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Energy Poverty and Economic Development in Nigeria

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Abstract

This study empirically examined the effect of energy poverty on economic development in Nigeria from 1990 to 2024. Energy poverty was proxied by access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption, while economic development was measured by Human Development Index. In order to achieve the objectives of the study, annual time series data were sourced from the Central Bank of Nigeria Statistical Bulletin, World Development Indicators of the World Bank, National Bureau of Statistics reports, Africa Energy Portal and the International Energy Agency. The data obtained were tested for stationarity using the Augmented Dickey-Fuller approach, which revealed a mixed order of integration among the variables. Consequently, the ARDL bounds cointegration test was used to establish the existence of a long-run relationship among the variables, while the Autoregressive Distributed Lag (ARDL) technique was employed to investigate the long-run and short-run parameters of the model. The results showed that access to electricity and renewable energy consumption have positive and significant effects on Human Development Index in Nigeria in both the short run and long run. Electricity tariff has a negative and significant effect on Human Development Index in both the short run and long run, while access to clean fuels and technologies has a positive but non-significant effect on Human Development Index in both the short run and long run. Based on the findings, the study concludes that energy poverty has a significant effect on economic development in Nigeria. The study recommends that the Nigerian government should prioritize expanding access to reliable electricity supply through increased investment in power generation, transmission and distribution infrastructure, and that electricity tariff reforms should balance cost recovery with affordability for households and businesses.

Keywords: energy poverty; economic development; Human Development Index; access to electricity; electricity tariff; renewable energy consumption; ARDL

1 Introduction

One of the impelling forces that boost economic growth and development is energy. Energy is a fundamental resource in the economy, and every facet of economic activity requires energy in one form or another to function effectively. The importance of energy has increased geometrically in recent decades; it is undoubtedly a fulcrum for sustainable business, economic and financial growth, globally and especially for emerging economies like Nigeria. Nations with higher per capita energy consumption and distribution are considered economically robust and industrialized, while those with low levels of consumption and distribution lag behind (Enu and Havi, 2014; Umeh et al., 2019). Energy poverty is a global challenge that disproportionately affects developing countries, particularly in Sub-Saharan Africa. More than 600 million people in Sub-Saharan Africa lack access to electricity, and Nigeria accounts for a significant share of this population. While energy poverty is often perceived as a household issue, its implications extend to the macroeconomic level, influencing industrial pro-

ductivity, investment decisions and overall economic growth. Despite being endowed with abundant energy resources, including oil, natural gas, solar and hydropower, Nigeria struggles to provide reliable energy to its population and businesses, with peak electricity generation capacity fluctuating between 4,000 and 5,000 megawatts, far below the estimated demand of over 30,000 megawatts (Atoyebi et al., 2023). Consequently, industries operate below capacity due to unreliable power supply, small and medium enterprises face high energy costs that erode profitability, and households experience reduced access to the modern technologies and services needed for education, healthcare and overall human development (Babatunde et al., 2022; Amadi et al., 2022).

Energy poverty remains a critical challenge for Nigeria, undermining the nation's potential for economic growth and development. Approximately 85 million Nigerians, about 43 percent of the population, lack access to electricity, and many more experience unreliable power supply. This persistent energy crisis poses a significant obstacle to economic activities across various sectors, reducing productivity and competitiveness. The industrial sector, which relies heavily on energy for production, faces high costs due to unreliable electricity supply, forcing businesses to rely on costly alternative sources such as diesel generators. In rural areas, where energy access is even more limited, the effects of energy poverty are more pronounced, hindering agricultural productivity, limiting access to clean water, and reducing educational and healthcare outcomes. While the Nigerian government has made efforts to address energy poverty through initiatives such as the Rural Electrification Agency and the Nigeria Electrification Project, progress has been slow, hampered by inadequate funding, policy inconsistencies and limited transition to renewable energy sources. It is against this background that this study sought to empirically determine the effect of energy poverty on economic development in Nigeria. The specific objectives of the study were to: ascertain the effect of access to electricity on Human Development Index in Nigeria; determine the effect of electricity tariff on Human Development Index in Nigeria; analyse the effect of access to clean fuels and technologies on Human Development Index in Nigeria; and evaluate the effect of renewable energy consumption on Human Development Index in Nigeria.

