + \alpha_1 RENC_{t-i} + \varepsilon_t \quad \text{.......} \quad [27]$$

$$RENC_t = \sum_{i=1}^{n} \alpha 0 RENC_{t-i} + \sum_{i=1}^{n} \alpha 1_R GDP_{t-i} + \varepsilon_t \quad \text{..................} \quad [28]$$

In Equation [27], current RGDP is related to its past values as well as past values of RENC. On the other hand, equation [28] postulates that RENC is related to its past values as well as past values of RGDP. If α1, α2, …,αk= 0 in equation [27] it implies RENC does not Granger Cause RGDP. Similarly, if α1, α2, …,αk= 0 in equation [28] it implies RGDP does not Granger Cause RENC.

3.2 Source of Data/Technique of Analysis

The study employed annual time series data spanning from 1990 – 2017. Data were collected from the World Development Indicator (WDI) and U.S Energy Information Administration various issues. The econometric methods used in this study are Ordinary Least Squares (OLS) method, Augmented Dickey Fuller (ADF) and Philips-Perron (PP) unit-root test, a version of analyzing multivariate cointegrated systems developed by Johansen and Juselius (1994) and Pairwise Granger Causality Test. The econometric view package (E-view version 7) was used to analyse data.

4. Results and Discussion

This section deals with the econometrics analysis of data obtained from the study. The chapter is dichotomized into Unit Root Test, Ordinary Least Squares (OLS) result, Co-integration Test and Causality Test.

Unit Root Test: To investigate the existence of stochastic non-stationary in the series, the unit root test using Augmented Dickey Fuller (ADF) and Philips-Perron statistic was conducted. The result is presented in Table 1.

Table 1 showed the test for unit root in the series with Augmented Dickey Fuller (ADF) and Phillips-Perron test statistics. The Augmented Dickey Fuller (ADF) developed by Dickey and Fuller (1979) showed that LnRGDP, LnRENC, LnLFE, LnCOE and LnEXCR were stationary at first differencing while LnGFCF was stationary at second differencing. On the other hand, the unit root result on Phillips-Perron showed that the entire series (including GFCF) was stationary at first differencing or integrated at order one i.e. I(1). This implies that the hypothesis of non-stationarity was rejected for all variables at their difference form. The result therefore justified the need to test for co integration. The reason for the discrepancy between ADF and PP coefficient on GFCF was explained by Phillip and Perron (1988) and Elliot, Rothenberg and Stock(1996) who opined that due to the poor size and power properties of ADF statistics, ADF coefficients are usually fairly larger than other conventional unit root tests. Hence, they are sometimes not reliable for small sample dataset as they tend to over reject the null hypotheses when it is true and accept the null hypothesis when it is false. This justifies the need to confirm the stationarity property of the series with the Phillips-Perron (PP) test.

Ordinary Least Squares (OLS) result

Table 1: Unit Root test result on the Variables

Series	ADF statistic	Critical values 1%	Critical values 5%	Order of Integration	Philips-Perron statistic	Critical values 1%	Critical values 5%	Order of Integration
LnRGDP	-3.787	-3.711	-2.981	I(1)	-3.787	-3.711	-2.981	I(1)
LnRENC	-6.786	-3.711	-2.981	I(1)	-6.860	-3.711	-2.981	I(1)
LnLFE	-5.321	-3.711	-2.981	I(1)	-5.446	-3.711	-2.981	I(1)
LnGFCF	-10.481	-3.737	-2.992	I(2)	-6.078	-3.711	-2.981	I(1)
LnCOE	-4.606	-3.711	-2.981	I(1)	-4.607	-3.711	-2.981	I(1)
LnEXCR	-4.918	-3.711	-2.981	I(1)	-4.917	-3.711	-2.981	I(1)

Source: Regression result (E-view version 7)

Result of the OLS regression is shown in Table 1.

