Energy Consumption Dynamics and Sustainable Growth in Nigeria

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Abstract**:** The paper empirically examined the energy consumption dynamics and sustainable growth in Nigeria using time series data spanning from 1980 to 2020. The major sources of data were from the World Development Index (WDI) and Central Bank of Nigeria (CBN) Statistical Bulletin various issues. In checking the stationary status of all the data engaged, the paper applied modified Ng-Perron unit root test to check the stationary properties of the series, and the results showed that GDP growth rate (GDPgr) was integrated at level (that is I(0)) while electricity consumption (ECNP), coal consumption (CCNP) and petroleum consumption (PCNP) were integrated of order one (that is, I (1)). This justified the application of Autoregressive Distributed Lag (ARDL) model of co-integration, whose results revealed that all series exhibited a stable long run relationship among them. The ARDL bound test result showed that the F-statistics was 4.35, which was greater than the upper bounds critical value of 3.79 at 5 percent level of significant. This further showed that the null hypothesis, which postulated that energy consumption dynamics has no significant impact on sustainable growth in Nigeria can be rejected. Based on the above findings, the paper submitted inter-alia that government should establish a renewable biomass as a supplement to energy sources in order to drive a sustainable growth in Nigeria.

Key Words: Energy Consumption, Economic Dynamism, Sustainable Growth, ARDL and Nigeria.

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1. Introduction

The importance of energy consumption as an engine for sustainable growth cannot be over-emphasized especially in developing economies such as Nigeria. There are varieties of sources of energy consumption as it does not necessarily come from a particular source. In Nigeria however, the most commonly sources of energy include among others electricity, crude oil, petroleum, natural gas, coal, briquette and renewable sources like wind, solar, geothermal and hydropower [1]. Many studies have investigated the link between energy consumption and growth and found a divergent result e.g. [2], [3], [4], [1] & [5]. Energy is a thrusting force behind any economic and industrial activity. Consequently, high grade energy resources will strengthen the impact of technology and create tremendous economic growth [6]. In other words, high grade resources can act as facilitator of technology while low grade resources can moisten the strength of new technology. It has been argued that the consumption of energy tracks with regards to per capita income is a key indicator of economic transformation [7].

In general, it can be stated that economies with higher per capita energy consumption are more developed than those with low level of energy consumption [8]. This is in a case of Nigeria where energy consumption has not been diversified because it has not been the main source of revenue for government. Further, it is obvious that Nigeria has placed so much interest on crude oil such that its demand for the product is relatively very high. The over reliance of crude oil in Nigeria is a major challenge because it has failed to diversify its energy industry in order to ensure a suitable energy mix [9]. However, the magnitude of energy available is dependent upon all other aspects of development. These include, a rise in foreign earnings emanated from exports of energy products, technological transfer in the process of exploration, production and marketing, increase in employment

in energy industries, improvement of workers welfare through increase in worker's salary and wages, improvement in infrastructure and socio-economic activities in the process of energy resource exploitation More explicitly, energy consumption is a driving force of economic activities of any nation, which invariably promotes sustainable growth. Today, Nigeria is seen as one of the greatest developing economies in Africa with highly endowed natural resources including potential energy resources. The figures below show the trend of energy consumption developments within 1980 to 2020.