2 Literature review

2.1 Theoretical framework

The theories adopted in this study are discussed in this section as follows:

2.1.1 *Energy ladder theory*

The Energy Ladder Theory was primarily developed and popularized by Leach Gerald in 1992, although earlier discussions on household energy transition appeared in works by Amulya Kumar Reddy and José Goldemberg in the late 1980s. The theory explains how households move progressively from traditional and inefficient energy sources to more modern and efficient forms of energy as their income levels improve. According to the Energy Ladder framework, energy use follows a hierarchical pattern consisting of three broad stages: traditional fuels such as firewood, charcoal and agricultural residues; transitional fuels such as kerosene and coal; and modern fuels, including electricity, liquefied petroleum gas and renewable energy sources. The theory suggests that as income, education and technological access increase, households gradually substitute cleaner and more efficient energy sources for traditional fuels, symbolizing a progression toward higher levels of energy efficiency, convenience and environmental sustainability (Leach, 1992; Barnes and Floor, 1999). The Energy Ladder Theory is built on several important assumptions. First, it assumes that income growth

is the primary driver of energy transition, meaning that households with higher incomes are more capable of adopting modern energy technologies. Second, it assumes that households make rational choices aimed at maximizing efficiency, convenience and health benefits when selecting energy sources. Third, the theory presumes that energy sources are hierarchical, with modern fuels being cleaner, more efficient and more desirable than traditional fuels. Another assumption is that technological availability and infrastructure, such as electricity networks and gas distribution systems, enable households to move upward along the energy ladder (Hosier and Dowd, 1987; Barnes and Floor, 1999).

In the context of Nigeria, the Energy Ladder Theory provides a useful explanation of how energy poverty affects economic development. A large proportion of Nigerian households and small enterprises remain at the lower rungs of the energy ladder, relying heavily on traditional biomass fuels due to limited access to electricity, high costs of modern fuels and inadequate energy infrastructure. This dependence on inefficient energy sources reduces productivity, increases health risks and limits opportunities for economic activities that require reliable energy supply. The theory therefore suggests that improving access to modern energy sources, such as electricity, solar power and liquefied petroleum gas, can enable households and businesses to climb the energy ladder, increase productivity and promote broader economic development in Nigeria, thereby providing theoretical grounding for the access to electricity, access to clean fuels and technologies, and renewable energy consumption variables examined in this study.

2.1.2 Energy substitution theory

The Energy Substitution Theory is commonly attributed to the neoclassical energy-economics literature and was formally articulated in the works of Robert M. Solow (1974) and Joseph E. Stiglitz (1974) in their influential studies on resource scarcity and the substitutability between production inputs. Energy Substitution Theory posits that when the price, availability or efficiency of one energy source changes, economic agents, whether households, firms or entire economies, adjust by substituting alternative energy sources or technologies to maintain production and consumption levels. The theory highlights the role of technological innovation, market prices and policy incentives in shaping energy consumption patterns and economic productivity (Solow, 1974; Stiglitz, 1974). Energy Substitution Theory is built on several key assumptions. First, it assumes that different energy sources are substitutable within production and consumption processes, meaning that economic agents can replace one form of energy with another without drastically reducing output. Second, the theory assumes that economic agents behave rationally, seeking to minimize costs and maximize efficiency when selecting energy inputs. Third, it presumes that relative prices influence energy choices, implying that increases in the cost or scarcity of a particular energy source will encourage the adoption of cheaper or more accessible alternatives (Stern, 2011; Pindyck and Rubinfeld, 2018).

In the context of Nigeria, Energy Substitution Theory helps explain how energy poverty affects economic development. Nigeria experiences persistent shortages of reliable electricity, leading households and firms to substitute grid electricity with alternative sources such as diesel generators, kerosene, firewood and charcoal. While substitution enables economic activities to continue in the short term, it often occurs at a higher economic and environmental cost, reducing profitability, discouraging investment and increasing the prices of goods and services. According to Energy Substitution Theory, improving access to affordable and reliable modern energy, such as electricity and renewable energy, would reduce inefficient substitution practices and enhance productivity, thereby promoting

sustainable economic development, which directly underpins the electricity tariff and access to electricity variables examined in this study.

2.2 Review of empirical literature

Okereke et al. (2025) analyzed the dimensions of energy poverty in the Nigerian national economy using secondary data from the Nigerian National Bureau of Statistics and World Bank database from 2015 to 2023. Descriptive statistics and Ordinary Least Squares were used to measure the interconnectivity among access to electricity, GDP per capita and billed electricity, while the Augmented Dickey-Fuller test and Johansen cointegration test were used to determine stationarity and long-run equilibrium. The results showed that electricity consumption has a statistically significant positive effect on GDP per capita, but electricity access is not statistically significant. The study concluded that electricity reliability, rather than access, is crucial to economic growth.