Variable	Coefficient	Standard Error	t-statistics	prob.
Constant	13.8597	3.2985	4.2018	0.0004
LnRENC	0.9569	0.2202	4.3460	0.0003
LnLFE	1.4684	1.6243	0.9040	0.3758
LnGFCF	0.1588	0.0516	3.0793	0.0012
LnCOE	0.0684	0.1205	0.5677	0.5760
LnEXCR	0.0011	0.0003	3.9695	0.0006

R-squared =0.7769
Adjusted R-squared =0.7707
F-statistic = 179.72
Durbin Watson statistic = 1.773

Ln represents natural logarithm
Dependent Variable: LnRGDP

From Table 2, the estimate of 0.957 for LnRENC, 0.159 for LnGFCF and 0.001 for LnEXCR are statistically significant ($p < 0.05$). The estimates showed that renewable energy consumption per capita (LnRENC), gross fixed capital formation (LnGFCF) and exchange rate (LnEXCR) has direct relationships with real gross domestic product (LnRGDP). This corroborates apriori expectations. This further implies that a unit increase in LnREC, LnGFCF and LnEXCR will bring about an approximate increase of 0.957, 0.159 and 0.001percent increase in LnRGDP respectively. The estimate of 1.468 for LnLFE and 0.068 for LnCOE showed direct but statistically insignificant relationship with the dependent variable (LnRGDP).

The overall goodness of fits of the model was satisfactory with an r-squared (R^2) and adjusted r-squared of 0.768 and 0.763 respectively. The values indicated that the model explained about 77.7 percent to 77.1 percent variations in the dependent variable (LnRGDP) while the residue of 22.3 percent to 22.9 percent variation is attributed to error or other relevant factors with prominent impact which were not captured in the model. The overall performance of the estimates in the model is measured by the F-statistic. The estimate of F-statistic 179.72 showed that independent variables jointly had statistically significant impact on the dependent variable at 5 percent level of significance. Therefore, the overall parameter estimates for the model are considered to be statistically significant. The Durbin Watson (D.W) statistic of the model is 1.773. Following the rule of thumb of 1.8 = D.W = 2.2, the statistic explains that there is no presence of serial auto-correlation between or among the independent variables.

Although, CO_2 emissions is one of the environmental sustainability issues that have been acclaimed by international protocols such as the United Nations (UN) and World Health Organization (WHO) to have adverse effect on health of the productive workforce. However, result showed that emissions from the consumption of carbon monoxide (CO_2) per capita had direct impact on economic growth. This may be due to the fact that increase in carbon emissions (CO_2) per capita emanates from increased land use, urbanisation, forest resource exploration and increase in productive activities from economic units – consumers, producers, and the government.

Co-integration Test

Economically speaking, two variables are cointegrated if they have a long-run or an equilibrium relationship between them (Gujarati, 2004:822). The Johansen (1991) likelihood ratio test statistics, the trace and maximal eigenvalue test statistics, were utilised to determine the number of cointegrating vectors. The decision rule is to reject the null hypothesis if the probability (p-value) is less than 5percent (0.05). Otherwise, we do not reject.

The result of the cointegration is summarized in the Tables 3 and 4.

Table 3: Cointegration Rank Test (Trace) on the Series

Series: LnRGDPLnRENCLnLFELnGPFLnCOELnEXCR
Lags interval (in first differences): 1 to 1

Hypothesized No. of CE(s)	Eigenvalue	Hypothesized No. of CE(s)	Eigenvalue	Hypothesized No. of CE(s)
None *	0.913415	None *	0.913415	None *
At most 1 *	0.672118	At most 1 *	0.672118	At most 1 *
At most 2 *	0.609088	At most 2 *	0.609088	At most 2 *
At most 3 *	0.484173	At most 3 *	0.484173	At most 3 *
At most 4	0.404883	At most 4	0.404883	At most 4
At most 5	0.042372	At most 5	0.042372	At most 5

Trace test indicates 4 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

From the trace statistics (Table 3) and maximum eigenvalue statistics (Table 4), the first and second null hypotheses at 5% level of significance is rejection based on our decision rule that the probability value(s) is or are less than 5% (0.05). The trace statistics revealed that there is at least four cointegrating equation or vector among the variables while the maximum eigen revealed that there is at least one cointegrating equation. Therefore, there is a long-run relationship among the variables in the model. This therefore justified the need to test for causality.

