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# Energy consumption and economic development in Nigeria

**Clever Ikiotimi Tuke[1]*, Victor E. Oriavwote[2]**
[1,2]*Department of Economics and Development Studies Faculty of Social Sciences, Federal University Otuoke, Bayelsa State, Nigeria*
*Corresponding author: cleverikiotimi@gmail.com
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**Abstract**
**Purpose:** The study investigated the effect of Energy consumption and economic development in Nigeria.
**Methodology:** The data for the study were sourced from World Bank Database from 1990- 2023. Following the unit root test, the Toda-Yamamoto Granger Causality or Block Exogeneity Wald was carried out.
**Results and conclusion:** Principally and no causality exists from Access to electricity for the urban population (UPEt), Electricity availability to rural populations (RPEt), energy production through renewable sources (EPRt) (hydro), electricity production through non-renewable sources (EPNt), and electric power transmission and distribution losses (EDLt) to per capita income in Nigeria. The findings suggested that enhancements in electricity access and production did not significantly contribute to economic development, as measured by per capita income during the period analyzed.
**Implication of findings:** The study, among others, recommended that stakeholders in the energy industry in Nigeria should synergize to enhance the provision of reliable and quality electricity supply instead of merely increasing access. The implication of this finding making energy utilization and affordability will be to improve the economy.

***Keywords:*** Energy consumption, Economic development, Endogenous growth theory, Electricity.

## 1. Introduction

Energy use has a major impact on societal well-being and industrial productivity, making it essential for a nation's economic growth (İnal et al, 2021). Given Nigeria's abundant energy resources and the numerous obstacles it has in ensuring secure and sustainable energy access, there, the connection between energy use and economic expansion is particularly apparent (David & Owolabi, 2023).Nigeria, one of the biggest economies in Africa, has had serious problems with energy access, particularly in rural regions, as a result of its energy infrastructure's inability to keep up with the needs of its expanding economy (Adeniran & Yusuf, 2023). Due to the underdeveloped energy sector, many Nigerians continue to rely on polluting and inefficient energy sources like kerosene and firewood, even though the country is a significant producer of gas and oil (Abdelgali, 2020; korolo & korolo, 2025). Many Nigerian stakeholders are concerned about the sustainability of energy practices in light of this circumstance.

Nigeria's energy access gap is still a major problem, especially for underserved and rural communities that frequently do not have access to dependable electricity (Okere et al, 2023). Economic activity is hampered by this lack of access since households and companies cannot operate at their best because of frequent power outages and inconsistent national grid supply. The ensuing negative impacts on productivity, especially in rural areas where energy access is most restricted, prolong cycles of poverty and underdevelopment. The nation's economic output therefore declines, underscoring the urgent need for energy access improvements to promote economic growth and raise Nigerians' standard of living. To fully realize Nigeria's economic potential and enhance societal well-being, these issues must be resolved.

Furthermore, Nigeria's energy distribution infrastructure is insufficient and unable to satisfy the demands of a fast-expanding population, and it is characterized by inefficiencies and injustices (Abdelgalil, 2020). Despite possessing enormous natural gas and oil reserves, the distribution infrastructure has not been updated, resulting in regular blackouts and power shortages that impact both the industrial and residential sectors (Makki et al, 2024). Renewable energy sources, including solar, wind, and hydropower, can diversify Nigeria's energy mix, but they haven't yet been fully utilized to drastically lower the nation's energy consumption (Mukhtarov, 2024). For Nigeria's energy sector to be sustainable and to solve the urgent issues of energy access and economic development, a shift to cleaner energy is essential.

Research has focused on the relationship between energy use and economic growth, with preliminary findings indicating multiple causation directions. Certain scholars, such as Akinlo (2008), believe that there is a one-way causal relationship between energy use and economic growth, implying that economic expansion necessitates increased energy consumption.

