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The Effect of Electricity Generation and Consumption on Standard of Living in Nigeria

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***Abstract*— *This study investigated the impact of electricity generation and consumption on standard of living in Nigeria. The study covered the period from 1990 to 2023. The proxies of electricity generation and consumption adopted are quantity of electricity generated, electricity consumed, access to electricity and electricity tariff while standard of living was measured by GDP per capita, PPP. To achieve the objectives, annual time series data were used and sourced from World Development Indicators of Nigerian Electricity Regulatory Commission (NERC) Reports, National Bureau of Statistics (NBS) Reports and World Development Indicators of the World Bank. The major technique of data analysis adopted is non-linear autoregressive distributive lag (NARDL) regression technique. The key findings revealed that evidence of long-run asymmetry in the effect of quantity of electricity generation on per capita income in Nigeria exists; negative shocks in quantity of electricity generation reduce per capita income in the long run, exerting stronger impacts than positive shocks; per capita income responded more significantly to negative quantity of electricity generation shocks than to positive ones, long-run asymmetry exists in the effect of electricity consumption on per capita income while short-run asymmetries effect of electricity consumption on per capita income are statistically insignificant; positive and negative shocks in electricity consumption have limited short-run effects and asymmetric long-run impacts primarily on per capita income; access to electricity shows no significant long-run or short-run asymmetric relationship with either GDP per capita. The study concluded that there is presence of a long-run asymmetric relationship between electricity dynamics (electricity generation and consumption) and key standard of living indicator in Nigeria. It was recommended among others that government should develop a national framework that incentivizes investments in decentralized renewable energy (e.g., solar mini-grids) to reduce dependence on the central grid and mitigate the asymmetric economic shocks from electricity disruptions. This can strengthen rural economies and foster inclusive growth.*

I. Introduction

Over the last three decades, Nigeria's electricity sector has undergone significant transformations, marked by fluctuations in generation capacity, consumption patterns, access rates, and tariff structures. In 1990, Nigeria's installed electricity generation capacity was approximately 4,000 megawatts (MW), with an operational capacity of about 1,750 MW. The majority of electricity was generated from hydropower (e.g., Kainji and Jebba dams) and gas-fired power plants. By 2000, installed capacity had increased to 5,900 MW, but operational capacity remained low at around 3,000 MW. The government launched the National Integrated Power Project (NIPP) in 2004 to address the generation gap, but progress was slow due to funding delays and bureaucratic inefficiencies. In 2010, installed capacity reached 7,000 MW, with operational capacity hovering around 4,000 MW. There was privatization of the power sector in 2013 aimed to improve efficiency and attract private investment. However, the expected gains were not realized due to structural challenges, including gas supply constraints and transmission losses (International Energy Agency, 2021). As of 2023, Nigeria's installed capacity stands at approximately 13,000 MW, but only about 4,000-5,000 MW is operational. The gap between installed and operational capacity is attributed to gas supply shortages, aging infrastructure, and inefficiencies in the power sector. However, over 80% of Nigeria's electricity is generated from gas-fired power plants. Also, hydropower accounts for about 20% of generation, but it is vulnerable to seasonal variations in water levels while other renewable energy sources, such as solar and wind, contribute less than 1% of total generation, despite Nigeria's significant potential (African Development Bank, 2023).

Access to electricity in Nigeria has seen gradual improvements over the decades. In 1990, only about 40% of Nigerians had access to electricity, with significant disparities between urban and rural areas. Urban access was around 60%, while rural access was less than 20%. By 2000, access had increased to 45%, but rural electrification remained a major challenge. The government launched the Rural Electrification Agency (REA) in 2006 to expand access, but progress was slow due to funding constraints and logistical challenges. In 2010, access reached 50%, but the population growth rate outpaced the expansion of electricity infrastructure. The privatization of the power sector in 2013 was aimed at improving access, but the expected gains were not realized (World Bank, 2020). As of 2023, Nigeria Electrification Project (NEP) (2023) reported that approximately 55% of Nigerians have access to electricity, with rural access at less than 30%. Over 90 million Nigerians still lack access to electricity, making Nigeria the country with the largest energy access deficit in the world. It is important to note that urban areas have higher access rates (about 80%), while rural areas lag behind due to inadequate infrastructure and high costs of grid extension. Off-grid solutions, such as solar home systems and mini-grids, have gained traction in recent years but remain underutilized due to high upfront costs and limited financing options. With respect to electricity tariffs in Nigeria were heavily subsidized in 1990, with an average tariff of about ₦2 per kWh (approximately $0.01 at the time). The subsidies were intended to make electricity affordable for consumers but placed a significant strain on government finances. By 2000, tariffs had increased to ₦5 per kWh ($0.04), but they remained below cost-reflective levels. The government continued to subsidize electricity, leading to financial losses for the power sector. In 2010, tariffs were further increased to ₦10 per kWh ($0.07), but subsidies persisted. The privatization of the power sector in 2013 aimed to introduce cost-reflective tariffs, but progress was slow due to political and social resistance. As of 2023, the average tariff is about ₦24 per kWh ($0.06), but it remains below the cost of production and distribution. The government has introduced cost-reflective tariffs for certain customer categories, but subsidies persist for residential consumers (Nigerian Electricity Regulatory Commission (NERC) (2023). All these have effect on standard of living in Nigeria.

