ADDRESSING THE ENERGY CONSUMPTION-ECONOMIC GROWTH NEXUS: THE NIGERIAN CASE

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ABSTRACT

Energy is critical to the survival and expansion of any economy. In Nigeria, energy consumption has been skewed towards household use, and below thresholds for sector-driven growth. The article updates, in time and methodology, those studies highlighting the significance of energy use for economic growth, using the Bound test and the Auto Regression Distributed Lag (ARDL) to establish the long- and short-run relationships between disaggregated energy consumption and economic growth in Nigeria from 1990 to 2016. The variables considered are real GDP, energy consumption decomposed into electricity and petroleum consumption, labour and capital. The findings show that, in the short and long run, petroleum consumption and labour have a significant positive relationship with GDP. Furthermore, the causality results show that feedback causation between economic growth and energy consumption as well as labour exists, while one-way causation runs from labour to economic growth. The study recommends diversification of the power-generation portfolio in the country, as this will improve energy consumption. Also, full deregulating policies in the energy sector would encourage industrialization and move energy demand towards increasingly productive uses. Finally, a strong institutional framework is needed to ensure energy policies achieve their objectives and targets.

Keywords: Energy Consumption, Economic Growth, Industrialization, Error Correction.

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1. A HISTORICAL PERSPECTIVE OF ENERGY CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA

A sustainable energy market is one that meets the present and future energy demands of its economy.[1] This point is a central concern to a thriving economy, given the role of energy in powering the various sectors of the economy.[2] The Nigerian energy market is dominated by petroleum and power industry.[3] The household sector is the highest determinant of its energy demand, as it accounts for more than 70 per cent of the country's energy consumption.[4] Other sectors, namely, industry, transport, commercial and public service also have a significant bearing on the country's energy demand.[5] The unstable energy and power supply through authorized grids in the country means that alternative energy resources, such as biomass and wood fuel, remain the most consumed energy resources.

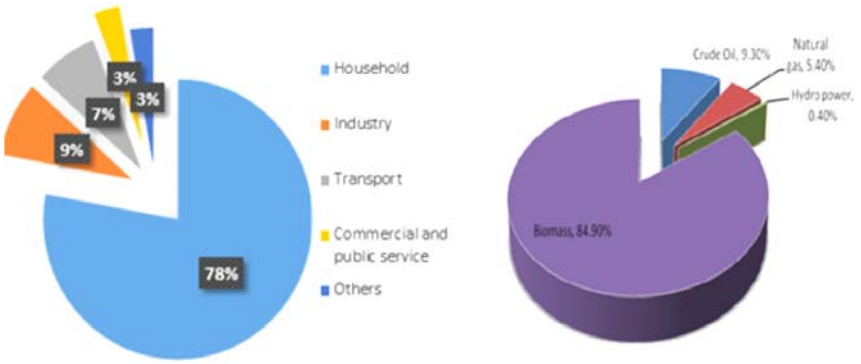

Fig. 1.1. Energy Demand
Source: Autours computation and data from EIA, 2015

1 Damilola Olawuyi, *Principles of Nigerian Environmental Law* (Afe Babalola University Press, 2015) 1-15.
2 Chukwueyem S. Rapu, Adeniyi O. Adenuga, Williams J. Kanya, Magnus O. Abeng, Peter D. Golit, Margaret J. Hilili, Ibrahim A. Uba, Emeka R. Ochu, *Analysis of the Energy Market Conditions in Nigeria* (October 2015 edn, Central Bank of Nigeria 2015) 55.
3 Lapegna A, "A Background on Nigeria and Its Oil" (*Aspeniaonline,* 15 December 2017) <http://www.aspeninstitute.it/aspenia-online/en/article/background-nigeria-and-its-oil> accessed 5 October 2018.
4 Damilola Olawuyi, *Extractives Industry Law in Africa* (Springer, 2018) 2-15.
5 Sunday Oyedepo, "Towards Achieving Energy for Sustainable Development in Nigeria" [2014] 34 *Renewable and Sustainable Energy Reviews* 255-272.