Kpagih and Olise (2025) examined the relationship between energy poverty and industrialization in Nigeria between 1990 and 2021. Data from the World Bank, EIA and NNPC were subjected to an Augmented Dickey-Fuller unit-root test, which showed mixed order of integration, while the bounds cointegration test confirmed the existence of long-run relationships among the variables. The estimation results showed that energy poverty significantly impacts industrialization in Nigeria.

Nweke et al. (2025) investigated the structural and institutional factors perpetuating energy poverty in Nigeria, including systemic corruption, infrastructure decay and over-reliance on fossil fuels, drawing on empirical data from the Nigerian Electricity Regulatory Commission. Using a mixed-methods approach, the study found that energy poverty exacerbates industrial inefficiency, constrains educational attainment and deepens gender disparities.

Tubotamuno and Oladosu (2025) empirically examined the impact of energy poverty on industrial sector performance in Nigeria from 1990 to 2023, using access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption as proxies of energy poverty. Using the Augmented Dickey-Fuller test, bounds cointegration approach and ARDL technique, the study found that access to electricity and access to clean fuels and technologies have positive and significant effects on industrial output in both the short run and long run, while electricity tariff has a significant negative effect.

Saad et al. (2025) examined the impact of energy consumption on economic growth in Nigeria using time series data from 1980 to 2020 and the ARDL co-integration model. The results revealed a significant positive impact of electricity consumption on economic growth, and the study recommended strategies to further enhance energy efficiency and strengthen sustainable energy sources.

Oshio et al. (2024) examined the effects of energy poverty on the daily operations of small businesses in Benin City, Edo State, using a questionnaire survey of ten small businesses. The study found that most business owners relied on an inconsistent and inadequate electricity grid supply, with declining income, extra expenses on alternative power sources, and low patronage identified as key consequences of poor electricity supply on business operations.

Çelik and Polat (2024) investigated the linkage between energy access and economic growth in D-8 nations using annual data from 1990 to 2021 and the Augmented Mean Group estimator following PANIC and CIPS unit root and Durbin-Hausman co-integration tests. The study found no statistically significant relationship between energy poverty and economic growth, and recommended that the

energy factor be used more effectively in poverty reduction, particularly through the expansion of renewable energy sources.

Temitope et al. (2024) examined the effects of traditional energy consumption and poverty on the health status of rural dwellers in Nigeria using primary survey data from 1,044 respondents in Osun State. The study found that income as a proxy for poverty, and energy consumption for cooking and lighting, significantly explained the health status of rural dwellers, and recommended that government make clean and modern energy technologies available to rural households.

Atoyebi et al. (2023) empirically investigated the relationship between energy poverty and economic growth in Nigeria from 1990 to 2021 using descriptive statistics, Ordinary Least Squares and the Johansen cointegration test. The results showed a statistically significant positive relationship between access to electricity and economic growth, and a long-term equilibrium relationship between the variables.

Mmbaga et al. (2023) examined the energy consumption and economic growth nexus in the East African sub-region from 2012 to 2021 using Pooled Ordinary Least Squares, Fixed Effects and the Generalized Method of Moments. The study found that higher energy prices negatively affect economic growth, underlining the need for energy price stability.

Haliru (2023) evaluated the impact of energy consumption on green growth in Nigeria, with a focus on renewable energy, using time series data from 1980 to 2021 and the ARDL model. The study found a positive and statistically significant relationship between electricity consumption and green growth, and recommended that the Nigerian government pay more attention to the development of renewable energy sources.

Amadi et al. (2022) explored the relationship between energy poverty and economic development in Nigeria from 1990 to 2022, proxying energy poverty by access to electricity, renewable energy consumption, renewable energy output and electric power consumption, and economic development by Human Development Index, using the Augmented Dickey-Fuller test and the ARDL model. The findings showed that access to electricity and renewable energy consumption positively and significantly influenced the Human Development Index in the short run.

Babatunde et al. (2022) assessed the energy poverty status and determinants of energy poverty among rural households in Kwara State, Nigeria, using a four-staged random sampling technique to select 150 households. The study found that the majority of households used a combination of modern and transitional energy types, and that years of schooling, distance to energy source and household income significantly influenced energy poverty.