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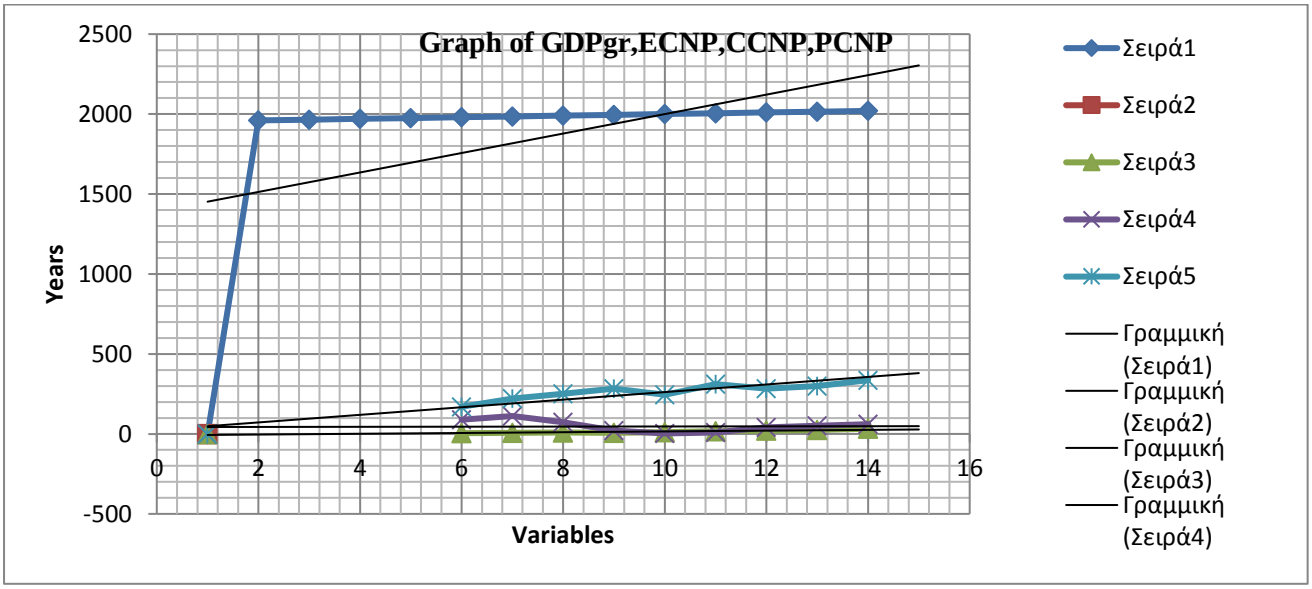
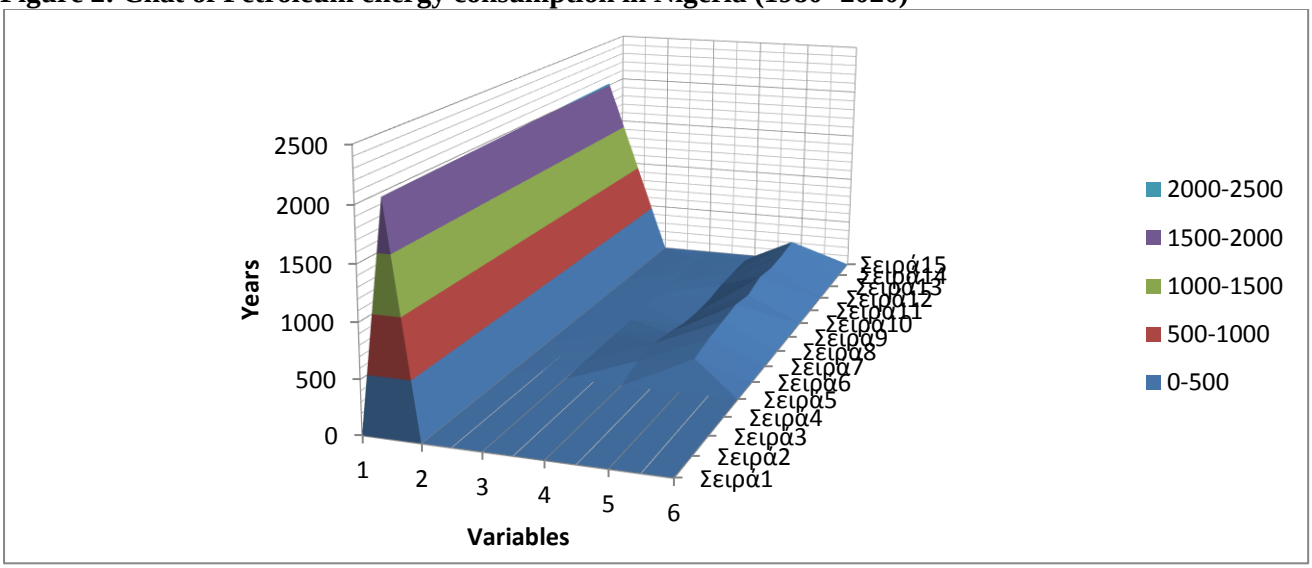
Figure 1: Graph of Petroleum energy consumption in Nigeria (1980 -2020)