Nigeria is blessed with various energy resources.[6] With an estimated oil reserve of about 36.2 billion barrels, the country has the Africa largest crude oil reserve and the sixth largest in the world. Proven gas reserves are close to 5,000 billion cubic meters, while coal and lignite reserves are estimated to be 2.7 billion tons. Furthermore, the country's hydroelectricity sites have an estimated capacity of about 14,250 MW.

Despite Nigeria's endowment in energy resources, there has been a wide disparity in the country's energy demand to the supply over the last two decades, access to energy services has been continuously challenging.[7] The inability to realize the necessary efficiency in the energy sector has meant a continuous fall in the supply of energy and an inability to meet growing energy needs.[8] This problem affects the growth of the two energy markets, that is, petroleum and electricity.

Concerning the crises in the electricity market, the Power Holding Company of Nigeria (PHCN) and associated government agencies have failed in providing sufficient and reliable electricity supply to various sectors of the economy. The household sector is most affected, with the majority of the people using more of unconventional alternative energies such as wood fuel, charcoal, and so on, all of which create environmental hazards. Also, other sectors such as industrial, manufacturing, service and so on invest heavily in generation facilities to complement the unreliable power supplies from the national grid, affecting profitability, return on investment and productivity. The other energy crises the country is battling within the petroleum sector includes the chronic severe shortages in the supply of petroleum (PMS, diesel, and kerosene) products over the years, which is caused mainly by the failing refineries, corruption and geopolitical conflicts in the Niger Delta area.

This issue indeed has adverse effects on the country's economy and may have contributed mainly to the high level of poverty, paralysing industrial and commercial activities.[9] The relationship between energy

6 Obinna Ubani, "Determinants of the Dynamics of Electricity Consumption in Nigeria" (2013) 37 *OPEC Energy Review* 149-161.

7 Olusegun Odularu and Chinedu Okonkwo, "Does Energy Consumption Contribute to Economic Performance? Empirical Evidence From Nigeria" (*Academicjournals.org*, 2009) <https://academicjournals.org/journal/JEIF/article-abstract/59ED4EC1892> accessed 8 October 2018.

8 Damilola Olawuyi, *Extractives Industry Law in Africa* (Springer, 2018) 2-15.

9 Choji, Lucy Davou, *Energy Demand And Economic Growth In Nigeria* (Master's Thesis submitted at Eastern Mediterranean University 2018) 54-57.

consumption and economic growth is complex, inconclusive, and has heated much debate in research. Previous studies have shown that energy consumption has a positive relationship with economic growth.[10] However, when testing whether cause and effect could be implied, no causal relationship has been found between energy consumption and growth in Nigeria.[11] It is in light of the distinction between studies on the long-run relationship and those on causality that this article chooses to examine the datasets on energy consumption and economic growth for both type relationships at once. This article focuses on the interactions of economic growth with petroleum and electricity consumption.

The article attempts to expand the literature on the relationship between economic growth and energy consumption in Nigeria, with a specific focus on petroleum and electricity consumption. According to the International Energy Agency (IEA), electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.[12] In practice, total electric power consumption is equal to the total net electricity generation plus electricity imports minus electricity exports minus electricity distribution losses. A contextual discussion on petroleum is specific to this article and is motivated by the knowledge that a significant proportion of the current energy consumption in Nigeria is at the household level, which powers their transportation and electricity generation machines using petrol. Given the linkage between energy consumption and economic growth in Nigeria, this article demonstrates that the expansion and diversification of the power-generation portfolio in the country would improve energy consumption towards a better output. Also, policies to encourage industrialization would move energy demand towards increasingly productive uses.

The rest of the article is organized as follows: section 2 focuses on the relevant literature on energy consumption and economic growth

10 Clement Ighodaro, "Co Integration and Causality Relationship between Energy Consumption and Economic Growth: Further Empirical Evidence for Nigeria." [2010] 11(1) *Journal of Business Economics and Management,* 97-111.