Generally, electricity is a fundamental driver of modern economic activities, influencing industrialization, job creation, and overall quality of life. In Nigeria, where economic growth is often constrained by energy shortages, the relationship between electricity generation and consumption and sustainable economic development is crucial. However, despite being Africa's largest economy, access to electricity remains uneven, with rural areas disproportionately affected—only about 50% of the rural population has access to the grid compared to over 80% in urban areas. The inefficiency in electricity distribution, coupled with high tariffs and inconsistent pricing policies, further exacerbates the problem, discouraging investment and stifling industrial productivity. Without reliable and affordable electricity, Nigeria's economic diversification, job creation, and industrialization efforts are severely constrained, undermining sustainable development goals. Additionally, the electricity sector's financial and operational inefficiencies pose a significant barrier to long-term economic sustainability. The tariff structure in Nigeria is often inconsistent, with subsidies and regulatory bottlenecks creating a disconnect between cost recovery and service delivery. This has led to massive debt in the power sector, discouraging private investment and limiting infrastructure expansion. The reliance on fossil fuels for electricity generation also contributes to environmental challenges, including high carbon emissions, which conflict with global climate commitments. Meanwhile, renewable energy sources remain underutilized despite Nigeria's vast solar, hydro, and wind potential. The lack of accessible and affordable electricity disproportionately affects small and medium-sized enterprises (SMEs), which are crucial for employment generation and poverty reduction. Consequently, Nigeria's inability to provide stable and sustainable electricity undermines its potential to achieve inclusive economic development, improve living standards, and compete in the global market. Addressing these challenges is essential to fostering a resilient economy that balances industrial growth, social equity, and environmental sustainability. It is against the identified problem that this study seeks to empirically examine the effect of electricity generation and consumption on standard of living in Nigeria.

II. Theoretical Literature

Energy Transition Theory

Energy transition theory refers to the conceptual framework and set of principles that guide the transformation of energy systems from traditional, fossil fuel-dependent sources to more sustainable, low-carbon, and environmentally friendly alternatives. This transition is driven by the recognition of the need to address pressing global challenges such as climate change, energy security, and environmental sustainability. Energy transition theory encompasses a multidisciplinary approach, involving aspects of economics, technology, policy, and social dynamics. Generally, the idea of linking energy consumption to economic growth is anchored on the energy transition theory. The proponents of the energy transition theory such as Hosier and Dowd (1987) and Leach (1992) linked the nature of energy consumed to income. Energy is argued to be one of the main drivers of modern economy especially across countries that have witnessed rapid growth in recent years. The theory explains that the type of energy consumed by a nation strongly depends on the level of per capita income. Drawing from consumer theory, the theory posits that as income increases, energy consumers tend to transit from traditional or inferior energy to modern energy due to ease of use and comfort. The theory holds that there is a direct link between level of income and energy consumption; high income countries tend to consume more quality energy than poor countries. Furthermore, Energy Transition theory maintains that poor access to modern energy limits a nation's potentials to reduce poverty and ensure sustainable growth. This is because access to energy is central to any poverty reduction drive (Pachauri & Spreng, 2004) as energy deprivation inhibits production and limits level of economic activities (Kaygusuz, 2011; Sovacool, 2012).

Empirical Literature

Using the Autoregressive Distributed Lag (ARDL) model and Causality Test, Joseph, Shaibu, and Miftahu (2024) investigated the connection between economic growth and electricity consumption in Nigeria during the sample period of 1986 to 2021. According to the ARDL findings, electricity consumption has a negative correlation with economic growth in the short term at the 5% level of significance, while electricity generation has a positive correlation with economic growth in the short term at the same level of significance. At a 5% significance level, electricity usage is positively correlated with economic growth over the long term.

The connection between electrical energy use and economic development in Nigeria from 1990 to 2022 was examined by Isah, Aiyedogbon, and Aigbedion (2024). A Threshold Regression Approach was used in the research. The data showed that in the regime with low electricity power usage values of -0.2381, the paper discovered a negative relationship with economic growth. In contrast, higher electricity power consumption values of 0.2556 created a positive correlation in the regime. These results highlighted the nonlinear link between electricity consumption and economic development.

Over the period of 1990–2019, Owolabi, Omeire, Okwudire, and Bolujoko (2023) investigated the impact of electricity access on income inequality in Nigeria. The study, which employed ARDL estimation, discovered that education and electricity access—two of the key drivers of income inequality—had no long-term relationship with it, but that electricity access was important for lowering income inequality in Nigeria, while education was not.

Etim, Nteegah and Barisua (2023) examined the causality relationship between electricity consumption and economic growth in Nigeria using time-series data between 1990 and 2020. The ARDL model was used as the analytical technique. The study found that electricity consumption by the commercial sector has a short-term negative and insignificant effect on Gross Domestic Product. There was a positive and statistically significant relationship between industrial consumption and Gross Domestic Product over both the short and long run. Gross Domestic Product and household consumption were strongly and consistently positively correlated over the long term.

Using the Autoregressive Distributed Lag (ARDL) model, Badamasi (2023) examined the effect of electricity usage on Nigeria's economic development from 1986 to 2021. The current cointegration is shown by the results of the ARDL bond test. Evidence from the short run indicates that the rate of change is both statistically significant and negative. The findings also demonstrated that energy consumption, inflation, and industrial output are statistically significant and have a favorable impact on Nigeria's economic development in both the short and long term.

Eseyin and Ogunjobi (2022) investigated the impact of sustainable electricity supply on poverty reduction in Nigeria. A time series data from 1981 to 2018 was analysed for this study. Based on the outcome of this study, it could be seen clearly that while electricity generation play a significantly role reducing poverty in the country. Also, apart from the fact that poverty level in the past period is found to have a direct and statistically significant effect on the poverty rate in the current period, it was also revealed that lower unemployment rate does not really translate into reduction in the poverty level in Nigeria.

Hünkar, Özkan and Selçuk (2022) examined the impact of the COVID-19 pandemic on the electricity consumption and economic growth nexus in 30 European countries using quarterly data between 2015Q1 and 2021Q3. The study employed the panel unit root, panel causality, and dynamic panel estimation tests, and the result shows that there is a bi-directional causality between electricity consumption and economic growth during the study period. This means that increased electricity consumption during the COVID-19 pandemic decreases economic growth.

Stungwa, Hlongwane and Daw (2022) investigated the relationship between electricity consumption and economic growth in South Africa for the period from 1971 to 2014. The study utilised borrowed time series data on an ARDL model to reveal short and long run relationships between the variables. The empirical results revealed that statistically significant short run and positive long run relationships between renewable electricity consumption and economic growth in South Africa.

Rafndadi, Aliyu and Usman (2022) analyzed empirically whether France current sustainable electricity use defies the theoretical and empirical literature. To achieve this objective, the standard tools of growth empiric were used over the period, 1961 2015. To evaluate the data, we used Autoregressive Distributed lag (ARDL) bounds testing and trended and de-trended structural break tests for Zivot Andrews. According to the results of this study, France's economic expansion is fueled by electricity consumption, financial sector growth, capital, imports, and exports.