Source: Authors' Design (Series 2 to 5 captures the variables)

Figure 2: Chat of Petroleum energy consumption in Nigeria (1980 -2020)



Source: Authors' Design (Series 4 to 13 captures the variables)

However, the depletion in energy consumption can have a detrimental effect on growth. Figures 1 shows that energy consumption has been fluctuating across the years, which signaled a redundant increase in the real sector. More worrisome is that electricity, which is a household affair, than coal and petroleum has not been consistent to address the epileptic power supply, as reflected in figure 1, while figure 2 reflects a chat demonstrating the current position of the energy

nexus. These inconsistencies have been grossly blamed by the provider of the power supply. According to past studies, e.g. [10], [11], [12] and [13], energy consumption has a favorable effect on growth in many countries, including Nigeria, but energy consumption has not been adequately managed, which as a consequence affected sustainable growth in Nigeria. Again, energy is important to achieving the interrelated economic, social and environmental aims of sustainable development, but available indices show that there are numerous challenges which mitigate adverse impacts on environment from energy activities [14], [15] and [16].

2 Literature Review

2.1 Theoretical Foundation

From the economic and social psychology perspective, there are numerous theories that explain energy and behavioural change. In this paper, few of them are as presented in table 1 below;

Table 1: Summary of Behavioural Models in Energy Literature

Theories	Key Authors	Major Contributions/Concepts
Rational Choice Theory	Elstar (1986) & Homans (1961).	Consumers weigh costs and benefits and choose the one with highest net profits.
Theory of Reasoned Actions.	Ajzen & Fishbein (1980).	Attitudes towards the behaviour and social norms lead to behavioural intensions
Theory of Planned Behaviour (TPB).	Ajzen (1991).	Attitudes, subjective norms and perceived behavioural control lead to behavioural intensions
Ecological Value Theory	Wiseman & Bogner (2003)	A set of ecological attitudes are incorporated to see the impact on personality and thus environmental related choices.
Value Believe Norm Theory (VBN).	Stern et al. (1999) & Stern (2000).	Values, believes and norms lead to pro-environmental behavior
Attitude Behaviour Context Model.	Stern & Oskamp (1987); Stern (2000).	Behaviour is an outcome of personal attitude and contextual factors.
Theory of Interpersonal Behaviour.	Triandis (1979).	Intentions and habits influence behaviour which are also affected by facilitating external conditions
Reasonable Person Model	Kaplain et al (2000)	Concurrence of self-interest as well as altruistic motives and personal control lead to behavioural intentions.

Source: Authors' Compilation, 2022

The above table x-rayed the behavioural models in energy literature, and highlighted the main theories, key proponents and their major contributions or concepts to economic literature.

2.2 Empirical Review

There are various evidences indicating some levels of relation between energy consumption and sustainable growth in many economies around the world. Most empirical literatures are dominated by conflicting evidences with respect to the nature of the relationship between energy consumption and growth. For instance, the recent work of [17], which investigated the dynamic interactions among energy consumption, economic growth, and trade in West Africa using the tri-variable Toda-Yamamoto model, has demonstrated that the positive impact of energy consumption on economic growth in West Africa showed a significant lag effect, and that energy consumption has a strong trade-dependent relationship to economic promotion, while trade opening and economic growth in West Africa were mutually reinforcing in the long run. [18] Documented that increased in crude oil price significantly led to a rise in energy consumption while Co_2 emissions exert negatively on growth in Venezuela, after investigating oil price, energy

consumption and carbon dioxide emissions using ARDL approach. But, [19] studied on energy consumption and economic growth using Cobb-Douglas production function based on ECM in China from 1978 to 1991 and from 1992 to 2016, and the results showed that total energy consumption has a one-way causal relationship with economic growths in China. The work of [20] studied on the relationship between economic growth and energy consumption in Pakistan, India, Bangladesh and Sri Lanka by using instrumental variable regression analysis. In the investigation process, data from energy consumption, economic growth, urban population, FDI and trade data were used from 1981-2015. Several outcomes were presented in this paper; increase in economic growth tends to increase in energy consumption, while a rise in trade has negative correlation with energy consumption as it introduces the energy efficient technology in those economies. Also, [21] examined the optimal electricity supply in Nigeria from 1980 to 2014 using partial adjustment model of electricity supply that is estimated in a fixed-effects OLS framework. The stationary properties of the series are explored using modified Ng-Perron unit root test. The results revealed that all the variables are I(1) process except electricity loss which is I(0). The ARDL Bound Testing approach to co-integration revealed an inconclusive evidence of long-run relationship among the variables of study. The finding indicates that actual electricity supply in Nigeria for the period under review has been less than the optimal level, except in 2014.