11 Aminu Mustapha and Mustapha Fagge, "Energy Consumption and Economic Growth in Nigeria: A Causality Analysis" [2015] 6(13) *Journal of Economic and Sustainable Development*. 42-53.

12 IEA (2014).

in Nigeria. Section 3 provides data on the short- and long-term implications of the energy consumption-economic growth nexus in Nigeria under current models. Section 4 discusses the need for energy diversification to boost economic productivity in Nigeria. Section 5 offers policy recommendations on how to better address the energy consumption-economic growth nexus in policy formulation and implementation in Nigeria. Section 6 is the conclusion.

2. ENERGY CONSUMPTION AND ECONOMIC GROWTH NEXUS: A REVIEW OF THE LITERATURE

Images of energy-powered industrial revolutions around the globe emphasize the role of energy in economic growth. At the same time, a rapidly growing labour force became an engine of industrial growth, against Malthusian predictions. Yet population and other pressures on scarce resources such as energy remain.

Energy remained relegated, in the earlier neoclassical growth sense, to an intermediate input into production, one that is assumed given due to its finite non-renewable nature. The introduction of natural resources into the growth framework depends on whether technical or institutional conditions drive their sustainability.[13] *Technical conditions* include a mix between renewable and non-renewable resources, the initial stock of natural resources and the elasticity of substitution between capital and various energy inputs. This is also theoretically related to demand elasticity of energy that describes the degree of substitution with other inputs into the production process. Consequently, how energy impacts on growth depends on its use relative to other inputs into the production process. This informs part of the bulk of literature within the growth discourse, on energy efficiency and economic output. Furthermore, energy inputs and efficiency varies by sector, enabling a sectoral discussion of energy and economic growth.

Institutional conditions include market structure (competitive versus no perfect structures), property rights and values driving sustainability in the sense of non-exhaustion for future generations. Cumulative

13 David Ian Stern and Cutler J. Cleveland, "Energy and Economic Growth" [2004] 4(10) Rensseraer Working Paper in Economics <https://www.researchgate.net/publication/24125107_Energy_and_Economic_Growth> accessed 9 October 2018. 2-43.

causation could be inferred between energy and economic growth as implied by the strand of literature on the determinants of energy demand. An earlier study of energy demand has examined the structure of demand for energy in the OECD and some developing countries.[14] For both developed and developing countries, the price of energy and income has a significant effect on demand in the long run for residential, industrial and transport sectors. Implicitly, poor socio-economic conditions reduce energy consumption, which in turn deters economic growth, and, ultimately, socio-economic conditions.

The idea that resources such as energy enhance growth has recurred throughout literature across time and space. For example, the relationship between energy consumption and economic growth of Pakistan from 1973 to 2006 has been thoroughly examined.[15] The results of ordinary least squares tests in the country show a positive relationship between GDP and energy consumption. In studies on the Nigerian economy, the nexus between energy consumption and Nigeria's economic growth for the period of 1975 to 2010, has been analysed using cointegration and ordinary least square techniques.[16] The study revealed that petroleum, electricity and aggregate energy consumption have a significant and positive relationship with economic growth in Nigeria. However, gas consumption, although positive, does not significantly affect economic growth. The impact of coal was negative though significant.

Through a similar technique, another study spanning 1970 to 2005, found a positive relationship between energy consumption and economic growth.[17] The study shows that energy efficiency in Nigeria has been on the decrease, it was stated that the major proportion of energy consumed in Nigeria is by households, implying reduced opportunities at the industrial level.

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14 Robert Pindyck, *The Structure Of World Energy Demand* (MIT Press, 1979). 309-317.

15 Ahmad Najid, Muhamed Hayat, Muhamed luqman, Naqvi Hammad, "Energy Consumption and Economic Growth: Evidence from Pakistan" (2012) *Australian Journal of Business and Management Research*, 9-14.

16 Adegbemi Onakoya, Olalekan Jimi-Salami, Babatunde Odedairo, "Energy Consumption and Nigeria Economic Growth" (2013). 9(4)*European Scientific Journal,* 25-38.