This opinion is supported by Omojolaibi (2014) and Manasseh et al. (2019), who point out that energy consumption is a key factor influencing Nigeria's economic growth. There is a demand for energy as economies grow, according to some experts, such as Alabi et al. (2010), who contend that economic growth promotes energy consumption. Several studies have demonstrated that a strong energy sector is critical for a healthy economy (Ajao & Emonena, 2024).

Prior studies have examined energy use by breaking it down into different sources, demonstrating varying effects on economic growth. For example, in contrast to the effects of traditional biomass or non-renewable sources, Nwosa and Philips (2013) discovered that electricity usage in Nigeria had a strong long-term link with economic growth. It's also important to distinguish between short-term and long-term effects. According to some research, there are complex short-term dynamics that may even link some energy sources to economic growth negatively, but long-term relationships are generally positive (Ajao & Emonena, 2024; Afaha & Agbede, 2025; Yusuf & Musa, 2025; Yusuf et al, 2025). The need for more research is highlighted by these findings' discrepancies, which are likely caused by different techniques and varying aggregations. Nigeria's energy sector is facing a significant obstacle in coordinating its infrastructure and consumption patterns with sustainable development goals because it is still heavily dependent on fossil fuels and lacks the funding and reforms needed to switch to renewable energy sources, which will impede both environmental sustainability and economic growth. The current study aims to provide updated empirical evidence that can guide sustainable energy and economic policy by investigating the relationship between energy use and economic development in Nigeria. Following the introduction, the study's remaining sections are organized as follows: methodology, data analysis, literature review, and conclusions.

## 2. Literature review

### *Theoretical review*

According to endogenous growth theory, human capital and technical developments—rather than merely external forces like capital accumulation—are the main drivers of economic progress (Stern & Kander, 2012). It suggests that Nigeria might increase productivity and creativity, especially in rural regions, by expanding energy access through renewable sources like solar and wind, therefore fostering general economic growth. Nigeria may eventually switch to renewable energy, according to another theory called the environmental Kuznets curve (EKC), which shows that although early industrial growth may cause environmental damage, rising wealth can facilitate the adoption of cleaner technologies (Stern & Kander, 2012). Furthermore, the Solow-Swan growth model emphasizes the vital significance of energy as a type of capital, showing that enhancing Nigeria's energy infrastructure is crucial for both economic stability and productivity. Lastly, energy access is essential for minimizing regional disparities and maximizing growth, as the Two-Sector Model emphasizes the significance of energy availability for economic performance, especially in energy-intensive sectors like oil and agriculture (Stern & Kander, 2012).

*Empirical studies*

Using the ARDL econometric technique, Bukar and Adamu (2023) evaluated the impact of trade openness, FDI, and Petroleum energy usage had an impact on Nigeria's economic growth between 1990 and 2021.According to their findings, all three factors had a considerable impact on economic growth, while the long-term positive impact of petroleum use was the greatest. The study's conclusion—which offers guidance to policymakers seeking sustainable growth—was that fostering these elements is critical to Nigeria's economic success.

The pollution haven hypothesis (PHH) in sub-Saharan Africa was examined by Gyamfi et al. (2021), who focused on urbanization, real income, carbon dioxide emissions, energy consumption, and foreign direct investment (FDI) between 1990 and 2016. The analysis supported the PHH, showing that the adoption of the impact of renewable energy was positive.

On environmental quality, foreign direct investment (FDI) had a negative impact, especially through the usage of fossil fuels. The authors underlined the need for low-carbon policies in the area and advised policymakers to give renewable energy initiatives top priority in order to reduce pollution and climate change.

Mukhtarov (2024) examined the relationships between China's oil prices, GDP, CO2 emissions, and REC from 1990 to 2020 using the CCR technique. The statistics showed that REC increased by 0.16% for every 1% increase in oil prices, indicating that higher oil prices could make renewable energy more competitive. In order to lessen dependency on fossil fuels and address China's high greenhouse gas emissions, the study underlined the necessity of regulatory frameworks supporting renewable energy programmes.