Causality Test

To determine the direction of causation between renewable energy consumption and economic growth in Nigeria, the Granger causality test developed by Granger (1969) was employed. According to this test, a variable is said to Granger cause another variable if the past and present values of the former predict the latter. Result of the causality test is presented in Table 5.

Table 4:Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.913415	63.61236	40.07757	0.0000
At most 1	0.672118	28.99267	33.87687	0.1714
At most 2	0.609088	24.42111	27.58434	0.1207
At most 3	0.484173	17.21156	21.13162	0.1623
At most 4	0.404883	13.49391	14.26460	0.0659
At most 5	0.042372	1.125683	3.841466	0.2887

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Table 5: Pair-wise Granger Causality test on the series

Null Hypothesis:	Obs	F-Statistic	Prob.
LnRENC does not Granger Cause LnRGDP	26	1.94928	0.1673
LnRGDP does not Granger Cause LnRENC		6.75754	0.0054
LnGFCF does not Granger Cause LnRGDP	26	3.86435	0.0372
LnRGDP does not Granger Cause LnGFCF		15.5305	7.E-05
LnEXCR does not Granger Cause LnRGDP	26	5.25888	0.0141
LnRGDP does not Granger Cause LnEXCR		0.02757	0.9728
LnCOE does not Granger Cause LnRENC	26	4.15755	0.0301
LnRENC does not Granger Cause LnCOE		0.86565	0.4353
LnEXCR does not Granger Cause LnCOE	26	7.68985	0.0031
LnCOE does not Granger Cause LnEXCR		0.61085	0.5523

Source: E-view result

The result (Table 5) of the pairwise granger causality tests conducted on the variables shows that there exist a unidirectional causality running from LnRGDP to LnRENC, LnEXCR to LnRGDP, LnCoe to LnRENC and from LnEXCR to LnCOE while a bidirectional relationship runs from LnGFCF to LnRGDP and vice-versa. This result therefore shows that real gross domestic product granger causes renewable energy consumption, exchange rate granger causes real gross domestic product, CO2 emissions granger cause renewable energy consumption and exchange rate granger causes CO2 emissions but a bi-directional relationship runs between gross fixed capital formation and real gross domestic product and vice versa.

The implication of causation running from real gross domestic product to renewable energy consumption is that RGDP causes renewable energy consumption without feedback. This result supports the conservation hypothesis which posits that there is unidirectional causality from GDP to energy consumption. The conservation hypothesis implies that energy conservation policies such as emission reductions or energy efficiency improvements will not adversely affect economic growth (Payne, 2010). At the micro perspective, this result is indicative of the fact that individuals renewable energy consumption increases when output rises. Consequently, renewable energy consumption increases with improvement in the productive capacity of the economy. The bidirectional causation between gross fixed capital formation and real gross domestic product showed that past and current capital formation drives growth and vice versa. The means that expenditure to boost capital formation has a multiplier effect on national income and in return; this could increase investment demand in the private sector leading to increased capital formation.