Hamid, Aondoawase and Naziru (2021) examined the dynamic relationship between electricity consumption and economic growth in Nigeria. The study employed Nonlinear Threshold Regression Model to address its objectives. It was found that there are positive and negative impact of electricity consumption and economic growth in Nigeria. Positive change in electricity consumption has a significant positive impact on economic growth, while a negative change in electricity consumption in Nigeria affects economic growth negatively.

Adewale and Adeiza (2020) investigates the impact of electricity consumption on Nigerian economy between 1986 and 2018. The estimation technique employed for the analysis is Autoregressive Distributed Lag Model. The ARDL result confirmed that both ELC and GDPR are positively and significantly correlated in the short-run but in the long-run, ELC impacted negatively and insignificantly on economic growth in Nigeria, while CFG exerts positive but insignificant impact on economic growth.

Abdulwahab, Onisanwa and Kanadi (2019) examined the relationship between electricity consumption and economic growth in Nigeria. The study employed econometric approach to investigate whether the relationship is time varying. The results of non-linear unit root test suggest that real GDP is stationary at levels, while electricity consumption is integrated of order (1) as such cointegration test is not valid when a time series is stationary. Further, whether energy variable has unit root has implications for the correct modelling of energy and economic growth.

III. METHODOLOGY

For the purpose of this study, *ex-post facto* research design was used. *Ex-post facto* research design, also known as an observational or retrospective design, is a type of research design where researchers analyze existing data or events to draw inferences about possible causes or effects. It involves studying variables that have already occurred naturally without any manipulation by the researcher.

Model Specification

Theoretically, the analytical framework of this study was anchored on Cobb-Douglas Production Function because of its relevance to this study. The choice of Cobb-Douglas Production Function is premised on the foundation that shows the relationship between the amount of inputs and the amount of output that can be produced. Furthermore, the model of this study was built on the work of Joseph, Shaibu and Miftahu (2024) who investigated the relationship between electricity consumption and economic growth in Nigeria. However, the baseline model is modified to accommodate all the variables of this study.

Model 1

$$GDPPC = f(VEG, REXC, FDI) \quad (3.1)$$

$$GDPPC_t = \alpha_0 + \alpha_1 VEG_t + \alpha_2 REXC_t + \alpha_3 FDI_t + \mu_t \quad (3.2)$$

A Priori Expectation: $\alpha_1 > 0$ in the GDP per capita model.

Model 2

$$GDPPC = f(ECS, EXCR, FDI) \quad (3.3)$$

$$GDPPC_t = \alpha_0 + \alpha_1 ECS_t + \alpha_2 EXCR_t + \alpha_3 FDI_t + \mu_t \quad (3.4)$$

A Priori Expectation: $\alpha_1 > 0$ in the GDP per capita model.

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Model 3

$GDPPC = f(AEC, INFL, EXCR)$ (3.5)

$GDPPC_t = \alpha_0 + \alpha_1 AEC_t + \alpha_2 INFL_t + \alpha_3 EXCR_t + \mu_t$ (3.6)

A Priori Expectation: $\alpha_1 > 0$ in the GDP per capita model.

Model 4

$GDPPC = f(ETR, INFL, EXCR)$ (3.7)

$GDPPC_t = \alpha_0 + \alpha_1 ETR_t + \alpha_2 INFL_t + \alpha_3 EXCR_t + \mu_t$ (3.8)

A Priori Expectation: $\alpha_1 < 0$ in the GDP per capita model.

Where: GDPPC = GDP per capital measured in terms of Purchasing Power Parity (PPP), VEG = Quantity of electricity generated, ECS = Electricity consumption, AEC = Access to electricity, ETR = Electricity tariff, REXC = Real exchange rate, FDI = Foreign Direct investment, INFL = Inflation rate, α_0 = Regression intercept, α_1 = Parameters of independent variable $_t$ = Time subscript, μ_t = Error term

Data Required and Sources

Annual time series data from 1990 to 2023 were used and sourced from World Development Indicators of Nigerian Electricity Regulatory Commission (NERC) Reports, National Bureau of Statistics (NBS) Reports and World Development Indicators of the World Bank.

Data Analysis Technique

The variables under consideration exhibit a mix of integration orders—some are stationary at level [I(0)], while others are stationary at first difference [I(1)]. This justifies the adoption of the Nonlinear Autoregressive Distributed Lag (NARDL) model as the preferred econometric technique. The NARDL framework, developed by Shin et al. (2014), extends the bounds testing approach to cointegration originally introduced by Pesaran et al. (2001). One of its key advantages is its flexibility: it can be applied regardless of whether the regressors are I(0), I(1), or a combination of both, provided none are integrated of order two [I(2)]. The NARDL model is preferred over the linear ARDL model in this study because the latter does not capture potential asymmetries in the behavior of electricity generation and consumption in Nigeria.

IV. Results and Discussions

Statistics Analysis

Table 1 shows that the mean statistic of GDP per capita is 3.69 while its standard deviation statistics is 1.47. This implies that, on average, the personal income stood at 3.69 thousand US dollars; and that there is no significant variation in the level of personal income. Moreover, the skewness (0.13 and1.20) and kurtosis (1.47 and 2.90) statistics implies a right-skewed (since the skewness statistic is positive) and platykurtic (fewer and less extreme outliers) (since the kurtosis statistic less than 3) distribution. While the skewness statistics of all the variables are positive (in exception of access to electricity), the kurtosis statistics of the majority of the main variables (in exception ETR) of interest is less than 3. Few outliers were evident in electricity tariff (ETR) as against more outliers in electricity generation (EGT) and electricity consumption (ECS).

Unit Root Tests

The results of the Augmented Dickey–Fuller (ADF) unit root test for each variable as presented in Table 2 show that GDPPC, VEG, AEC, ETR, EXCR, and REXC are integrated of order zero, indicating stationarity at level. Conversely, ECS, INFL, and FDI are integrated of order one, becoming stationary only after first differencing.