Using a cointegration model, Rehman (2024) examined the relationships between corruption, environmental quality, energy consumption, and economic growth in five ASEAN nations between 1960 and 2021. The results of the study demonstrated that higher degrees of corruption had a negative impact on both economic growth and environmental quality, which validated the environmental Kuznets curve theory. Transparency is essential for sustainable economic development in the region, according to the report, which also emphasized the significance of strong governance and regulatory measures to reduce corruption.

Selcuk et al. (2022) used Poisson regression and negative binomial fixed effect approaches to examine how economic and environmental factors affected innovation in 22 nations (11 that imported oil and 11 that exported it) between 1990 and 2018. According to their findings, innovation in oil-exporting countries was positively correlated with GDP, energy use, foreign direct investment, and oil prices. The majority of independent factors, with the exception of renewable energy, strongly predicted innovation. According to the study's conclusion, certain policy measures are necessary to promote innovation. It was suggested that while oil-importing nations should expand trade openness and control carbon emissions, oil-exporting nations should improve foreign direct investment and manage changes in oil prices.

Cengiz and Manga (2021) examined the causal relationships between Oil Prices (OP), CO2 Emissions (CO2), Economic Growth (GDP), and Renewable Energy Consumption (REN) in a selection of OECD countries between 1980 and 2014 using the Kónya Panel Bootstrap causality technique. They identified several significant causal relationships, including the one-way causal relationship between GDP and REN in Switzerland and Belgium, and the two-way causal relationship between REN and CO2 emissions in Canada and Italy. In order to support renewable energy and lessen its negative effects on the environment, the study underlined the necessity of customized policy measures depending on national dynamics.

Lahrech et al. (2023) examined the relationship between economic growth in GCC nations and global renewable energy consumption (GREC) between 2001 and 2019. They found a significant negative relationship, suggesting that growing global demand for renewable energy could impede economic growth in these oil-dependent economies. To aid in the shift to sustainable growth, they emphasized the value of economic diversity and suggested investments in renewable energy, especially solar projects. The report emphasized how urgent it is that authorities create plans that encourage investments in renewable energy while tackling the financial difficulties brought on by the world's transition to cleaner energy sources.

From 1990 to 2020, Aliyev et al. (2024) investigated the causal connection between Iceland and Azerbaijan's expansion of the economy and their use of renewable energy, and they discovered a strong bilateral causal association in both nations. According to the findings, increasing Iceland's use of renewable energy could boost its economy, and Azerbaijan should give priority to the advancement of renewable energy to increase the variety of its energy sources. For economies looking to match sustainable energy policy with financial goals, the study offered insightful information.

In their assessment of the effects of oil production on Nigeria's economy, Adedara and Adetifa (2024) found that although it increased exports and revenue, it also resulted in the neglect of important sectors and prolonged poverty because of corruption and poor management. They maintained that Nigeria needed to diversify its economy to reduce the dangers associated with its reliance on oil, even though the country benefited from OPEC's controls. In order to improve living standards, the research recommended measures targeted at economic diversification and underlined the importance of transparent and strong governance in the management of oil income.

Nosheen et al. (2024) found a significant relationship between economic growth and the usage of renewable energy when they examined the effects of non-renewable and renewable energy consumption on economic growth in a few selected countries between 1990 and 2021. They pointed out that non-renewable energy sources were still important in some situations, emphasizing the necessity of context-specific regulations to maximize the advantages of renewable energy. In order to create infrastructure and policies that support sustainable economic growth, the report recommended government action as well as international collaboration.

Hacıimamoğlu and Sandalcılar (2018) investigated the connection between economic stability and the use of renewable energy using panel data from 35 countries between 1990 and 2016. They discovered a significant long-term correlation that varied between industrialized and developing nations. The need for a customized energy policy was highlighted by the fact that while some nations, like Egypt and Germany, saw favourable outcomes, others saw negative ones. The analysis concluded that while encouraging renewable energy could improve economic stability, a one-size-fits-all strategy was insufficient.