5. Recommendations/ Conclusion

The paper investigates the relationship between renewable energy consumption and economic growth in Nigeria over the period 1990-2017.The casual link between the pairs of variables of interest were established using Granger casuality test while an Ordinary Least square (OLS) estimation technique was used to estimate the regression model. The result of the analysis indicates that renewable energy consumption has positive and significant impact on economic growth. Renewable energy consumption boosts economic growth. The pairwise granger causality tests showed a unidirectional causality running from real gross domestic product to renewable energy consumption. The implication of causation running from real gross domestic product to renewable energy consumption is that RGDP causes renewable energy consumption without feedback. This confirms the conservative growth hypothesis. This is unsurprising given the energy crisis currently bedeviling the country. To address this worrisome phenomenon, government should invest massively on renewable energy technologies and increase public awareness on deleterious energy practice and their environmental consequences. A renewable energy cost subsidy frameworks to serve as a powerful incentives for the deployment of renewable energy technologies such as the use of solar energy panels at homes and business places to power basic appliances and machineries as against relying heavily on premium motor spirit (fuel) and diesel consumption with attendant environmental hazards. Towards this end, government should encourage research and development in the renewable energy sector so that innovation can be fostered to tap into alternative energy sources such as solar, water, wind, biogas as against the use of fossil fuels.

REFERENCES

Adusei, A. (2011). Africa, renewable energy and economic development. Retrieved from http://www.africanexecutive.com/modules/magazine/articles.php?article=6215

Aminu, M. M. and Aminu M. F. (2015).Energy consumption and economic growth in Nigeria: A causality analysis. Journal of Economics and Sustainable Development www.iiste.org Vol.6, No.13, 2015

Amri, F. (2017).Intercourse across economic growth, trade and renewable energy consumption in developing and developed countries.Renewable and Sustainable Energy Reviews, 69, pp.527- 534.

Apergis, N, and Danuletiu, D. (2014). Renewable energy and economic growth: Evidence from the sign of panel long-run causality. International Journal of Energy Economics and Policy, 4(4): 578-587. Retrieved fromhttp://www.econjournals.com/index.php/ijeep/article/viewFile/879/515.

Apergis, N. and Payne, J. E. (2012). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34(3), pp.733-738.

Apergis, N. and Payne, J. E. (2014). Renewable energy, output, CO 2 emissions, and fossil fuel prices in Central America: evidence from a nonlinear panel smooth transition vector error correction model. Energy Economics, 42, pp.226-232.

Apergis, N. and Payne, J.E., (2011). The renewable energy consumption–growth nexus in Central America. Applied Energy, 88(1), pp.343-347.

Apergis, N., and Payne, J. (2011a). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34, 733-738. Retrieved from http://www.sciencedirect.com/science/article/pii/S0140988311000909

Apergis, N., Chang, T., Gupta, R. &Ziramba, E. (2016). Hydroelectricity consumption and economic growth nexus: Evidence from a panel of ten largest hydroelectricity consumers. Renewable and Sustainable Energy Reviews, 62, pp.318-325.

Bai, J., and Perron, P. (2003), "Computation and analysis of multiple structural change models," Journal of Applied Econometrics, 18, 1–22.

Central Bank of Nigeria (CBN) Statistical Bulletin 2016,

Chand, R. and Kaul, J. L. (1986) A note on the use of the Cobb–Douglas profit function. American Journal of AgriculturalEconomics.,68, 162–164.

Dickey, D.A. & Fuller, W.A. (1979).Distribution of the estimators for autoregressive series with a unit root.Journal of American Statistics Association, 74: 427-431.

Elliot, G. Rothenberg, T. J. and Stock, J. H. (1996).Efficient test for an autoregressive unit root.Econometrica. 64 (4): 813-836.

Engle, R. F. and Granger, C. W. J. (1987). Co-integration and error correlation: representation, estimation and testing. Econometrics, 55, 251-276.

Global Trends in Sustainable Energy Investment (2007): Analysis of trends and issues in the financing of renewable energy and energy Eefficiency in OECD and developing countries. unep.org. United Nations Environment Programme. 2007. p. 3.

Granger, C. W. J., (1969).Investigating causal relationships by econometric models and cross spectral methods.Econometrica, 17(2): 424-438.

Gujariti, D. N. (2004).Basic Econometrics (Fourth Edition).NewYork: McGrawHill

Halkos, G. E. and Tzeremes, N. G., (2014). The effect of electricity consumption from renewable sources on countries' economic growth levels: Evidence from advanced, emerging and developing economies. Renewable and Sustainable Energy Reviews, 39, pp.166-173.