Iyabo and Segun (2022) examined the dynamic relationship among energy consumption, foreign direct investment and economic growth in Sub-Saharan Africa, using data from 42 countries spanning 1991 to 2018 and the Generalised Method of Moments. The findings showed that a percentage increase in energy consumption engenders economic growth by 1.3 percent, and the study advocated that governments in Sub-Saharan Africa should ensure more energy access to enhance economic growth.

Afaha and Ifarajimi (2021) determined the short and long-run effects of energy poverty and climate change on economic growth in Nigeria using the ARDL model and data from 1980 to 2018. The results indicated that energy poverty has a negative relationship with GDP growth, and that traditional and dangerous forms of energy use are predominant in Nigerian households.

Aigheyisi and Oligbi (2020) examined the development effect of energy poverty in Nigeria using the S-estimation method of the robust least squares estimator on annual time series data spanning 1990 to 2017. The study found that energy poverty adversely affects the nation's economic development, implying that improved access to electricity is development-enhancing.

Ekeocha et al. (2020) evaluated the relationship between energy consumption and economic growth in Nigeria over the period 1999Q1 to 2016Q4 using a nonlinear ARDL model and an ARDL-ECM specification. The study found that the role of energy consumption as a driver of growth remained negligible throughout, and that a unidirectional causality ran from energy consumption to economic growth, concluding that there is an urgent need for policies to address Nigeria's energy challenges.

Ekone and Amaghionyeodiwe (2020) examined the effect of renewable energy consumption on economic growth in Nigeria for the period 1990 to 2016 using descriptive analysis and econometric techniques including unit root, correlation, co-integration, regression and Granger causality tests. The study found that renewable energy consumption had no significant positive impact on economic growth and no causality between the variables.

Ishioro (2020) examined the relationship between energy consumption and economic growth in the Nigerian economy using five definitions of energy consumption within the Vector Auto-regression framework. The results showed evidence of substitutability of shocks among energy components and growth variables, and the study recommended that comprehensive energy consumption, labour and capital accumulation, and growth-enhancing policies be designed for the Nigerian economy.

Adegoriola and Agbanuji (2018) investigated the impact of electricity consumption on the Nigerian economy between 1986 and 2018 using the Autoregressive Distributed Lag Model. The results showed that electricity consumption and economic growth rate were positively and significantly correlated in the short run, but electricity consumption impacted negatively and insignificantly on economic growth in the long run. The study recommended measures to enhance efficient consumption of electricity to increase economic growth in Nigeria.

3 Methodology

The research design adopted in this study is ex-post facto research design, since it is based on facts or events that have already happened. Annual time series data ranging from 1990 to 2024 were used in this study. These data were sourced from the Central Bank of Nigeria Statistical Bulletin, World Development Indicators of the World Bank, National Bureau of Statistics reports, Africa Energy Portal and the International Energy Agency.

3.1 Model specification

Theoretically, the model for this study was based on the Energy Ladder Theory, which explains how improved access to modern, efficient energy sources enables households and firms to move up the energy ladder, thereby enhancing productivity and economic development. Empirically, the model for this study was adapted from the work of Amadi et al. (2022), who explored the relationship between energy poverty and economic development in Nigeria. This model was modified in line with the broad aim and specific objectives of this study to capture the effect of energy poverty indicators on Human Development Index in Nigeria.

3.1.1 Functional model

Expressing the model in functional form gives the equation below:

$$HDI_t = f(AEP_t, ETR_t, ACFT_t, REC_t) \quad (1)$$

3.1.2 Mathematical model

Expressing Equation (1) in mathematical form gives the equation below:

$$HDI_t = \beta_0 + \beta_1 AEP_t + \beta_2 ETR_t + \beta_3 ACFT_t + \beta_4 REC_t \quad (2)$$

3.1.3 Econometric model

Expressing Equation (2) in econometric form gives the equation below:

$$HDI_t = \beta_0 + \beta_1 AEP_t + \beta_2 ETR_t + \beta_3 ACFT_t + \beta_4 REC_t + \varepsilon_t \quad (3)$$

The log-linear form of the model, which was adopted for estimation, is specified as follows:

$$\ln HDI_t = \beta_0 + \beta_1 \ln AEP_t + \beta_2 \ln ETR_t + \beta_3 \ln ACFT_t + \beta_4 \ln REC_t + \varepsilon_t \quad (4)$$

Where: HDI = Human Development Index, AEP = Access to electricity (% of the population), ETR = Electricity tariff, ACFT = Access to clean fuels and technologies, REC = Renewable energy consumption (% of total final energy consumption), t = Time period, β_0 = Intercept, $\beta_1 - \beta_4$ = Coefficients of the explanatory variables, ε = Stochastic or error term.