According to Okere et al. (2023), there was a favourable correlation between Nigeria's democratic institutions and fossil fuel use between 1975 and 2020, but it waned as the country's reliance on oil increased. They advocated energy diversification towards greener options, arguing that an over-reliance on oil wealth could threaten democratic institutions. For Nigeria's socioeconomic progress, the study underlined how crucial it is to comprehend how democracy and energy use interact (Okere et al., 2023).

Yürük (2023) investigated the relationships between the use of renewable energy and several economic variables, including stock market indices and crude oil prices, between January 2010 and February 2022 using a Structural Vector Autoregression model. The findings demonstrated that while there was no appreciable Granger causality between the price of crude oil and the utilization of renewable energy, changes in crude oil prices had a significant effect on stock market indices. The report emphasized the necessity for countries to diversify their energy sources and develop comprehensive energy strategies that include renewable sources in order to lessen the risks associated with oil dependence.

## 3. Methodology

The study used a correlational research strategy to estimate the parameter of the link between the variables in the model and a quasi-experimental approach (ex post facto) for data collection. The model's theoretical foundation is the endogenous growth theory. According to the idea, economic growth is not only influenced by external forces like capital accumulation but also by internal variables like technical advancement, the development of human capital, and the efficient use of resources. According to this concept, energy is seen as a vital component that promotes innovation and production, which results in long-term growth. According to this analysis, Nigeria's energy sector confronts problems like unstable supply, inadequate generation capacity, and subpar distribution networks because it predominantly relies on fossil fuels.

The scope of this study is 1990-2023. The data for the study were sourced from World Bank Database, 2024. The variables used are urban population (UPEt), Electricity availability to rural populations (RPEt), energy production through renewable sources (EPRt) (hydro), electricity production through non-renewable sources (EPNt), and electric power transmission and distribution losses (EDLt) to per capita income in Nigeria. By boosting energy availability, particularly through clean and efficient energy sources like solar and wind, Nigeria might drive technical developments and improve productivity across multiple sectors. Improved energy supplies would enable better healthcare, education, and industrial development in rural areas with limited access to energy. This would boost human capital and promote overall economic growth and development. The study's factors include per capita income (a proxy for economic development), access to electricity for both rural and urban populations, sources of non-renewable and renewable energy, and distributional loss of electricity. The other variables are independent, but the dependent variable is economic development, or per capita income.

The model in mathematics is described as

PCIt = f (UPEt, RPEt, EPRt, EPNt, (1)

Where:

PCI stands for per capita income.

UPEt is the urban population's electrical access.

RPEt is access to electricity for rural populations

EPRt is the production of electricity from a renewable source (hydro).

EPNt is the amount of electricity produced using non-renewable resources (coal, gas, and oil).
EDLt stands for electric power distribution and transmission losses.

The explicit mathematical model for PCIt:

$$PCIt = \beta 0 + \beta 1UPEt + \beta 2RPEt + \beta 3EPRt + \beta 4EPNt + \beta 5EDLt \quad (2)$$

This is the formula for the econometric model:

$$PCIt = \beta 0 + \beta 1UPEt + \beta 2RPEt + \beta 3EPRt + \beta 4EPNt + \beta 5EDLt + Ut \quad (3)$$

Per capita income (PCIt), a measure of economic development, is dependent on several factors, including the availability of electricity to urban and rural populations (UPEt and RPEt), energy production from renewable sources (EPRt) (hydro), electricity production from non-renewable sources (EPNt) (oil, gas, and coal), and electric power transmission and distribution losses (EDLt).

The endogenous growth mode states that per capita income (PCIt) should be inversely correlated with electric power transmission and distribution losses (EDLt) and positively correlated with energy production from renewable sources (EPRt) (hydro), electricity production from non-renewable sources (EPNt) (oil, gas, and coal), and urban and rural population access to electricity (UPEt and RPEt). Consequently, $\beta 4 < 0$ and $\beta 1$, $\beta 2$, and $\beta 3 > 0$.