17 Odularu Gbadebo, "Does Energy Consumption contribute to Energy Consumption in Nigeria? Empirical Evidence from Nigeria" (2009) 12(2), *Journal of Economics and Business,* 43-78.

Other studies have found a unidirectional causation running from only economic growth to consumption, and that energy consumption does not influence economic activity; it is the other way round.[18] Alternatively, a unidirectional causality runs from energy consumption to economic growth in the Eastern and Southern African Sub-region.[19]

Similarly, using panel data techniques to investigate the long-run relationship between energy consumption and GDP for a panel of 19 African countries (COMESA) based on annual data for the period, results indicate that long-run and short-run causality is unidirectional, running from energy consumption to GDP.[20] Similarly, studies suggest a unidirectional causality between electricity consumption and economic growth, domestic crude oil production and economic growth, as well as between gas utilization and economic growth in Nigeria.[21] Furthermore, there is a positive relationship between electricity consumption and real GDP and the inverse between fuel price and real GDP.[22]

Other studies such as on the United States find no causation between energy and economic growth.[23] However, in the Central and West African sub-regions, the same study observed that causality between energy consumption and economic growth was absent.[24] Using the vector autoregression analysis of energy consumption and economic growth spanning 1980 to 2011, Aminu and Aminu (2015) find no causal relationship between economic growth and energy consumption.

18 John Kraft and Arthur Kraft "On the Relationship between Energy and GNP" [1978] 3(2) *The Journal of Energy and Development*, 401-403.

19 Chali Nondo, Mulugeta Kahsai, and Peter Schaeffer, "Energy Consumption and Economic Growth: Evidence from Comesa Countries" (2012) 39(1) *Southern Economic Review.*

20 Fatai Oyeniran, "Energy Consumption and Economic Growth Nexus: Panel Co-Integration and Causality Tests for Sub-Saharan Africa" [2014] 25(4) *Journal of Energy in Southern Africa*, 93-100.

21 Clement Ighodaro, "Co Integration and Causality Relationship between Energy Consumption and Economic Growth: Further Empirical Evidence for Nigeria" [2010] 11(1) *Journal of Business Economics and Management*. 97-111.

22 Lucy Davou Choji, "Energy Demand and Economic Growth in Nigeria" (Masters, Eastern Mediterranean University 2018), 54-57.

23 Akarca A.T and Long T.V "One the Relationship between Energy and GNP: a Re-examination" [1980] 5 *J Energy and Develop*., 326-331.

24 Chali Nondo,Mulugeta Kahsai, and Peter Schaeffer, "Energy Consumption and Economic Growth: Evidence from COMESA Countries" [2012] 39(1) *Southern Economic Review*.

Energy consumption had a bidirectional relationship with GDP growth and directly contributed significantly to economic development in Nigeria.[25] The authors found a unidirectional causality from gas consumption to GDP in the short-run and bidirectional causality between the variable in the long-run.[26] Although no causality was found in either direction between oil consumption and GDP in the short-run, a unidirectional causality from oil consumption to GDP was found in the long run.

The reviewed literature presents evidence on the relationship between energy consumption and economic growth, but the result is inconclusive. While there is mostly a positive relationship between energy consumption and economic growth, the direction is mostly inconsistent and mixed.[27] Observably, the sample country matters in determining the direction of causality as well as the type of energy variables considered.

3. DOES ENERGY CONSUMPTION AFFECT NIGERIAN GROWTH?

Neoclassical models, such as the Solow growth model, consider capital and labour as the primary factors of production but assume energy has a subsumed role.[28] While ecological-economic theories emphasize the role of energy and take as given other classical inputs such as capital and labour,[29] it is possible to benefit from an understanding of the two

25 Antai Sylvester, Udo Benedict and Ikpe Kingsley "A VAR Analysis of the Relationship between Energy Consumption and Economic Growth in Nigeria"[2016] 6(12) *Journal of Economics and Sustainable Development*. <https://www.iiste.org/Journals/index.php/JEDS/article/view/23636/24074> accessed 12 October 2018.