[22] Examined the energy-GDP relationship for six renewable sources (biomass, geothermal, hydroelectric, solar, waste and wind) using panel error correction model to determine their long-run and short-run relationships. They found that there is a positive long-run relationship between biomass, hydroelectric, waste and wind and GDP. With hydroelectricity and waste exhibiting bidirectional causality with GDP growth in the short-run, capital use Granger causes electricity consumption. [23] investigated the causal relationship between economic growth and three different forms of electricity which were residential, industrial, and others in Turkey using the Granger-Causality and VAR model, which revealed a bidirectional causal relationship between the mentioned variables. [4], the causal relationship between energy consumption and economic growth is considered for the period 1975-2010 in Nigeria, using secondary time-series data which was analyzed using co-integration and ordinary least square techniques. Their results of co-integration showed a long-run relationship among the variables used. It further showed that in the long run total energy consumption had a similar movement with economic growth except in the case of coal consumption. Their results showed that petroleum, electricity, and the aggregate energy consumption have significant and positive relationships with economic growth in Nigeria. According to [25], annual time series data was used taking 1970 to 2009 investigated relationships between electricity supply and economic development in Nigeria. The study employed ordinary least square estimated by using ECM which shows that PCGDP, lagged electricity supply, technology, and capital are the relevant variables that influence economic development in Nigeria.

Again, [26] empirically analyzed the dynamics of demand and supply of electricity in Nigeria, using RFRM and VECM approach. The analysis revealed that electricity demand is price inelastic while income is elastic. In a related study, [27] examined the causal long run relationship between electricity supply, fossil fuel consumption, carbon emissions and growth in Nigeria. Their study used ARDL and VECM to test their relationships and the bound result indicated the long run short run estimates that emissions is highly responsive to changes in GDP growth, fossil fuel consumption and electricity supply in Nigeria.

2.3 Research Hypothesis

$H_{0:}$ Energy consumption has no significant relationship with sustainable growth in Nigeria.
$H_{1:}$ Energy consumption has a significant relationship with sustainable growth in Nigeria.

3. Model Set Up

3.1 Model Specification

The study adopted a simple model relating the variables under investigation and employed a simple theoretical framework of the Cobb Douglas production function with constant returns to scale [28]. The model is as stated below;

$$Y = AK^{\alpha}L^{\beta} \quad (1)$$

Where; Y is the total production (output), L is the Labor input, K is capital input and A is the total factor productivity, α and β are the output

elasticity of labor and capital respectively. Incorporating the variables, the model in equation 2 was developed.

$$Y = f(E, C, P) \quad (2)$$

Where: Y is the growth rate of GDP, E represents the Electricity consumption, C denotes the Coal consumption while P captures the Petroleum consumption. However, this paper adopted the model developed by [4], and was modified to address the key objective of the paper. Here, energy consumption was decomposed into electricity, coal and petroleum consumption while sustainable growth was proxied by growth rate of GDP. Therefore, stating the model in its explicit form gives credit to equation (3) as shown below;

$$GDPgr = \alpha + \beta_1 ECNP + \beta_2 CCNP + \beta_3 PCNP + ut \quad (3)$$

Where all variables are as previously defined, β_1 to β_3 are the parameter estimate, while ut is the white noise. A priori, it is expected that all variables would be non-negative.

3.2 Variable Descriptions

The table below gives the full description of the variables under investigation.