## 4. Results and discussion

To select the best estimation technique and prevent spurious regression, the data are put through stationarity and cointegration tests. Below are the findings from the estimation and the preliminary time series test.

**Table 1: Phillip Perron (pp) unit root test**

| Variable | Test | Level | | First Difference | | Second Difference | | Order |
|---|---|---|---|---|---|---|---|---|
| | Equation | Stat | PV | Stat | PV | Stat | PV | |
| LEDL | I | -5.8871 | 0.0000 | | | | | I(0) |
| | I & T | -5.8561 | 0.0002 | | | | | |
| | N | 0.0661 | 0.6969 | -32.203 | 0.0000 | | | |
| LEPN | I | -0.6687 | 0.8410 | -7.3524 | 0.0000 | | | I(1) |
| | I & T | -3.2679 | 0.0893 | -7.2745 | 0.0000 | | | |
| | N | 0.7755 | 0.8762 | -6.7160 | 0.0000 | | | |
| LEPR | I | -0.5648 | 0.8652 | -6.9924 | 0.0000 | | | I(1) |
| | I & T | -2.7196 | 0.2357 | -6.8477 | 0.0000 | | | |
| | N | -1.0700 | 0.2514 | -6.4869 | 0.0000 | | | |
| LPCI | I | -0.6515 | 0.8452 | -2.9881 | 0.0468 | -7.8441 | 0.0000 | I(2) |
| | I & T | -1.7328 | 0.7137 | -2.9345 | 0.1657 | 0.63762 | 0.0000 | |
| | N | 1.2754 | 0.9455 | -2.7156 | 0.0082 | -0.3456 | 0.0000 | |
| LRPE | I | -6.9589 | 0.0000 | -15.801 | 0.0000 | | | I(1) |
| | I & T | -8.7587 | 0.0000 | -31.315 | 0.0000 | | | |
| | N | 0.8228 | 0.8846 | -14.993 | 0.0000 | | | |
| LUPE | I | -4.7779 | 0.0005 | -15.964 | 0.0000 | | | I(1) |
| | I & T | -5.3536 | 0.0006 | -17.869 | 0.0000 | | | |
| | N | 1.6080 | 0.0000 | -14.623 | 0.0000 | | | |

Source: Author’s Compilation

The probability value of each variable's test statistic is compared to the study's selected level of significance, which is 0.05, in order to assess the unit root test result. If the probability value of the variable's test statistic is less than the selected level of significance (0.05), the null hypothesis is rejected. The study's selected level of significance. From Table 1's unit root result's final column. Order zero variables (I(0)), order one variable (I(1)), and order two variables (I(2)) make up the order of integration. Per capita income (LPCI) is integrated at order two (I(2)), electricity distribution loss (EDL) is integrated at order I(0), and all other variables are integrated at order one (I(1)).

Certain variables are stationary at the level, first difference, and second difference, according to the results of the unit root test. Consequently, the parameter of the relationship between the models is estimated using the Toda-Yamamoto approach.

**Table 2: VAR Lag order selection criteria**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 206.0264 | NA | 1.50e-13 | -12.50165 | -12.22683 | -12.41055 |
| 1 | 334.8367 | 201.2660 | 4.73e-16 | -18.30229 | -16.37852* | -17.66462 |
| 2 | 388.2850 | 63.46991* | 2.05e-16* | -19.39282* | -15.82008 | -18.20856* |

Source: Author's Compilation

The ideal lag length (K), as determined by the minimum values of the AIC, SC, and HQ criteria, is 2. The unit root test result of Table 2 demonstrated that the greatest order of integration is I (2), which suggests that the dmax is 2. To perform the Toda-Yamamoto approach and display the Granger Causality or Block Exogeneity Wald test result, the (k+dmax)th order is 4th, and a 4th VAR is required.