26 Orhewere. B. and Henry M. "Energy Consumption and Economic Growth in Nigeria" [2011] 9(1). *Journal of Research in National Development*. 153-165.

27 Obinna Ubani, "Determinants of the Dynamics of Electricity Consumption in Nigeria" (2013) 37 *OPEC Energy Review*.

28 David Ian Stern and Cutler J. Cleveland, "Energy and Economic Growth" (2004) 0410 Rensseraer Working Papper in Economics <https://www.researchgate.net/publication/24125107_Energy_and_Economic_Growth> accessed 9 October 2018.

29 About Azzouni, "Institutional Frameworks and the Development of Sustainable Power and Energy Sectors in Resource-Rich Developing Countries" (*Energy.duke.edu*, 2018) <https://energy.duke.edu/events/institutional-frameworks-and-development-sustainable-power-and-energy-sectors-resource-rich> accessed 8 October 2018.

frameworks by adopting a production function approach, which incorporates capital and labour inputs as well as energy considered in a growth model. Hence, we retain that energy consumption affects economic growth in Nigeria predominantly through technical conditions, or as a mix of renewable and non-renewable resources. A conceptualization that energy affects growth through its stock shows

GDP = f (A, L, K,) . . . (1)

Where L is labour, K is capital, and A is technological progress, which explains energy consumption. This energy consumption is decomposed into electric and petroleum consumption. This is to capture the dynamics in the two key energy markets (petroleum and power sector) and their distinct relationship with economic growth in Nigeria. From the model, GDP is explained through petroleum consumption, electricity consumption, labour and capital. The model is explicitly stated below. The level of technology, A, scales up various resource inputs into the production process, which this article disaggregates into electricity and petroleum measured by their consumption, so that:

$$GDP_t = F(PEC, ELC_t, LAB_t, CAP_t) \quad \ldots (2)$$

$$GDP_t = \beta_0 + \sum_{t=1}^{k-1} \beta_1 PEC_t + \sum_{t=1}^{k-1} \beta_1 ELC_t + \sum_{t=1}^{k-1} \beta_2 LAB_t + \sum_{t=1}^{k-1} \beta_3 CAP_t \quad \ldots (3)$$

Where

GDP_t represents Gross Domestic Product;
ELC_t is Electricity Consumption
PEC_t means Petroleum Consumption;
LAB_t is Labour
CAP refers to CAPITAL and U_t is the Error term.

The Bound test and autoregression distributed lag (ARDL) was used in estimating the short-run and the long-run dynamics of the model. Secondary data (from 1981 to 2016) was collected from the international energy agency (IEA) and the World Bank website. Estimation on time series data demands that the series be stationary; hence, the Augmented Dickey and Fuller (1979) and Phillip Perron tests were employed to determine unit root. The disparities in the order of integration found in stationarity results of Table 1 necessitates the Bound testing and ARDL estimation of the model. The Bound test

is used to test for the long-run relationship while the short-run dynamics was seen through the ARDL short-run estimate. Furthermore, the Granger causality test determined the causal relationships among the variables; here we considered total energy consumption, economic growth, labour and capital.

Table 1. Results of Unit Root Test

	Augmented Dickey-Fuller (ADF)		Phillips Perron		Order of Integration
Variable	Levels	1st dif.	Levels	1st diff.	
GDP	-5.51*	-10.63*	-5.50*	-20.27*	1(0)
PEC	-5.98*	-7.25*	-5.99*	-21.89*	1(0)
ELC	-5.97*	-7.84*	-6.00*	-14.64*	1(0)
TEC	-1.99	-1.52	-2.12	-9.15*	1(1)
LAB	-2.73	-9.54*	-2.58	-9.97*	1(1)
CAP	-3.32*	-11.25*	-5.32*	-14.75*	1(0)

Notes: * Denotes rejection of hypothesis at 5% significance level ** denotes rejection of hypothesis at 10% significance level.
Source: Authors' computation.