Table 2: Description of Variables

Variables	Descriptions	Sources	Measurements
GDPgr	The growth rate of Gross Domestic Product (GDP) is the rate at which a nation's GDP changes or grows from one year to another. On the other hand, Nigeria GDP is the market value of all the goods and services produced in Nigeria over a given time period.	World Development Indicators, 2021.	Measured in percentage (constant 2000 US$)
ECNP	Electricity energy consumption is the form of energy consumption that uses electric energy. It is the actual energy demand made on existing electricity supply.	Central Bank of Nigeria Statistical Bulletin, 2021	As a percentage of GDP
CCNP	Coal energy consumption is the quantity of coal burned for the generation of electric power (in short tons) including fuel used for maintenance of standby service.	World Development Indicators, 2021	As a percentage of GDP
PCNP	Petroleum consumption is the rate at which an engine uses petrol, expressed in units such as miles per gallon or litres per kilometer.	World Development Indicators, 2021	As a percentage of GDP in KwH

Source: Authors' Compilation, 2022

3.3. Estimation Procedures

The paper first examined if the data were usable by testing the non-stationarity and the order of integration using modified Ng-Perron unit root test, which construct four statistics that are based upon the GLS detrained data Y^d_t [29]. These tests statistic are assumed to be modified forms of Philips and Perron (Z_α and Z_t). The choice of Ng-Perron test over the traditional (ADF, PP and KPSS) unit root tests is based on the fact that it is more suitable in dealing with a small group of data and efficient in its estimation. The Ng-Perron unit root test can therefore be specified as follows;

$$k = \sum_{r=2}^{r} \left({}^{d}_{yt-1} \right) / T^2 \quad (4)$$

Where k = GDPgr and represents the endogenous variable of our choice. Thus, the modified Ng-Perron statistics may then be written as;

$$MZ^d_\alpha = (T^{-1}(y^d_T)^2 - f_0)/(2_k) + ut \quad (5)$$

Where, MZ^d_t represent MZ_α (MSB); MSB^d denotes $(K/f_0)^{1/2}$ and ut is the white noise.

However, equation (5) tested the null hypothesis of a unit root against a trend stationary alternative. If the paper justifies that the series are stationary, further tests can be conducted. The paper also applied the Autoregressive Distributed Lag (ARDL) bounds testing procedure developed by [31] to examine the co integration relationship between electricity consumption, coal consumption, petroleum consumption and sustainable growth in

Nigeria. The ARDL approach has numerous advantages over other co integration methods. In addition, unlike the residual based test such as [32] and the maximum likelihood based test such as [33] and [34] for testing the long-run relationship, the ARDL approach does not require that the underlying series included in a model have same order of integration. Further, an ARDL is a least squares regression containing lags of the dependent and explanatory variables. ARDLs are usually denoted with the notation ARDL (p, q^1, …..k) where p is the number of lags of the dependent variable, q^1 is the number of lags of the first explanatory variable, and k is the number of lags of the k-th explanatory variable. In this paper, the ARDL model can be specified thus;

$$GDPgr_t = \alpha + \sum_{i=1}^{p} \lambda t GDPgr_{t-1} + \sum_{i=1}^{k} \lambda t ECNP_{t-1} \sum_{i=1}^{k} \lambda t CCNP_{t-1} + \sum_{i=1}^{k} \lambda t PCNP_{t-1} + u_t \quad (6)$$

Where; $GDPgr_{t-1}$ is the endogenously lag of growth rate of GDP, and $ECNP_{t-1}$, $CCNP_{t-1}$, $PCNP_{t-1}$ are the exogenously lag of electricity consumption, coal consumption and petroleum consumption respectively. Thus, the above ARDL specification showed that there is AR (3) since all the three regressors were lagged in the model. The paper used annual time series data ranging 1980 to 2020, sourced from World Development Indicators [30], while e-view 9.0 was used for the model estimation and analysis.

4. Presentation and Discussion of Findings

4.1 Unit Root Test

The stationary test of this paper showed that the series were integrated of different order, which justifies the application of ARDL approach. The Ng and Perron critical values at 1%, 5% and 10% were respectively – 3.62, - 2.94 and -2.61 which is significant compared to the Ng-Perron test statistics taking the absolute value only. See table 4 below;