**Table 3: Toda-Yamamoto causality (block exogeneity Wald) test result**

| Null Hypothesis | Chi-sq | Prob. Value | Direction of causality |
|---|---|---|---|
| LEPN does not cause LPCI | 0.177 | 0.916 | No causality |
| LEPR does not cause LPCI | 0.715 | 0.699 | No causality |
| LRPE does not cause LPCI | 4.001 | 0.135 | No causality |
| LUPE does not cause LPCI | 0.026 | 0.988 | No causality |
| LEDL does not cause LPCI | 0.1748 | 0.916 | No causality |
| All | 7.987 | 0.630 | No causality |

Source: Author's Compilation

If the test statistic's probability value is less than 0.05 (5%), the null hypothesis should be rejected as the causality judgment criterion. With per capita income (LPCI) as the dependent variable, Table 3 shows that the probability values of the independent variables—electric power transmission and distribution losses (EDLt), energy production through renewable sources (EPRt) (hydro), electricity production through non-renewable sources (EPNt) (oil, gas, and coal), and urban and rural population access to electricity (UPEt and RPEt)—are all greater than 0.05. It is impossible to reject the hypothesis that there is no causal relationship between any of the independent variables and per capita income (LPCI).

Electric power transmission and distribution losses (EDLt), energy production through renewable sources (EPRt) (hydro), electricity production through non-renewable sources (EPNt) (oil, gas, and coal), and urban population access to electricity (UPEt) and rural population access to electricity (RPEt) were the results of the joint causality analysis. Likewise, 0.6301, the all-probability value, is higher than 0.05.

**Table 4: Toda-Yamamoto causality (block exogeneity Wald) test result**

| Null Hypothesis | Chi-sq | Prob. Value | Direction of causality |
|---|---|---|---|
| LPCI does not cause LEPN | 7.307 | 0.025 | Causality exists |
| LEPR does not cause LEPN | 0.931 | 0.627 | No causality |
| LRPE does not cause LEPN | 0.234 | 0.889 | No causality |
| LUPE does not cause LEPN | 0.059 | 0.970 | No causality |
| LEDL does not cause LEPN | 2.300 | 0.316 | No causality |
| All | 7.986 | 0.630 | No causality |

Source: Author's Compilation

According to Table 4, which shows electricity production from non-renewable sources (oil, gas, and coal) as the dependent variable, the probability value of electricity production from non-renewable sources (EPNt) is 0.0259. This suggests that there is a causal relationship between PCI and EPNt. Electric power transmission and distribution losses (EDLt), electricity production through renewable sources (EPRt) (hydro), per capita income (PCI), urban population access to electricity (UPEt), and rural population access to electricity (RPEt) all have probability values greater than 0.05. It is impossible to reject the hypothesis that there is no causal relationship between any of the independent variables and the generation of electricity from non-renewable sources (EPNs).

Electric power transmission and distribution losses (EDLt), energy production through renewable sources (EPRt) (hydro), electricity production through non-renewable sources (EPNt) (oil, gas, and coal), and urban population access to electricity (UPEt) and rural population access to electricity (RPEt) were the results of the joint causality analysis. Likewise, 0.6301, the all-probability value, is higher than 0.05.

**Table 5: Toda-Yamamoto causality (block exogeneity Wald) test result**

| Null Hypothesis | Chi-sq | Prob. Value | Direction of causality |
|---|---|---|---|
| LPCI does not cause LEPRt | 3.766 | 0.152 | No causality |
| LEPN does not cause LEPRt | 1.249 | 0.535 | No causality |
| LEPN does not cause LEPRt | 0.452 | 0.797 | No causality |
| LUPE does not cause LEPRt | 0.148 | 0.928 | No causality |
| LEDL does not cause LEPRt | 5.312 | 0.070 | No causality |
| All | 7.986 | 0.630 | No causality |