TABLE 1. The results of summary statistics for selected variables ($T = 34$)

Variables	Mean	SD	Min	Max	Skewness	Kurtosis
GDPPC	3.69	1.47	2.01	6.21	0.13	1.47
VEG	23.77	9.37	12.03	42.50	0.49	1.87
ECS	118.13	29.16	74.49	177.08	0.06	1.91
AEC	48.07	8.41	27.30	61.20	-0.39	2.42
ETR	28.55	21.99	11.40	94.92	1.97	5.99
INFL	18.28	15.90	5.39	72.84	2.18	6.85
EXCR	161.22	143.19	8.04	645.19	1.43	5.18
REXC	109.50	48.09	49.78	273.01	1.83	6.49
FDI	1.30	0.84	-0.04	2.90	0.17	1.89

Source: Authors' computation, 2025.

TABLE 2: Augmented Dickey–Fuller test for Unit Root

Variables	Level			First Difference			I (…)
	Constant + Trend	Constant	None	Constant + Trend	Constant	None	
	Stat. (5% Crit.)	Stat. (5% Crit.)	Stat. (5% Crit.)	Stat. (5% Crit.)	Stat. (5% Crit.)	Stat. (5% Crit.)	
GDPPC	2.43 (3.57)	0.49 (2.98)	2.33** (1.95)	-	-	-	I (0)
VEG	1.92 (3.57)	0.76 (2.98)	3.03*** (1.95)	-	-	-	I (0)
ECS	2.26 (3.57)	0.46 (2.98)	1.16 (1.95)	4.80*** (3.57)	4.80*** (2.98)	4.50*** (1.95)	I (1)
AEC	4.17** (3.57)	1.27 (2.98)	2.42*** (1.95)	-	-	-	I (0)
ETR	0.33 (3.57)	1.97 (2.98)	2.74*** (1.95)	-	-	-	I (0)
INFL	3.16 (3.57)	2.71 (2.98)	1.50 (1.95)	4.26** (3.57)	4.32*** (2.98)	4.40*** (1.95)	I (1)
EXCR	1.95 (3.57)	2.92 (2.98)	3.33*** (1.95)	-	-	-	I (0)
REXC	2.96 (3.57)	3.02** (2.98)	0.79 (1.95)	-	-	-	I (0)
FDI	2.14 (3.57)	1.86 (2.98)	1.11 (1.95)	4.59*** (3.58)	4.66*** (2.98)	4.71*** (1.95)	I (1)

Note: *, **, and *** signifies significance at 10%, 5%, and 1% levels respectively

Source: Authors' computation, 2025.

Electricity Generation and Standard of Living

The results of the Bounds Testing in nonlinear ARDL (BDM) and Pesaran, Shin, and Smith (2001) Bounds Test (PSS) for the model estimated to examine the impact of quantity of electricity generated on GDP per capita are presented Table 3. While the Bounds Testing in NARDL assesses whether a long-run asymmetric relationship exists between the dependent and decomposed independent variables (i.e., positive and negative changes), long-run level relationship exists between variables in an ARDL. Firstly, from the result presented in Table 3, a long-run asymmetric (since 4.36 > 2.034) and level (7.33 > 3.32) relationship exists between the dependent and decomposed independent variables in the model estimated to examine the impact of quantity of electricity generated on GDP per capita.

Cointegration Test

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TABLE 3: Results of the bounds cointegration tests for estimators assessing the impact of electricity generation quantity on GDP per capita

Model	Bounds Testing in NARDL (Shin, Yu, Greenwood-Nimmo,2014) t_{BDM}	Pesaran, Shin, and Smith (2001) Bounds Test F_{PSS}
$GDPPC_t$	4.36	7.33

Note: While the t_{crit} at 95% confidence interval is ±2.034, the F_{crit} at 95% confidence interval is 3.32.
Source: Authors' computation, 2025.

Wald Test of Asymmetry

The results of the test for the positive (+) and negative (−) asymmetric long-run effects, as well as long- and short-run asymmetries, are presented in Table 4. In the per capita income model, both positive and negative long-run changes in the quantity of electricity generated produced statistically significant but opposing effects: a negative effect (–0.092, p-value = 0.037 < 0.05) for positive changes, and a positive effect (0.577, p-value = 0.000 < 0.01) for negative changes. Furthermore, a significant long-run asymmetry was detected (p-value = 0.044 < 0.05), whereas short-run asymmetry was found to be insignificant (p-value = 0.202 > 0.05). These findings suggest that electricity generation has a long-run asymmetric impact on standard of living indicator: in the GDP per capita model, positive and negative changes have divergent effects.

TABLE 4: Results of Wald test of asymmetry for estimators assessing the impact of electricity generation quantity on GDP per capita

	Long-run effect [+]			Long-run effect [-]		
	Coeff	F-stat	P>F	Coeff	F-stat	P>F
$VEG_t \rightarrow GDPPC_t$	-0.092**	5.795	0.037	0.577***	27.28	0.000
	Long-run asymmetry			Short-run asymmetry		
	F-stat		P>F	F-stat		P>F
$VEG_t \rightarrow GDPPC_t$	43.53***		0.044	1.865		0.202

Note: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

Parameter Estimates and Asymmetry Multiplier Effect

The long- and short-run run nonlinear ARDL results are reported in Table 5. The Wald test provides evidence for the presence of long-run asymmetry, which implies the asymmetric impact of quantity of electricity generation (VEG) on per capita income in Nigeria. However, the short-run Wald test results indicate the presence of symmetry in both models. This implies the short-run symmetric impact of VEG on per capita income in Nigeria. The estimated coefficients for the positive shock of VEG in the per capita income (coeff. = -0.033; std. error = 0.013; p-value = 0.030 < 0.05) model proved to statistically significant in the long run. However, a positive shock in the quantity of electricity generated reduced per capita income. Moreover, estimated coefficients for the negative shock of VEG, in the long run, in the per capita income (coeff. = -0.210; std. error = 0.051; p-value = 0.002< 0.01) model. However, a negative shock in the quantity of electricity generated reduced per capita income, in the long run. Since the Wald test results indicate the presence of symmetry in both models in the short run, the signs and significance of the short run results are inconsequential.