4. SHORT- AND LONG-RUN IMPACT OF ENERGY CONSUMPTION ON THE NIGERIAN ECONOMY

The article proceeds with diagnostic tests for the stationarity status of the selected time series data to determine their order of integration. The two criteria applied, that is, the Augmented Dickey-Fuller (ADF) and Philip Peron unit root test show that variables such as gross domestic product (GDP), petroleum consumption (PEC), electricity consumption (ELC), and Gross capital formation (CAP) are found stationary at levels, while variables such as total energy consumption (TEC), and Labour (LAB) were found stationary after first difference.

The stationarity test depicts that the variables are not the same order of integration. Hence the auto-regression distributed lag (ARDL) model is the best for the model. Determination of the lag length is crucial for accuracy in the ARDL method. We select four lags based on AIC and SC criterion. Furthermore, the cointegration Bound test checked for a long-run relationship in the model; this is shown in Table 2.

Table 2: Results of Bound Test

F-statistic	K	
6.934525	4	
Critical Value Bounds		
Significance Level	Lower Bound	Upper Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.74	5.06

Source: Author's computation

Table 2 indicates F-statistics (5.03) which is calculated at k = 4 (number of independent variables) exceeds the upper critical value at 10 per cent, 5 per cent, and 1 per cent significance level, respectively. We reject the null hypothesis and accept the alternative that there is a long run relationship among the variables in the model. Table 3 further reveal the long-run coefficient of the models.

Table 3: Long Run Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable = ΔGDP				
PEC	1.20	0.46	2.59	0.01
ELC	0.19	0.25	0.75	0.46
LAB	7.44	3.41	2.18	0.04
CAP	0.37	0.25	1.47	0.15
C	-0.03	0.08	-0.35	0.73

Notes: * Denotes rejection of hypothesis at 0.05 significant level ** denote rejection of hypothesis at 0.10 significant level
Source: Authors' computation.

The long-run estimates of the ARDL model are shown in Table 3. The results reveal that petroleum consumption (PEC) and labour (LAB) have a significant positive long-run relationship with the gross domestic product (GDP). While no significant long-run relationship between

electricity consumption and economic growth was found. The short-run dynamics of the model is revealed in Table 4.

The short-run estimates revealed in Table 4 include the error correction estimate, which is significant, followed by the short run coefficients of the explanatory variables. The result shows that petroleum consumption (at levels) and labour (at 2 lagged periods) both have a positive relationship with economic growth at 5 per cent significance level, while electricity and capital were found statistically insignificant.

Table 4. Short Run Estimate

Variable	Co-efficient	Std. Error	t-Statistic	Prob.
Dependent Variable = ΔGDP				
ECM (-1)	-1.21	0.17	-7.04	0.00
ΔPEC	1.45	0.55	2.61	0.02
ΔELC	0.23	0.31	0.74	0.46
ΔLAB	-3.91	5.03	-0.78	0.45
ΔLAB (-1)	1.21	5.00	0.24	0.81
ΔLAB (-2)	-10.82	4.79	-2.26	0.03
ΔCAP	0.16	0.22	0.73	0.48
ECM = GDP - (1.20*PEC + 0.19*ELC + 7.44*LAB + 0.37*CAP -0.03)				

Diagnostic Tests			
R-squared:	0.66	Serial Correlation LM Test:	2.700069(0.2592)
F-statistic:	4.723(0.001)	Heteroscedasticity Test:	15.41887(0.0801)
Akaike info criterion:	0.590422	Normality Test (Jarque-Berra):	1.114(0.447)
Schwarz criterion:	1.048465		

Notes: *denote rejection of hypothesis at 0.05 significant level ** denote rejection of hypothesis at 0.10 significant level
Source: Authors' computation.

The short and long run results imply that petroleum consumption positively correlates with economic growth, while electricity consumption does not explain growth. A possible explanation for this result is the dependence of the economy on petroleum products. Furthermore, the inadequate electricity supply limits its contribution to output. Thus, most of the energy consumption in Nigeria is at the household level, deterring growth.[30] The results also confirm that labour positively correlates with the gross domestic product both in the short and long run, pointing to the key role the household sector plays in shaping the economy.