Heidari, N., Pearce, J. M. (2016). A Review of greenhouse gas emission liabilities as the value of renewable energy for mitigating lawsuits for climate change related damages. Renewable and Sustainable Energy Reviews. 55C: 899–908. doi:10.1016/j.rser.2015.11.025

International Renewable Energy (IEA, 2017) Renewable energy review, Annual review 2017, Retrieved from http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/

International Energy Agency (IEA, 2014). Africa Energy Outlook: A focus on energy prospects in Sub-Saharan Africa. Retrieved from http://www.worldenergyoutlook.org/africa/

International Energy Agency (IEA, 2015a). WEO 2015 Electricity access database. Retrieved from http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase

International Energy Agency (IEA, 2015b). Energy and Climate Change. Retrieved from http://www.worldenergyoutlook.org/energyclimate

International Renewable Energy Agency (IRENA, 2015) Renewable energy and jobs, Annual review 2015, IRENA

Johansen, S. (1991). Estimation and hypothesis testing for cointegration vectors in Gausian vector autoregressive models, Econometrica, 59, 1551-1580.

Khobai, H. (2017): Does renewable energy consumption drive economic growth: Evidence from Granger-causality technique. https://2017.essa.org.za/fullpaper/essa_3526.pdf

Kiselev, U. N. and Orlov, M. V. (2010) Investigating a two-sector model of economic growth with the Cobb–Douglas production function.Moscow Univ. Comput.Math.Cybernet.,34, 66–73.

Lin, H. (2014). Renewable energy consumption and economic growth in nine OECD countries: Bounds test approach and causality analysis. The Scientific World Journal 2014. Retrieved from http://www.hindawi.com/journals/tswj/2014/919167/

Mao Lin Cheng and Yun Han(2013) A modified Cobb–Douglas production function model and its application MA Journal of Management Mathematics (2014) 25, 353–365

doi:10.1093/imaman/dpt012 Advance Access publication on 2 June 2013

Odularu, G.O. and Okonkwo, C. (2009): Does energy consumption contribute to economic performance? Empirical evidence from Nigeria: East-West Journal of Economics and Business, XII – 2009, No 2

Ogundipe, A. A. and Apata, A. (2013): Electricity consumption and economic growth in Nigeria. Journal of Business Management and Applied Economics 1(4), 12-24.

Ohler, A. and Fetters, I., (2014). The causal relationship between renewable electricity generation and GDP growth: A study of energy sources. Energy economics, 43, pp.125-139.

Omri, A., Mabrouk, N. B. and Sassi-Tmar, A., (2015).Modeling the causal linkages between nuclear energy, renewable energy and economic growth in developed and developing countries.Renewable and Sustainable Energy Reviews, 42, pp.1012-1022.

Payne, J. (2010). Survey of the international evidence on the causal relationship between energy consumption and growth.Journal of Economic Studies, 37(1), 53-95. Retrieved from http://www.emeraldinsight.com/journals.htm?issn=01443585&volume=37&issue=1&articleid=1834309&show=html

Pendharkar, P. C., Rodger, J. A. and Subramanian, G. H. (2008) An empirical study of the Cobb–Douglas production function properties of software development effort. Inform. Softw. Tech., 50, 322–328.

Phillips. P.C.B and Perron, P. (1988) Testing for a unit root in time series regression, Biometrika, 75 (2): 336-346.

Renewable Energy Policy Network for the 21st Century (2013). "Renewables global futures report 2013

Renewable Energy Policy Network for the 21st Century (2016) Global Status Report 2016

Renewable Energy Policy Network for the 21st Century (2010). Renewables 2010 Global Status Report.

Renewable Energy Policy Network for the 21st Century. (2015). Renewables 2015 global status report. Retrieved from http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf

Sebri, M. and Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO 2 emissions and trade openness: fresh evidence from BRICS countries. Renewable and Sustainable Energy Reviews, 39, pp.14-23.