Table 3: Summary of Ng and Perron Modified Unit Root Tests

V	Mza	MZt	MSB	MPT	O
GDPgr	-17.68	-2.96	0.17	1.41	I(0)
1%	-13.80*	-2.58*	0.17*	1.78*	
5%	-8.10**	-1.98**	0.23**	3.17**	
10%	-5.70**	-1.62**	0.28**	4.45**	
ECNP	-16.93	-2.58	0.17	1.48	I (1)
1%	-13.80*	-2.58*	0.17*	1.78*	
5%	-8.10**	-1.98**	0.23**	3.17**	
10%	-5.70**	-1.62**	0.28**	4.45**	
CCNP	-17.99	-2.99	0.17	1.37	I (1)
1%	-13.80*	-2.58*	0.17*	1.78*	
5%	-8.10**	-1.98**	0.23**	3.17**	
10%	-5.70**	-1.62**	0.28**	4.45**	
PCNP	-17.59	-2.96	0.17	1.41	I (1)
1%	-13.80*	-2.58*	0.17*	1.78*	
5%	-8.10**	-1.98**	0.23**	3.17**	
10%	-5.70**	-1.62**	0.28**	4.45**	

Source: Authors' Compilation, 2022.
* Stationary at 1%
** Not Stationary at 5% and 10%
V = Variables
O = Order

From table 4 above, the results indicated that all the variables were consistent with the presence of a unit root in each of the series investigated.

4.2 ARDL Co-integration Result

In this test, the null hypothesis stipulates that there is "a random walk" which was rejected at 0.05 critical values, indicating that electricity consumption (ECNP), coal consumption (CCNP) and petroleum consumption (PCNP) were co-integrated. However, in the ARDL regression output, the F*(Stat.) was 12.26, which suggested that there exists a long-run relationship among the series.

Having established the co integration relationship, the next step is to estimate the long-run coefficients by estimating an ARDL of order Γ and Π in the first

part of equation, which are the short-run dynamic elasticities of the model's convergence to long-run equilibrium. After the estimation, the result showed that the long-run overall model is well fitted as the exogenous variables explained over 57 percent movement in the endogenous variable. The long run coefficients showed that electricity consumption and petroleum consumption exhibited a positive and significant relationship with economic growth in Nigeria while coal consumption showed a negative relationship with growth though significant. This evidence coincides with the economic apriori expectations. This is so because, a 1.0 percent increase in one period lag of electricity consumption increases economic growth by 0.55 percent point. Also, a 1.0 percent rise in petroleum consumption causes economic growth to rise by 0.014 percent. Contrary to the above, a 1.0 percent increase in coal consumption reduces economic growth by 0.06 percent point. See table 5 below;

Table 4 ARDL Co integrating and Long Run Form

Included observations: 35

Cointegrating Form

Variables	Co- efficient	Std. Error	t-Statistic	Prob.
D(GDPGR(-1))	0.1397	0.1697	0.8229	0.4180
D(ECNP)	0.5553	0.8248	0.6732	0.5067
D(ECNP(-1))	-2.1046	1.0586	-1.9883	0.0574
D(ECNP(-2))	1.5709	0.8571	1.8328	0.0783
D(CCNP)	-0.0688	0.0262	-2.6197	0.0145
D(PCNP)	0.0143	0.0521	0.2759	0.7848
CointEq(-1)	-1.0748	0.2437	-4.4090	0.0002

Cointeq = GDPGR - (0.2397*ECNP -0.0641*CCNP + 0.0134*PCNP -0.1627)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECNP	0.239656	0.2313	1.0360	0.3097
CCNP	-0.064056	0.0232	-2.7575	0.0105
PCNP	0.013387	0.0478	0.2795	0.7820
C	-0.162670	11.3419	-0.0143	0.9887

Source: Estimated from E-view 9.0

Table 5: ARDL Bound Test:
Null Hypothesis: No long-run relationships exist

Dependent Variable: D(GDPGR)
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPGR(-1)	0.1144	0.1875	0.6101	0.5471
D(ECNP)	0.6703	0.8618	0.7778	0.4437
D(ECNP(-1))	-0.4853	0.9200	-0.5275	0.6023
D(ECNP(-2))	1.6728	0.9185	1.8210	0.0801
C	3.2086	13.942	0.2301	0.8198
ECNP(-1)	0.1684	0.2680	0.6285	0.5351
CCNP(-1)	-0.0548	0.0350	-1.5627	0.1302
PCNP(-1)	0.0010	0.0579	0.0175	0.9861
GDPGR(-1)	-1.0076	0.2706	-3.7230	0.0010