A Priori Expectation: $\beta_1 > 0$; $\beta_2 < 0$; $\beta_3 > 0$; $\beta_4 > 0$

3.2 Variables description and a priori expectation

3.2.1 Dependent variable

Economic development is the dependent variable in this study and it is measured by Human Development Index.

Human Development Index: The Human Development Index (HDI) is a composite statistic developed by the United Nations Development Programme (UNDP) to measure a country's overall achievement in its social and economic dimensions, covering life expectancy, education and income per capita.

3.2.2 Independent variables

Energy poverty is the independent variable in this study and it is proxied by access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption.

Access to Electricity: This refers to the percentage of the population with a functional electricity connection. Based on economic theory, the study expects access to electricity to have a positive effect on Human Development Index: $\beta_1 > 0$.

Electricity Tariff: This refers to the pricing structure or rate charged by electricity providers for the consumption of electrical power. Based on economic theory, the study expects electricity tariff to have a negative effect on Human Development Index: $\beta_2 < 0$.

Access to Clean Fuels and Technologies: This measures the percentage of the population with access to and use of clean cooking fuels and technologies. Based on economic theory, the study expects access to clean fuels and technologies to have a positive effect on Human Development Index: $\beta_3 > 0$.

Renewable Energy Consumption: This refers to renewable energy consumption as a percentage of total final energy consumption. Based on economic theory, the study expects renewable energy consumption to have a positive effect on Human Development Index: $\beta_4 > 0$.

3.3 Data analysis techniques

The method of data analysis used in this study is the Autoregressive Distributed Lag (ARDL) technique. This approach includes descriptive statistics, the Augmented Dickey-Fuller unit root test, the ARDL bounds cointegration test, and the estimation of long-run and short-run parameters, with hypotheses tested at the 5% level of significance. Analysis was carried out using EViews statistical software version 12.

4 Data analysis and discussion of findings

4.1 Descriptive statistical analysis

Table 1 presents the descriptive statistics of the data for this study:

Table 1. Descriptive statistics.

	HDI _t	AEP _t	ETR _t	ACFT _t	REC _t
Mean	0.509143	48.17114	38.87457	3.000857	86.91714
Median	0.506000	50.13000	19.42000	1.960000	86.85000
Maximum	0.565000	60.16000	219.5900	9.030000	93.78000
Minimum	0.465000	27.30000	11.40000	0.220000	82.96000
Std. Dev.	0.032032	8.398479	50.37537	2.636580	1.925833
Skewness	0.159118	-0.495363	2.721029	0.783491	0.885756
Kurtosis	1.639469	2.379046	9.331770	2.311035	6.137277
Jarque-Bera	2.847133	1.993720	101.6565	4.273072	18.93027
Probability	0.240853	0.369036	0.000000	0.118063	0.000078
Sum	17.82000	1685.990	1360.610	105.0300	3042.100
Sum Sq. Dev.	0.034886	2398.171	86281.05	236.3529	126.1003
Observations	35	35	35	35	35

Source: Authors' Computation, 2026.

Table 1 shows that there are thirty-five (35) observations for each variable over the period 1990 to 2024. The average Human Development Index is 0.509, with a maximum of 0.565 and a minimum of 0.465, indicating gradual improvement in human development over the study period. The average access to electricity is 48.17%, ranging between 27.30% and 60.16%. The average electricity tariff is ₦38.87/kWh, with a high standard deviation of 50.38, reflecting substantial increases in tariffs in later years. The average access to clean fuels and technologies is 3.00%, while the average renewable energy consumption is 86.92% of total final energy consumption, reflecting Nigeria's continued reliance on biomass-based renewable sources such as firewood.

4.2 Pre-estimation tests

4.2.1 Unit root test

The Augmented Dickey-Fuller (ADF) unit root test was conducted to determine the stationarity properties of the variables and avoid spurious regression results. The results are presented in Table 2:

Table 2. Augmented Dickey-Fuller (ADF) unit root test results.