Source: Author's Compilation, 2025

For the dependent variable, electricity production through renewable sources (EPRt), the probability values of all the independent variables, such as per capita income (PCI), electricity production from non-renewable (oil, gas, and coal), electricity production through non-renewable sources (EPNt), urban population access to electricity (UPEt), and electric power transmission and distribution losses (EDLt), are greater than 0.05 (Table 5). The hypothesis that there is no causal association between any of the independent variables and the production of energy from renewable sources (EPRt) cannot be rejected.
There is no joint causal influence stretching from the independent variables to the production of power from renewable sources, according to the All-probability value of 0.6301, which is more than 0.05 in terms of joint causality.

**Table 6: Toda-Yamamoto causality (block exogeneity Wald) test result**

| Null Hypothesis | Chi-sq | Prob. Value | Direction of causality |
|---|---|---|---|
| LPCI does not cause LUPE | 0.277 | 0.870 | No causality |
| LEPN does not cause LUPE | 9.811 | 0.007 | Causality exists |
| LEPR does not cause LUPE | 15.370 | 0.000 | Causality exists |
| LRPE does not cause LUPE | 1.454 | 0.483 | No causality |
| LEDL does not cause LUPE | 16.381 | 0.000 | Causality exists |
| All | 7.986 | 0.630 | No causality |

Source: Author's Compilation, 2025

Electricity production from non-renewable (oil, gas, and coal) sources (EPNt), electricity production from renewable sources (EPRt), and electric power transmission and distribution losses (EDLt) are all less than 0.05, according to Table 6's results on urban population access to electricity (UPEt), which is the dependent variable.

The idea that there is no causal relationship between these independent factors and urban population access to electricity (UPEt) is disproved. Nonetheless, the probability values of rural population access to electricity (RPEt) and per capita income (PCI) are more than 0.05, suggesting that these factors do not influence urban population access to electricity (UPEt).

**Table 7: Toda-Yamamoto causality (block exogeneity Wald) test result**

| Null Hypothesis | Chi-sq | Prob. Value | Direction of causality |
|---|---|---|---|
| LPCI does not cause LEDL | 2.385 | 0.303 | No causality |
| LEPN does not cause LEDL | 1.153 | 0.561 | No causality |
| LEPR does not cause LEDL | 2.142 | 0.342 | No causality |
| LRPE does not cause LEDL | 1.469 | 0.479 | No causality |
| LUPEdoes not cause LEDL | 0.932 | 0.627 | No causality |
| All | 7.986 | 0.630 | No causality |

Source: Author's Compilation, 2025.

Every variable's probability value is greater than 0.05 in Table 7, which employs electric power transmission and distribution losses (EDLt) as the dependent variable. This proved that per capita income (PCI), electricity production from non-renewable (oil, gas, and coal) sources (EPNt), electricity production from renewable sources (EPRt), urban population access to electricity (UPEt), or rural population access to electricity (RPEt) do not contribute to electric power transmission and distribution losses (EDLt).

***Diagnostic test***

**Table 8: VAR residual serial correlation LM test of HDI model**

| Lag | LRE* stat | Df | Prob. | Rao F-stat | Df | Prob. |
|---|---|---|---|---|---|---|
| 1 | 35.025 | 25 | 0.087 | 1.535 | (25, 49.8) | 0.098 |
| 2 | 34.414 | 25 | 0.099 | 1.500 | (25, 49.8) | 0.110 |
| 3 | 18.2961 | 25 | 0.829 | 0.6928 | (25, 49.8) | 0.838 |

Source: Author's Compilation, 2025.

**Table 9: Null hypothesis: no serial correlation at lags 1 to h**

| Lag | LRE* stat | Df | Prob. | Rao F-stat | Df | Prob. |
|---|---|---|---|---|---|---|
| 1 | 35.0252 | 25 | 0.087 | 1.535 | (25, 49.8) | 0.098 |
| 2 | 70.5971 | 50 | 0.029 | 1.610 | (50, 39.8) | 0.061 |
| 3 | 112.671 | 75 | 0.003 | 1.668 | (75, 18.6) | 0.107 |

Source: Author's Compilation, 2025.