In the diagnostic tests, the joint significance of all the independent variables to the Real GDP is revealed by the F-statistics, the result shows that the explanatory variables are jointly significant to GDP. Also, the goodness of fit ($R^2 = 0.73$) that is, the coefficient of determination, shows that the independent variables cumulatively explain up to 73 per cent of the GDP equation. This implies that the RGDP model is fit and the explanatory variables are appropriately selected. To further check for the efficiency of the model and ensure they are in line with the white noise assumption, residual-based tests such as Breusch-Godfrey L-M test for autocorrelation, Jacqui Berra test for normality and Breusch-Pegan Godfrey test for Heteroskedasticity were conducted for the model. The serial correlation result reveals that the absence of autocorrelation among the variables, the Heteroscedasticity Test, shows that residual values are not correlated with the error term.

4. CAUSALITY ANALYSIS

Table 5 reveals the Granger causality result between total energy consumption, labour and capital and gross domestic product (GDP).

The results depict a bidirectional relationship between total energy consumption and gross domestic product, similar to results from Onakoya *et al* 2013. Similarly, labour and gross domestic product have a bidirectional causal relation. Furthermore, the result shows a one-way causation from labour to petroleum consumption. The causality implies a feedback impact between petroleum consumption and

30 See Gbadebo and Okonkwo (2009).

economic growth, also from labour and economic growth. This result aligns with proponents of feedback energy and growth causation.[31]

Table 5: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
TCON does not Granger Cause GDP		6.36803	0.0013*
GDP does not Granger Cause TCON		5.04878	0.0103*
LAB does not Granger Cause GDP		2.56320	0.0944*
* GDP does not Granger Cause LAB+		0.33704	0.0045*
CAP does not Granger Cause GDP		0.90055	0.4174
GDP does not Granger Cause CAP		2.26044	0.1224
LAB does not Granger Cause TCON		3.31071	0.0507*
TCON does not Granger Cause LAB		2.10244	0.1404
CAP does not Granger Cause TCON		1.45304	0.2504
TCON does not Granger Cause CAP		1.52409	0.2348
CAP does not Granger Cause LAB		0.47987	0.6237
LAB does not Granger Cause CAP		1.31826	0.2832

* denote rejection of hypothesis at 0.05 significant level ** denote rejection of hypothesis at 0.10 significant level
Source: Author's computation

5. RECOMMENDATIONS AND POLICY PRESCRIPTIONS

This article presented the relationship between economic growth and energy consumption disaggregated into petroleum and electricity consumption using the ARDL approach. The Bound test and long-run estimate suggest a long-run relationship between economic growth and petroleum as well as labour. Similarly, the short-run estimation suggests that both petroleum consumption and labour have a significant positive relationship with economic growth, while electricity consumption is not significant. The country's reliance on petroleum

31 Yemane Wolde-Rufael, "Energy Demand and Economic Growth: The Africa Experience" (2018) 28(8) *Journal of Policy Modelling* 891-903.

resources, which is the major source of revenue, explains why economic growth is positively affected by petroleum resources. Indeed, as living conditions improve with income, so does electricity consumption. Electricity, which is mostly consumed by the household, has no significant bearing on economic growth over the years, implying any productive effect their consumption may have on the economy is not visible through electricity use.

The causality result reveals that feedback causation runs from economic growth to total energy consumption and labour, respectively, and one-way causation from labour to economic growth. This result depicts the key role the household sector plays in shaping energy demands in Nigeria and economic growth. Based on the foregoing, the article makes some recommendations as indicated in the following sub-sections.

5.1 Diversification of the Power-Generation

To meet the growing energy demand in Nigeria, there is a need to look for alternative sources of energy that would guarantee a sustainable flow. Nigeria is endowed with renewable energy resources. For example, an average of the country's solar radiation is 7.0kWh/m^2/day.[32]

If well harnessed, this can generate 27 times the country's total energy generated by the conventional energy sources. Renewable energy sources like solar, wind and biomass should be harnessed to compliment the conventional energy sources in power generation to help meet the massive electricity demand in the country.