$R^2 = 0.57$; Adj $R^2 = 0.44$; F-test = 4.35; Prob. (F stat) = 0.0000; DW stat. = 1.97
Source: Computation from E-view 9.0

It can be inferred from table 5 above that the trace statistic showed the presence of one co-integrating equation at 0.05 critical value, which suggested that all the variables engaged in this study are co-integrated. This further showed that the null hypothesis of no co-integration should be rejected while the study upholds the alternative. The implication of this findings revealed that there is existence of a stable long run relationship between energy consumption (electricity, coal and petroleum) and sustainable growth in Nigeria.

4.3 ARDL Bound Test

In performing the bounds testing procedure, the study estimated equation (4) using the ARDL approach to co integration as shown below;

GDPgr = 3.208605 + 0.168495ECNP - 0.054839CCNP - 0.001016PCNP + ε_t (7)
(0.230124) (0.628541) (-1.562763) (0.017534)

All the values in parenthesis are the asymptotic t-values while all variables are as defined previously see table 6 above for ARDL bound test estimate. Under the ARDL approach, the calculated F-statistics are compared against the critical values, which were extracted from the work of [21]. The value of F-statistics when GDP growth rate is taken as endogenous variable is 4.359834, which is greater than the upper bounds critical value of 3.79 at 5 percent level of significant. Therefore, the null hypothesis of no co integration relationship can be rejected. This indicated that electricity consumption, coal consumption and petroleum consumption and sustainable growth in Nigeria exhibited a stable long-run relationship within the period under review.

Overall, the estimated model showed that the long-run result is well fitted as the exogenous variables explained over 57 percent movement in the endogenous variable. Specifically, the long run coefficients showed that electricity and petroleum consumption exhibited a positive and significant relationship with growth in Nigeria while coal consumption showed a negative relationship with growth though significant. This evidence coincides with the economic apriori expectations. This is so because, a 1.0 percent increase in one period lag of electricity consumption increases economic growth by 0.55 percent point. Also, a 1.0 percent rise in petroleum consumption causes economic growth to rise by 0.014 percent. Contrary to the above, a 1.0 percent increase in coal consumption reduces economic growth by 0.06 percent point.

Contrary to our expectation, the evidence documented here contradicts with the work of [19], who studied on energy consumption and economic growth using Cobb-Douglas production function based on ECM in China from 1978 to 1991 and from 1992 to 2016. The results showed that total energy consumption has a one-way causal relationship with economic growth in China. In line with our expectation, the evidence coincides with the work of [4], who examined the causal relationship between energy consumption and economic growth in Nigeria for the period 1975-2010 in Nigeria, using secondary time-series data which was analyzed using co-integration and ordinary least square techniques. Their results of co-integration showed a long-run relationship among the variables used. It further showed that in the long run total energy consumption had a similar movement with economic growth except in the case of coal consumption. Their results further showed that petroleum, electricity, and the aggregate energy consumption have significant and positive relationships with economic growth in Nigeria, which is the idea of this paper.

5. Conclusion and Recommendations

So far, this paper has shown that there is a link between energy consumption and sustainable growth in Nigeria. There is no doubt that evidences exist relating to the abundant resources of fossil fuels as well as renewable energy resources in Nigeria. In spite of this, Nigeria is confronted with inefficient usage of energy in the country, due mainly to a focus on one aspect of energy resources (that is; petroleum). Consequently, there is an urgent need to encourage the evolvement of an energy mix that would emphasize the conservation of energy resources in such a manner that enables a continued exportation for foreign earnings for as many years as possible, and diversify other sectors of the economy to preserve energy usage in Nigeria. Based on the findings, the paper is of the opinion that there should be establishment of a renewable biomass as a supplement to energy in order to drive a sustainable growth in Nigeria.

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Authors' Contribution:
Ogbonnaya Ikwor has organized and executed the methodological issues and analysis of results. Agbanike Tobechi handled the background of the entire paper and problem statement, Ohalete Precious has implemented the theoretical and empirical bases, while Otta Nkama and Timothy Enyinnaya were responsible for the Statistics, Graphical and Chat designs.