TABLE 5: Results of the nonlinear ARDL estimators examining the impact of quantity of electricity generated (VEG) on GDP per capita as dependent variable

Variables	GDP Per capita ($GDPPC_t$)		
	Coeff.	Std. error	P>|t|
LR			
$GDPPC_{t-1}$	-0.364***	0.083	0.001
VEG^+_{t-1}	-0.034**	0.013	0.030
VEG^-_{t-1}	-0.210***	0.051	0.002
SR			
$\Delta GDPPC_{t-1}$	0.407*	0.186	0.053
$\Delta GDPPC_{t-2}$	0.363	0.322	0.286
$\Delta GDPPC_{t-3}$	0.217	0.243	0.393
ΔVEG^+_t	0.003	0.013	0.835
ΔVEG^+_{t-1}	0.021	0.015	0.200
ΔVEG^+_{t-2}	0.019	0.015	0.236
ΔVEG^+_{t-3}	0.025	0.015	0.135
ΔVEG^+_{t-4}	0.035**	0.113	0.020
ΔVEG^-_t	-0.070**	0.031	0.049
ΔVEG^-_{t-1}	0.108**	0.040	0.022
ΔVEG^-_{t-2}	0.053	0.037	0.007
ΔVEG^-_{t-3}	0.114***	0.033	0.008
ΔVEG^-_{t-4}	0.047	0.039	0.248
REXC	0.0002	0.0007	0.790
FDI	-0.003	0.062	0.965
Constant	0.645**	0.207	0.011

Note 1: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

Post-Estimation Diagnostics

TABLE 6 Results of model diagnostics for estimators assessing the impact of electricity generation quantity on GDP per capita

	$VEG_t \rightarrow GDPPC_t$	
	Stat.	P-value
Portmanteau Serial Correlation (SC) test (χ^2)	15.94	0.1939
Breusch/Pagan heteroskedasticity (HET) test (χ^2)	0.9497	0.3298
Ramsey RESET test (F)	0.4136	0.7486
Jarque-Bera test on normality(χ^2)	1.215	0.5448

Source: Authors' computation, 2025.

The results presented in Table 6 shows that the model performed well under each of the post-estimation diagnostic tests by indicating there is no significant serial correlation, there's no evidence of heteroskedasticity in the model, there's no statistical evidence of functional form misspecification for both models and lastly, the residuals are approximately normally distributed.

Electricity Consumption and Standard of Living Cointegration Test

TABLE 7: Results of the bounds cointegration tests for estimators assessing the impact of electricity consumption on GDP per capita

Model	Bounds Testing in NARDL (Shin, Yu, Greenwood-Nimmo,2014) t_{BDM}	Pesaran, Shin, and Smith (2001) Bounds Test F_{PSS}
$GDPPC_t$	1.62	1.50

Note: While the t_{crit} at 95% confidence interval is ±2.034, the F_{crit} at 95% confidence interval is 3.32.
Source: Authors' computation, 2025.

The results of the Bounds Testing in NARDL (BDM) and Pesaran, Shin, and Smith (2001) Bounds Test (PSS) in Table 7 showed that long-run level relationship exists between variables

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in an ARDL. Specifically, a long-run asymmetric (since 1.62 < 2.034) and level (1.50 < 3.32) relationship does not exist between the dependent and decomposed independent variable in the model estimated to examine the impact of electricity consumption on GDP per capita. Based on the results in Table 7, it can be concluded that long-run relationship does not exist between the asymmetric variables and the indicators of standard of living. Moreover, long-run relationship does not exist between the variables at level and the indicator of standard of living —GDP per capita.

Wald Test of Asymmetry

TABLE 8: Results of Wald test of asymmetry for estimators assessing the impact of electricity consumption on GDP per capita

	Long-run effect [+]			**Long-run effect [-]**		
	Coeff	F-stat	P>F	Coeff	F-stat	P>F
$ECS_t \rightarrow GDPPC_t$	0.023***	24.89	0.001	0.006	0.3697	0.557
	Long-run asymmetry		Short-run asymmetry			
	F-stat	P>F	F-stat	P>F		
$ECS_t \rightarrow GDPPC_t$	27.36***	0.000	0.662	0.435		

Note: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

The results of the test for the positive (+) and negative (−) asymmetric long-run effects, as well as long- and short-run asymmetries, are presented in Table 8. In the per capita income model, positive long-run changes (0.023, p-value = 0.001 < 0.01) in the level of electricity consumption proved to be statistically significant and also appeared with a positive sign. Furthermore, a significant long-run asymmetry was detected (p-value = 0.000 < 0.01), whereas short-run asymmetry was found to be insignificant (p-value = 0.066 > 0.05). Secondly, in the unemployment rate model, insignificant coefficients were also observed for both These findings suggest that while electricity consumption has a long-run asymmetric impact on GDP per capita model, positive changes also have a positive effect on per capita income.

Parameter Estimates and Asymmetry Multiplier Effect

The long- and short-run run nonlinear ARDL results are reported in Table 9. The Wald test provides evidence for the presence of long-run asymmetry in the per capita income model, which implies the asymmetric impact of electricity consumption (ECS) on per capita income in Nigeria in the long run. However, the short-run Wald test results indicate the presence of symmetry in both models. This implies the short-run symmetric impact of ECS on per capita income in Nigeria. The estimated coefficients for the positive shock of ECS in the per capita income (coeff. = 0.013; std. error = 0.010; p-value = 0.217> 0.05) model proved to statistically insignificant in the long run. Moreover, estimated coefficients for the negative shock of ECS, in the long run, in the per capita income (coeff. = -0.003; std. error = 0.004; p-value = 0.470> 0.05) model also proved to statistically insignificant. These results imply that positive and negative shocks in electricity consumption exerts insignificant positive and negative effect on per capita income. Since the Wald test results indicate the presence of symmetry in both models in the short run, the signs and significance of the short run results are inconsequential.

TABLE 9: Results of the nonlinear ARDL estimators examining the impact of electricity consumption (ECS) on GDP per capita as dependent variables.