United Nations Environment Program (UNEP, 2015). Global trends in renewable energy investment 2015.

VadMathiesen, & Brian; et al. (2015).Smart energy systems for coherent 100% renewable energy and transport solutions".Applied Energy. 145: 139–154.

Wickens, M. R. (1970) Estimation of the vintage Cobb–Douglas production function for the United States 1900–

1960. Rev. Econ. Stat., 52, 187–193.

World Bank (2008).World Development Indicators 2008. Washington, DC.

World Bank (2017).World Development Indicators 2017. Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/26447 License: CC BY 3.0 IGO."

Worldwatch Institute. (2005). Energy for development the potential role of renewable energy in meeting the millennium development goals. Retrieved from http://www.worldwatch.org/system/files/ren21-1.pdf

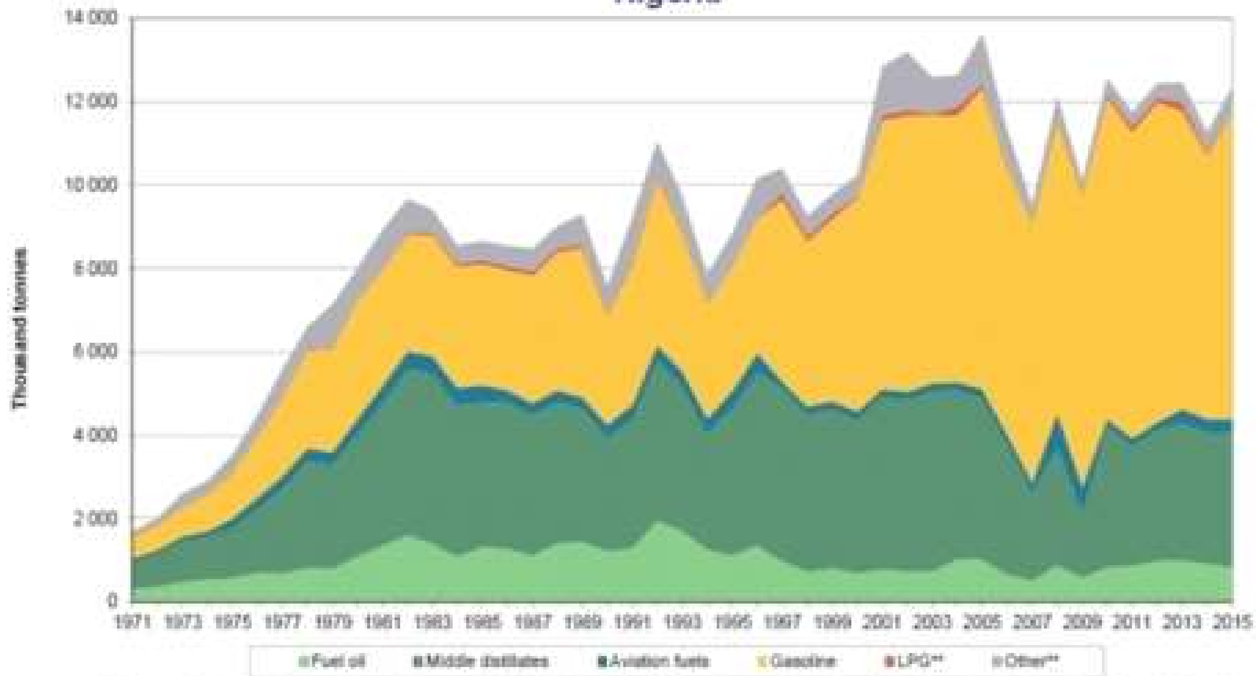
Wu, H. M. (2006) An empirical study on the economic growth in the guangdong province based on new C-D production. South China J. Econ., 7, 75–86.

Ziramba, E., 2013. Hydroelectricity consumption and economic growth nexus: time series experience of three African countries. European Scientific Journal, ESJ, 9(4), 25-50.