Variables	ADF	Mackinnon Critical Value @ 5%	P-value (Prob.*)	Decision	Order of Integration
At Levels					
$\ln \text{HDI}_t$	0.406697	-2.951125	0.9803	Non-stationary	
$\ln \text{AEP}_t$	-3.108235	-2.963972	0.0366	Stationary	
$\ln \text{ETR}_t$	3.388900	-2.963972	1.0000	Stationary	
$\ln \text{ACFT}_t$	-4.410253	-2.951125	0.0013	Stationary	
$\ln \text{REC}_t$	-0.961555	-2.951125	0.7556	Non-stationary	
At First Difference					
$\ln \text{HDI}_t$	-6.437183	-2.954021	0.0000	Stationary	I(1)
$\ln \text{AEP}_t$	-	-	-	-	I(0)
$\ln \text{ETR}_t$	-	-	-	-	I(0)
$\ln \text{ACFT}_t$	-	-	-	-	I(0)
$\ln \text{REC}_t$	-5.039069	-2.954021	0.0002	Stationary	I(1)

Source: Authors' Computation, 2026.

Table 2 shows that Human Development Index and renewable energy consumption were non-stationary at level but became stationary after first differencing, that is, integrated of order one [I(1)]. On the other hand, access to electricity, electricity tariff, and access to clean fuels and technologies were stationary at level, that is, integrated of order zero [I(0)]. This mixed order of integration justifies the adoption of the Autoregressive Distributed Lag (ARDL) estimation technique, which is appropriate when variables are integrated at I(0), I(1), or a combination of both.

4.2.2 ARDL bounds cointegration test

Having established a mixture of variables of order I(0) and I(1), the bounds testing technique was used to test for cointegration. The result of the ARDL Bounds Cointegration Test for this study is reported in Table 3:

Table 3. ARDL bounds cointegration test result.

Significant Level	I(0) Bound	I(1) Bound	Hypothesis	F-Statistics
10%	2.2	3.09	H0: There is long run relationship	11.55044***
5%	2.56	3.49		
2.5%	2.88	3.87		
1%	3.29	4.37		

Source: Authors' Computation, 2026.

The result of the ARDL Bounds Test presented in Table 3 shows that the computed F-statistic (11.55044) is greater than the upper bound critical values of 3.09, 3.49, 3.87 and 4.37 at the 10%, 5%, 2.5% and 1% significance levels respectively. Hence, there is sufficient statistical evidence to reject the null hypothesis of no cointegration and conclude that there exists a long-run relationship among Human Development Index, access to electricity, electricity tariff, access to clean fuels and technologies, and renewable energy consumption. The confirmation of long-run dynamics among the variables gives credence to the estimation of the ARDL long-run and short-run parameters for the Human Development Index model.

4.3 Autoregressive distributed lag (ARDL) estimation

The long-run and short-run dynamic effects of energy poverty on Human Development Index in Nigeria were estimated using the ARDL method. The results are presented in Table 4:

Table 4. ARDL long-run and short-run estimation results (dependent variable: lnHDI).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ARDL Long-Run Results				
lnAEP	1.127597	0.139996	8.054500	0.0000
lnETR	-2.567431	0.243809	-10.53049	0.0000
lnACFT	0.255624	0.142374	1.795435	0.1062
lnREC	4.196303	0.362284	11.58290	0.0000
C	-0.424115	0.177213	-2.393246	0.0293
ARDL Short-Run Results				
D(lnAEP)	3.214331	0.551082	5.832765	0.0002
D(lnETR)	-0.018191	0.004498	-4.044377	0.0009
D(lnACFT)	0.611356	0.370158	1.651607	0.1330
D(lnACFT(-1))	0.230528	0.105988	2.175039	0.0496
D(lnREC)	5.087562	1.170779	4.345452	0.0019
CointEq(-1)*	-0.626886	0.054188	-11.56881	0.0000
Adjusted R ² = 0.823685; Durbin-Watson stat = 2.174190				

Source: Authors' Computation, 2026.

From the ARDL long-run estimate results in Table 4, access to electricity has a positive coefficient value of 1.127597 and a p-value of 0.0000, which is less than 0.05, indicating that access to electricity has a positive and significant effect on Human Development Index in Nigeria in the long run. Also, the short-run estimate shows a positive coefficient of 3.214331 with a p-value of 0.0002, confirming a positive and significant effect in the short run as well.