Variables	**GDP Per capita ($GDPPC_t$)**		
	Coeff.	Std. error	P>|t|
LR			
$GDPPC_{t-1}$	-0.565	0.349	0.136
ECS^+_{t-1}	0.013	0.010	0.217
ECS^-_{t-1}	-0.003	0.004	0.470
SR			
$\Delta GDPPC_{t-1}$	0.529	0.327	0.137
$\Delta GDPPC_{t-2}$	-0.373	0.289	0.226
$\Delta GDPPC_{t-3}$	-0.021	0.225	0.925
ΔECS^+_t	0.007**	0.003	0.027
ΔECS^+_{t-1}	-0.009	0.009	0.331
ΔECS^+_{t-2}	0.001	0.007	0.942
ΔECS^+_{t-3}	-0.001	0.006	0.911
ΔECS^+_{t-4}	0.002	0.004	0.681
ΔECS^-_t	0.003	0.003	0.444
ΔECS^-_{t-1}	0.009*	0.005	0.075
ΔECS^-_{t-2}	0.004	0.005	0.424
ΔECS^-_{t-3}	0.010*	0.005	0.084
ΔECS^-_{t-4}	0.0002	0.005	0.966
REXC	-0.001	0.0005	0.182
FDI	0.092**	0.039	0.041
Constant	1.052	0.673	0.149

Note 1: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

Post-Estimation Diagnostics

The results presented in Table10 shows that the model performed well under each of the post-estimation diagnostic tests by indicating there is no significant serial correlation, there's no evidence of heteroskedasticity in the model, there's no statistical evidence of functional form misspecification for both models and lastly, the residuals are approximately normally distributed

TABLE 10: Results of model diagnostics for estimators assessing the impact of electricity consumption on GDP per capita

	$ECS_t \rightarrow GDPPC_t$	
	Stat.	P-value
Portmanteau Serial Correlation (SC) test (χ^2)	7.355	0.8333
Breusch/Pagan heteroskedasticity (HET) test (χ^2)	0.1659	0.6837
Ramsey RESET test (F)	1.406	0.3187
Jarque-Bera test on normality(χ^2)	1.549	0.4609

Source: Authors' computation, 2025.

Access to Electricity and Standard of Living

Cointegration Test

The results of the Bounds Testing in NARDL (BDM) and Pesaran, Shin, and Smith (2001) Bounds Test (PSS) for the models estimated to examine the impact of access to electricity on GDP per capita are presented Table 11. From the result presented in Table 11, a long-run asymmetric relationship does not exist between the dependent and decomposed independent variable in the model estimated to examine the impact of access to electricity on GDP per capita. Based on the result, it can be concluded that long-run asymmetric and level relationships does not exist between access to electricity and both indicator of standard of living —GDP per capita.

TABLE 11: Results of the bounds cointegration tests for estimators assessing the impact of access to electricity on GDP per capita

Model	Bounds Testing in NARDL (Shin, Yu, Greenwood-Nimmo,2014) t_{BDM}	Pesaran, Shin, and Smith (2001) Bounds Test F_{PSS}
$GDPPC_t$	2.62	2.29

Note: While the t_{crit} at 95% confidence interval is ±2.034, the F_{crit} at 95% confidence interval is 3.32.
Source: Authors' computation, 2025.

Wald Test of Asymmetry

TABLE 12: Results of Wald test of asymmetry for estimators assessing the impact of access to electricity on GDP per capita

	Long-run effect [+]			**Long-run effect [-]**		
	Coeff	F-stat	P>F	Coeff	F-stat	P>F
$AEC_t \rightarrow GDPPC_t$	0.153*	4.26	0.066	-0.044	0.118	0.739

	Long-run asymmetry		Short-run asymmetry	
	F-stat	P>F	F-stat	P>F
$AEC_t \rightarrow GDPPC_t$	3.558*	0.089	3.408*	0.095

Note: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

The results of the test for the positive (+) and negative (−) asymmetric long-run effects, as well as long- and short-run asymmetries, are presented in Table 12. Firstly, in the per capita income model, positive and negative long-run changes in the level of access to electricity proved to be statistically significant. Furthermore, an insignificant long-run and short-run asymmetry was detected. Secondly, in the unemployment rate model, insignificant coefficients were also observed for both the positive and negative long-run changes in electricity consumption. Similarly, an insignificant long-run and short run asymmetry were present. These findings suggest that access to electricity has no long-run impact of positive and negative changes as well as no long-run and short-run asymmetric impact on GDP per capita.

Parameter Estimates and Asymmetry Multiplier Effect

The long- and short-run run nonlinear ARDL results are reported in Table 13. The Wald test provides evidence for the absence of long-run and short run asymmetry in both the per capita income model. Since the Wald test results indicate the presence of symmetry in the model in the long-run and short run, the signs and significance of the asymmetry coefficient are inconsequential. However, the result shows that while lag of the long run coefficient of per capita income ($GDPPC_{t-1}$) had a significant negative impact on level per capita income ($GDPPC_t$). Moreover, while one-period lag of the short run coefficient of per capita income ($\Delta GDPPC_{t-1}$) had a significant positive impact on level per capita income ($GDPPC_t$).

An asymmetric dynamic visual analysis of the impact of positive and negative AEC shock in that highlights the correction of asymmetry in the current long-run is inconsequential in the nexus between access to electricity and economic development since the absence of a significant long-run and short-run was observed from the result of the Wald test.