For the serial VAR Residual Serial Correlation LM Tests, the null hypothesis is that there is no serial correlation in the model. The null hypothesis is rejected if the p-value at the selected latency is less than 0.05. The null hypothesis, which states that there is no serial correlation in the model, cannot be refuted because all of the test statistics' probability values at lag 2 are greater than 0.05. As a result, the model does not include serial correlation.

**Table 10: Grander causality test results**

| | | | |
|---|---|---|---|
| Causality runs from LEPN to LPCI | 7.307 | 0.025 | Causality exists |
| Causality runs from LUPE to LEPN | 9.811 | 0.007 | Causality exists |
| Causality runs from LUPE to LEPR | 15.370 | 0.000 | Causality exists |
| Causality runs from LUPE to LEDL | 16.381 | 0.000 | Causality exists |

Source: Author's Compilation, 2025.

Only unidirectional causality was found between non-renewable electricity production (LEPN) and per capita income (LPCI); between urban population access to electricity (LUPE) and non-renewable (oil, gas, and coal) (LEPN); between urban population access to electricity (LUPE) and renewable electricity production (LEPR); and between urban population access to electricity (LUPE) and distribution losses of electric power transmission and distribution (LEDL). The availability of electricity for both urban and rural populations (UPEt, RPEt), energy production from renewable sources (EPRt) (hydro), electricity production from non-renewable sources (EPNt), and electric power transmission and distribution losses (EDLt) are generally unrelated to Nigerian per capita income.

The study concluded that improvements in electricity did not significantly increase economic growth because there was no causal relationship between Nigeria's per capita income and various forms of power production and access (Adeniran & Yusuf, 2021). This outcome was attributed to the inefficiency and instability of Nigeria's electrical industry, which hindered the potential benefits of increased output and accessibility (Olayemi, 2012). Furthermore, the impact of grid electricity on income levels was lessened by the predominance of self-generated electricity from gasoline and diesel generators, indicating a lack of integration between energy production and productive economic activities (Akpan et al., 2013). Additionally, even though energy transmission and distribution losses were troublesome, they had no direct effect on economic performance—possibly because businesses switched to other power sources in reaction to unreliable power (Uduma & Arciszewski, 2010). However, other studies have shown that access to power and economic growth are positively correlated in many circumstances, highlighting the importance of good infrastructure and efficient energy use for development (Esso, 2010; Karanfil & Li, 2015).

## 5. Conclusion

With an emphasis on the causal linkages between per capita income, electricity availability, and energy production sources, the study examined the relationship between Nigeria's economic development and energy consumption. The findings suggested that increases in power output and availability did not stimulate Nigeria's economy because there was no causal association between energy variables and per capita income. This lack of causality brought to light the fundamental problems in the energy sector, such as erratic supply and ineffective transmission, and distribution. Furthermore, the reliance on self-generated electricity due to frequent outages likely reduced the potential benefits of improved energy availability on income development. Overall, the analysis revealed that energy output from renewable or non-renewable sources has not significantly affected per capita income, suggesting that energy investments and policies have not yet yielded significant economic gains.

The findings demonstrated that there is no discernible relationship between Nigeria's per capita income and the different forms of energy access and production. Therefore, we recommended that stakeholders collaborate to enhance the delivery of a reliable and high-quality electrical supply rather than merely increasing access. This necessitated investing in state-of-the-art grid infrastructure and lowering transmission losses in order to support economic growth and development. Incentives and subsidies should also be utilized to support increased investment in renewable energy sources and to promote the efficient use of power in small businesses and industries. Priorities should be established for energy governance reform, transmission and distribution inefficiencies, and the advancement of research and development in the energy sector in order to use energy consumption to boost economic development and improve per capita income growth in Nigeria.

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