Desired power generation and supply goals can only be achieved if renewable energy generation is given more emphasis as the country is endowed with abundant renewable energy sources. Policies that will promote development and expand the supply of renewable energy resources should be implemented to fully explore other energy options. There is also a need to increase research and development in the energy sector. This will foster innovations in the energy sector, improve services, and drive policy reforms targeted towards the expansion and diversification of the power-generation portfolio in the country and

32 Theo Chineke, Ita Aina and S. Jagtap, "Solar Radiation Data Base for Nigeria" (1999) Discovery and Innovation. <https://www.researchgate.net/publication/271348487_Solar_Radiation_Data_Base_for_Nigeria/download> accessed 9 October 2018.

help provide efficient energy sources. In the absence of efficient energy generation identified in this article, full deregulation the power sub-sector of the economy to private sector participation in the generation, transmission and distribution of electricity would improve energy consumption.

5.2 Full Deregulation of the Power Sub-Sector

The huge deficit in energy demand requires full deregulation of the power sector of the economy to encourage more investors and private participation. Although in recent times, the power industry has been partially deregulated, there is a need to fully deregulate it to allow full participation of the private sector in the generation, transmission and distribution of power supply.

Deregulation drives competition and improves energy consumption under effective market structure, which requires the establishment of detailed market rules, design and regulation.[33] In a regulated market, pricing policies are fixed by the government and the consumer has no say in it. Most consumers do not care about the rates and usage. In the deregulated electricity market, however, consumers can choose from a variety of options according to their needs and as per their choice and budget. This will also encourage competition, which will be of great benefit to consumers. The benefits derivable from this include lower electricity prices, increase choice and customer awareness, and productivity, innovation, and better services.

5.3 Strong Institutional Framework

One of the impediments to achieving the desired growth in the energy sector is week institution. Similar to many sub-Saharan countries, Nigeria lacks robust institutional frameworks,[34] and this has affected the development and delivery of services in the energy sector. A robust institutional framework is essential to the development of sustainable energy system and services. Regulatory agencies should ensure that

33 Nigeria Electricity Hub, "Electricity Deregulation: Where Are We?" (2017) <http://www.nigeriaelectricityhub.com/2017/05/05/electricity-deregulation-where-are-we/> accessed 9 October 2018.

34 BRIDGES AFRICA (2018) 5 <https://www.ictsd.org/bridges-news/bridges-africa/overview> accessed 9 October 2018.

energy policies are well executed and monitored.[35] A strong institutional framework should protect the interests of energy consumers and producers in Nigeria, attract private investment and provide a foundation for sustainable energy production, which is vital for the country's economic growth.

6. CONCLUSION

This article uses the Bound test and the Auto regression Distributed Lag (ARDL) to establish the long- and short-run relationships between disaggregated energy consumption and economic growth in Nigeria. The findings show a long- and short-run relationship between economic growth and petroleum consumption. However, electricity consumption was not found to be significant, partly explained by the inefficient production and consumption resulting from the epileptic and inadequate supply at the national level. Also, the causality result reveals feedback causation between economic growth and total energy. This explains the importance of energy consumption in shaping the economic outlook of the country. Hence, the study recommends the diversification of the power-generation portfolio in the country, as this will improve energy consumption towards better output. The study suggests full deregulation policies in the energy sector as this will encourage industrialization and move energy demand towards increasingly productive uses. Finally, a strong institutional framework is needed to make energy policies achieve their objectives and targets.

35 About Azzouni, "Institutional Frameworks and the Development of Sustainable Power and Energy Sectors in Resource-Rich Developing Countries" (*Energy.duke.edu*, 2018) <https://energy.duke.edu/events/institutional-frameworks-and-development-sustainable-power-and-energy-sectors-resource-rich> accessed 8 October 2018.