TABLE 13: Results of the nonlinear ARDL estimators examining the impact of access to electricity (AEC) on GDP per capita

Variables	**GDP Per capita ($GDPPC_t$)**		
	Coeff.	Std. error	P>|t|
LR			
$GDPPC_{t-1}$	-0.399**	0.152	0.026
AEC^+_{t-1}	0.061	0.038	0.137
AEC^-_{t-1}	0.018	0.052	0.741
SR			
$\Delta GDPPC_{t-1}$	0.683**	0.303	0.048
$\Delta GDPPC_{t-2}$	-0.046	0.337	0.894
$\Delta GDPPC_{t-3}$	0.340	0.309	0.297
ΔAEC^+_t	0.012	0.016	0.478
ΔAEC^+_{t-1}	-0.030	0.039	0.457
ΔAEC^+_{t-2}	-0.009	0.035	0.798
ΔAEC^+_{t-3}	0.017	0.035	0.644
ΔAEC^+_{t-4}	-0.033	0.028	0.268
ΔAEC^-_t	0.017	0.044	0.710
ΔAEC^-_{t-1}	0.039	0.047	0.434
ΔAEC^-_{t-2}	0.041	0.045	0.385
ΔAEC^-_{t-3}	-0.0003	0.043	0.995
ΔAEC^-_{t-4}	0.032	0.024	0.202
INFL	0.004	0.004	0.311
EXCR	-0.001	0.001	0.119
Constant	0.113	0.385	0.775

Note 1: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

Post-Estimation Diagnostics

TABLE 14: Results of model diagnostics for estimators assessing the impact of access to electricity on GDP per capita

	$AEC_t \rightarrow GDPPC_t$	
	Stat.	P-value
Portmanteau Serial Correlation (SC) test (χ^2)	17.50	0.1317
Breusch/Pagan heteroskedasticity (HET) test (χ^2)	0.050	0.8223
Ramsey RESET test (F)	1.432	0.3123
Jarque-Bera test on normality(χ^2)	0.052	0.974

Source: Authors' computation, 2025.

The results presented in Table 14 shows that the model performed well under each of the post-estimation diagnostic tests by indicating there is no significant serial correlation, there's no evidence of heteroskedasticity in the model, there's no statistical evidence of functional form misspecification for both models and lastly, the residuals are approximately normally distributed

Electricity Tariff and Economic Development

Cointegration Test

TABLE 15: Results of the bounds cointegration tests for estimators assessing the impact of electricity tariff on GDP per capita

Model	Bounds Testing in NARDL (Shin, Yu, Greenwood-Nimmo,2014) t_{BDM}	Pesaran, Shin, and Smith (2001) Bounds Test F_{PSS}
$GDPPC_t$	0.11	1.21

Note: While the t_{crit} at 95% confidence interval is ±2.034, the F_{crit} at 95% confidence interval is 3.32.
Source: Authors' computation, 2025.

The results of the Bounds Testing in NARDL (BDM) and Pesaran, Shin, and Smith (2001) Bounds Test (PSS) for the models estimated to examine the impact of electricity tariff on GDP per capita are presented Table 15. Firstly, from the result presented in Table 15, a long-run asymmetric (since 0.11< 2.034) and level (1.21 < 3.32) relationship does not exist between the dependent and decomposed independent variable in the model estimated to examine the impact of electricity tariff on GDP per capita. Based on the results in Table 15, it can be concluded that a long-run asymmetric and level relationships do not exist between the electricity tariff and GDP per capita

Wald Test of Asymmetry

TABLE 16: Results of Wald test of asymmetry for estimators assessing the impact of electricity tariff on GDP per capita

	Long-run effect [+]			**Long-run effect [-]**		
	Coeff	F-stat	P>F	Coeff	F-stat	P>F
$ETR_t \rightarrow GDPPC_t$	-1.051	0.009	0.926	63.185	0.012	0.915

	Long-run asymmetry		Short-run asymmetry	
	F-stat	P>F	F-stat	P>F
$ETR_t \rightarrow GDPPC_t$	0.012	0.915	1.831	0.206

Note: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

The results of the test for the positive (+) and negative (−) asymmetric long-run effects, as well as long- and short-run asymmetries, are presented in Table 16. Firstly, in the per capita income model, positive (-1.051, p-value = 0.926 > 0.05) and negative (63.185, p-value = 0.915> 0.05) long-run changes in the level of electricity tariff proved to be statistically insignificant. Furthermore, an insignificant long-run and short-run asymmetry was also detected. Secondly, in the unemployment rate model, while a significant coefficient was observed for positive (0.291, p-value = 0.015 < 0.05) long-run changes, an insignificant coefficient was observed for negative 9.364, p-value = 0.082>0.05) long-run changes in electricity tariff.

Post-Estimation Diagnostics

The results presented in Table 17 shows that the model performed well under each of the post-estimation diagnostic tests by indicating there is no significant serial correlation, there's no evidence of heteroskedasticity in the model, there's no statistical evidence of functional form misspecification for both models and lastly, the residuals are approximately normally distributed.

TABLE 17: Results of model diagnostics for estimators assessing the impact of electricity tariff on GDP per capita

	$ETR_t \rightarrow GDPPC_t$	
	Stat.	P-value
Portmanteau Serial Correlation (SC) test (χ^2)	7.517	0.8217
Breusch/Pagan heteroskedasticity (HET) test (χ^2)	1.382	0.2397
Ramsey RESET test (*F*)	2.50	0.1435
Jarque-Bera test on normality(χ^2)	0.732	0.6934

Note: ***, **, and * signifies p-values less than 0.01, 0.05, and 0.10 respectively.
Source: Authors' computation, 2025.

Discussion of Findings

From the analysis of data, evidence for the presence of long-run asymmetry was found. This implies a long run asymmetric impact of quantity of electricity generation (VEG) on per capita income in Nigeria. However, a negative shock in the quantity of electricity generated reduced per capita income, in the long run. Per capital income respond more to negative shocks of quantity of electricity generated (VEG) than to positive shocks in the long run. The findings of the study on the long run asymmetry does to conforms with the study by Isah, Aiyedogbon, and Aigbedio (2024) who found a short run asymmetry and that positive changes in electricity power generation have a greater and more immediate impact on economic growth. Also, this study found that asymmetry manifested in the long-run for the per capita income model; asymmetries do not manifest significantly in the short run. Moreover, positive and negative shocks in electricity consumption exerts insignificant positive and negative effect on per capita income. Also, negative shocks in electricity consumption exert disproportionately larger and faster negative impacts on per capita income than the benefits accrued from increased electricity consumption. The findings align with work of Hamid, Aondoawase, and Naziru (2021) and Ekeocha, Penzin, and Ogbuabor (2020) who found nonlinearity between electricity consumption and economic growth; and that a positive change in electricity consumption has a positive impact on economic growth, while a negative change affects economic growth negatively. Moreover, the findings suggest that access to electricity has no long-run impact of positive and negative changes as well as no long-run and short-run asymmetric impact on GDP per capita. Also, a long-run asymmetric relationship does not exist between the dependent and decomposed independent variable in the model estimated to examine the impact of access to electricity on GDP per capita. These findings agree with Ahmed, Abu, and Inedu (2023) who noted that even with sufficient generation and supply, electricity access may not automatically impact poverty due to affordability issues, where poor households might only use electricity for basic lighting, limiting its income-generating benefits.