IEA Energy Statistics Statistics on the web: http://www.iea.org/statistics/

Consumption of oil products*

Nigeria

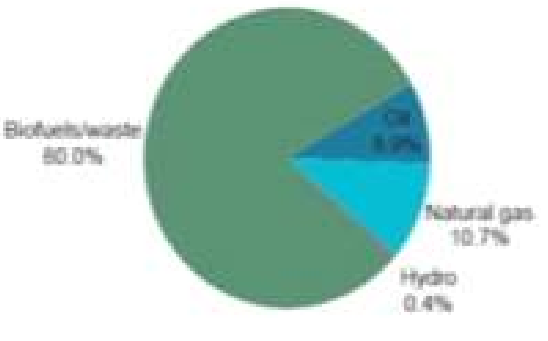


* Consumption includes international bunkers. ** LPG includes LPG, NGL, ethane and naphtha. Other also includes direct use of crude oil and other hydrocarbons.

IEA Energy Statistics Statistics on the web: http://www.iea.org/statistics/

Share of total primary energy supply* in 2015

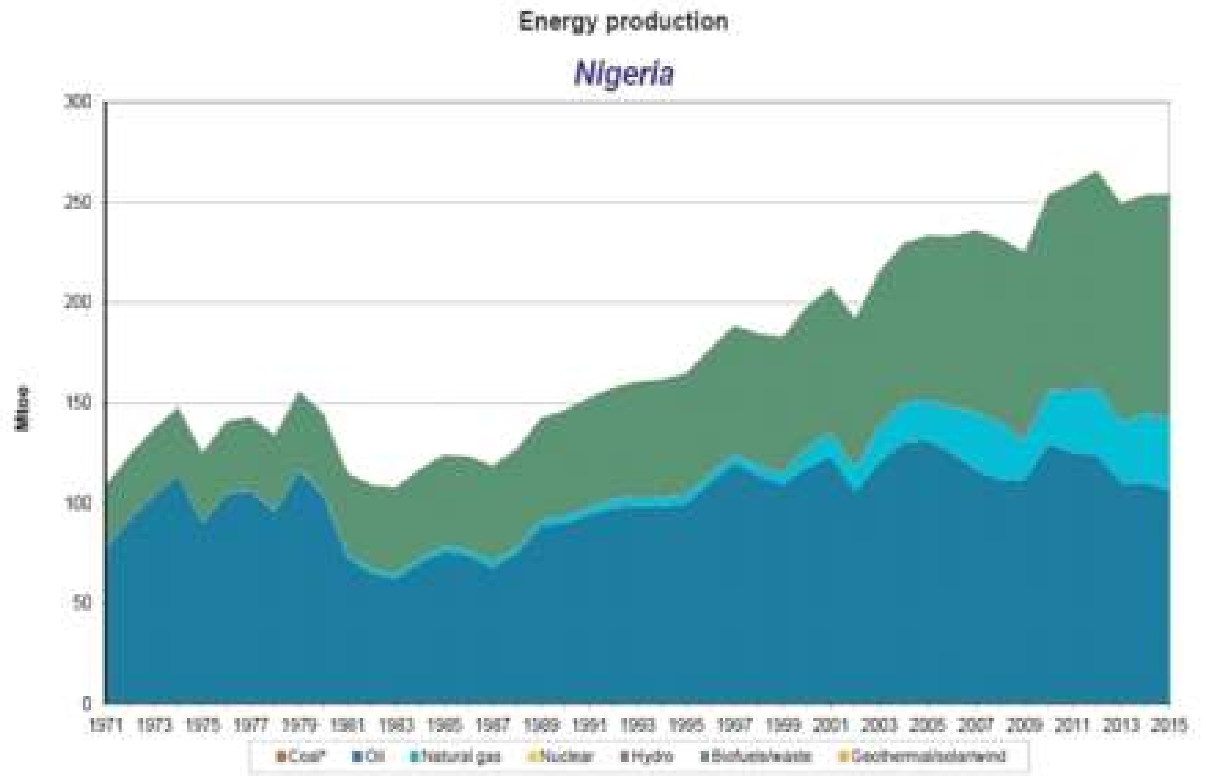
Nigeria



139 Mtoe

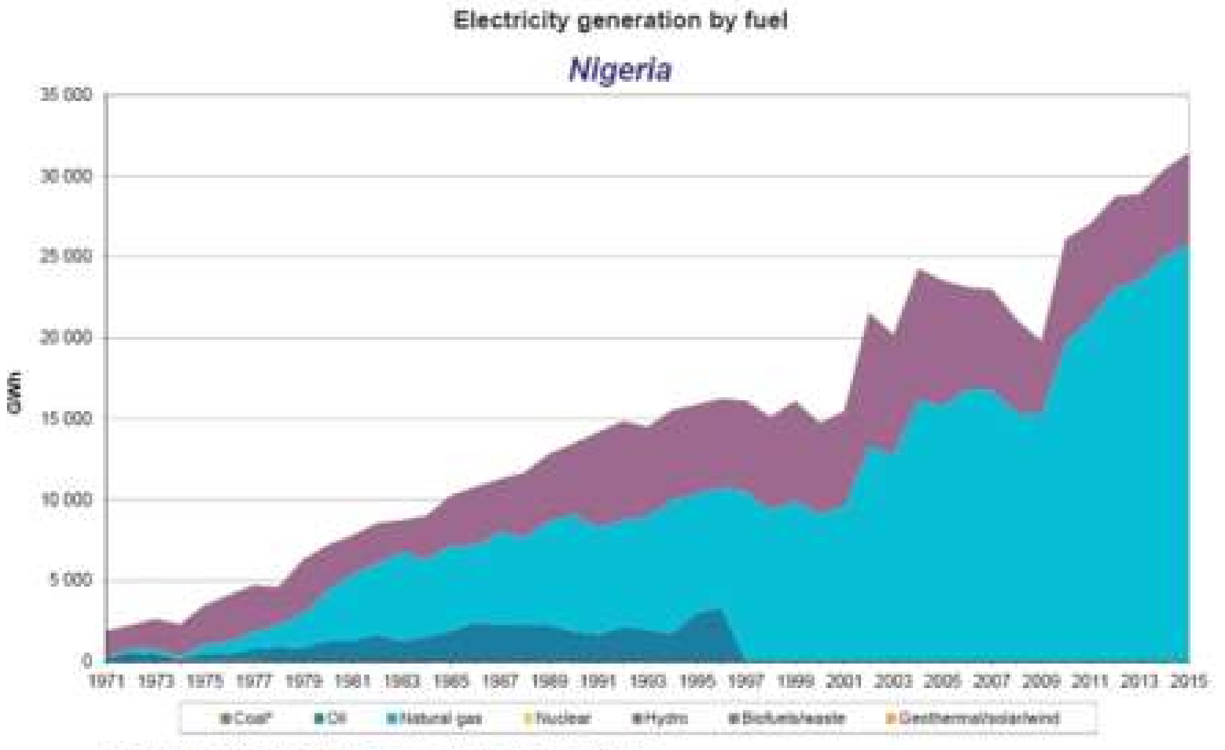
* Share of TPES excludes electricity trade. ** In this graph, peat and oil shale are aggregated with coal, when relevant.
Note: For presentational purposes, shares of under 0.1% are not included and consequently the total may not add up to 100%.

IEA Energy Statistics Statistics on the web: http://www.iea.org/statistics/



* In this graph, peat and oil shale are aggregated with coal, when relevant.

IEA Energy Statistics Statistics on the web: http://www.iea.org/statistics/



* In this graph, peat and oil shale are aggregated with coal, when relevant.

 For more detailed data, please consult our on-line data service at http://data.iea.org.