V. CONCLUDING REMARKS AND RECOMMENDATIONS

The findings collectively underscore the presence of a long-run asymmetric relationship between electricity dynamics and standard of living indicator in Nigeria, particularly highlighting the disproportionate and adverse effects of negative shocks in electricity generation on per capita income. Per capita income exhibits greater sensitivity to reductions in electricity output than to increases, emphasizing the vulnerability of standard of living to electricity supply disruptions. While electricity consumption shows long-run asymmetry in its influence on income alone, no significant asymmetric effects—whether in the short or long run—are associated with access to electricity. Hence, the study concluded that there is presence of a long-run asymmetric relationship between electricity dynamics (electricity generation and consumption) and standard of living indicator in Nigeria. Based on the findings, the study recommended that: Government should develop a national framework that incentivizes investments in decentralized renewable energy (e.g., solar mini-grids) to reduce dependence on the central grid and mitigate the asymmetric economic shocks from electricity disruptions. This can strengthen rural economies and foster inclusive growth. Government should

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implement tiered electricity pricing that protects low-income households and SMEs from regressive energy costs while ensuring cost recovery for utilities. This includes targeted subsidies and digital metering to enhance billing transparency and reduce revenue leakages.

REFERENCES

[1]. Abdulwahab, H., Onisanwa, O., & Kanadi, M. (2019). The causality between electricity consumption and economic growth for Nigeria: A Time Varying Framework. *Abuja Journal of Economics & Allied Fields, 10*(5), 15-26.

[2]. Adewale, E. A., & Adeiza, D. A. (2020). Impact of electricity consumption on economic growth in Nigeria. *The International Journal of Humanities & Social Studies, 8*(5), 143-150.

[3]. African Development Bank (AfDB). (2020). *The high cost of electricity in Africa: Causes, consequences, and recommendations.* AfDB Energy Report.

[4]. Ahmed, S. I., Abu, S. I., & Inedu, H. (2023). Impact of electricity generation and supply on poverty in nigeria. *Nigerian Journal of Energy Environmental Economics (NJEE), 13*(1), 69 – 83.

[5]. Badamasi, S. M. (2023). Electricity consumption and economic growth: Evidence from Nigeria. *Journal of Sharia and Economic Law, 3*(1), 1-21.

[6]. Ekeocha, P. C., Penzin, D. J., & Ogbuabor, J. E. (2020). Energy consumption and economic growth in Nigeria: A test of alternative specifications. *International Journal of Energy Economics and Policy, 10*(3), 369-379.

[7]. Eseyin, O., & Ogunjobi, J. O. (2022). Sustainable electricity supply and poverty reduction in Nigeria. *International Journal of Energy Economics and Policy, 12*(1), 54-61.

[8]. Etim, A., Nteegah, A., & Barisua, N. (2023). Electricity Consumption and Economic Growth in Nigeria: A Causality Analysis using ARDL Approach. *SSRG International Journal of Economics and Management Studies, 10*(10), 35-46.

[9]. Hamid, A. A., Aondoawase, A., & Naziru, Y. A. (2021). Dynamics of electricity consumption and its impacts on Nigeria's economic growth: Empirical evidence from (Nonlinear) Threshold Regression Model. *Journal of Economics, Business Management and Administration, 2*(2), 8-19.

[10]. Hosier, R. & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy*, 9: 347–361.

[11]. Hünkar G., Özkan H., & Selçuk Ö. (2022). Does the electricity consumption and economic Growth? nexus alter during the COVID-19 pandemic? Evidence from European countries. *The Electricity Journal*, *35*(6), 1-10.

[12]. International Energy Agency (IEA). (2021). *Nigeria energy outlook*. Retrieved from https://www.iea.org

[13]. Isah, U, S., Aiyedogbon, J. O., & Aigbedion, M. (2024). Impact of electricity power consumption on economic growth in Nigeria: A threshold regression analysis approach. *International Journal of Research and Innovation in Social Science, 8*(8), 64-76.

[14]. Joseph, N. A., Shaibu, J. M. and Miftahu, I. (2024). relationship between electricity consumption and economic growth in Nigeria. *Jalingo Journal of Social and Management Sciences 5*(3), 170-185

[15]. Kaygusuz, K. (2011). Energy and environment issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews*, 253-270.

[16]. Leach, G. (1992). The energy transition. *Energy Policy*, *20*(2), 116-123.

[17]. Nigeria Electrification Project (NEP). (2023). *Mini-grid deployment in rural areas*. Retrieved from https://www.nep.org.ng

[18]. Owolabi, O. A., Omeire, M. C., Okwudire, B. O., & Bolujoko, O. T. (2023). Education, Electricity Access, and Income Inequality in Nigeria. *International Journal of Energy Economics and Policy, 14*(5), 149-161.

[19]. Pachauri, S., & Spreng, D. (2004). Energy use and energy access in relation to poverty. *Economic and Political Weekly, 39*(3), 271–278.

[20]. Rafndadi, A. A., Aliyu, I. B., & Usman, O. (2022). Revisiting the electricity consumption-led growth hypothesis: Is the rule defied in France? *Journal of Economic Structures, 11*(27), 138-155.

[21]. Sovacool, B. K. (2012). *The costs of energy justice*. Energy Policy.

[22]. Stungwa, S., Hlongwane, N. W., & Daw, O. D. (2022). Consumption and supply of electricity on economic growth in South Africa: An econometric approach. *International Journal of Energy Economics and Policy*, *12*(1), 266-274.

[23]. World Bank. (2020). *Nigeria - access to electricity (% of Population).* Retrieved from https://data.worldbank.org