Electricity tariff has a negative coefficient value of -2.567431 ($p = 0.0000$) in the long run and -0.018191 ($p = 0.0009$) in the short run, indicating that electricity tariff has a negative and significant effect on Human Development Index in Nigeria in both the short run and long run.

Access to clean fuels and technologies has a positive coefficient value of 0.255624 ($p = 0.1062$) in the long run and 0.611356 ($p = 0.1330$) in the short run, both of which are greater than 0.05, indicating

that access to clean fuels and technologies has a positive but non-significant effect on Human Development Index in Nigeria in both the short run and long run.

Renewable energy consumption has a positive coefficient value of 4.196303 ($p = 0.0000$) in the long run, indicating a positive and significant effect on Human Development Index in the long run. In the short run, the one-period lag of renewable energy consumption has a coefficient of 0.230528 with a p -value of 0.0496, which is marginally significant at the 5% level.

The error correction coefficient, $CointEq(-1)$, is -0.626886 with a p -value of 0.0000, which is highly significant, negative, and less than one in absolute value, as theoretically expected. This indicates a high speed of adjustment to equilibrium, implying that approximately 63% of any deviation from long-run equilibrium in Human Development Index is corrected within one year. The Adjusted R -squared value of 0.823685 indicates that the model is well fitted, as changes in access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption jointly explain approximately 82% of the variation in Human Development Index in Nigeria, while the remaining 18% is explained by factors outside the model. The Durbin-Watson statistic of 2.174190, being approximately 2, indicates the absence of serial autocorrelation in the model.

4.4 Post-estimation tests

In order to ensure the reliability of the model, residual and stability diagnostic tests were conducted. The results are presented in Table 5:

Table 5. Post-estimation test results.

Test	Null Hypothesis (H_0)	Test Type	F-stat.	Prob.
Normality Test	Normal distribution exists	Jarque-Bera Test	1.012379	0.6028
Serial Correlation Test	Serial correlation does not exist	Breusch-Godfrey LM Test	0.929849	0.4177
Heteroscedasticity Test	Homoscedasticity exists	Breusch-Pagan-Godfrey	1.689118	0.1568
Functional Form Test	Model is stable	Ramsey RESET	1.560470	0.1395

Source: Authors' Computation, 2026.

The Jarque-Bera test result shows a probability value of 0.6028, which is greater than 0.05, indicating that the residuals are normally distributed. The Breusch-Godfrey test shows a probability value of 0.4177, greater than 0.05, indicating the model is free from serial correlation. The Breusch-Pagan-Godfrey test shows a probability value of 0.1568, greater than 0.05, indicating the presence of homoscedasticity, meaning relevant variables were not omitted. Lastly, the Ramsey RESET test shows a probability value of 0.1395, greater than 0.05, indicating that the model is correctly specified. The cumulative sum (CUSUM) stability test further confirmed that the CUSUM line remained within the 5% critical bounds, indicating stability of the long-run coefficients of the model.

4.5 Discussion of findings

Evidence that emerged from the study showed that access to electricity has a positive and significant effect on Human Development Index in Nigeria in both the short run and long run. This implies that increased access to electricity contributes substantially to improvements in living standards, education, healthcare delivery and income generation in Nigeria. This finding aligns with Aigheyisi and Oligbi (2020), who found that energy poverty adversely affects economic development in Nigeria and

that improved access to electricity enhances development outcomes. The finding is also consistent with Atoyebi et al. (2023), who established a statistically significant positive relationship between access to electricity and economic growth in Nigeria, and with Saad et al. (2025), who reported that electricity consumption positively and significantly influences economic growth. The finding further supports Amadi et al. (2022), who found that access to electricity positively and significantly improves the Human Development Index in Nigeria, and corroborates Tubotamuno and Oladosu (2025), who found that electricity access positively and significantly affects industrial output in Nigeria. However, the result contradicts Çelik and Polat (2024), who found no statistically significant relationship between energy poverty and economic growth in D-8 nations, a divergence that may arise from differences in methodology, sample composition and the developmental peculiarities of Nigeria compared to other D-8 countries.

The study further revealed that electricity tariff has a negative and significant effect on Human Development Index in Nigeria in both the short run and long run. This implies that rising electricity tariffs worsen living conditions and reduce economic welfare among households and businesses, increasing production costs for firms and reducing disposable income for households. This finding supports Oshio et al. (2024), who found that inconsistent and inadequate electricity supply leads to declining business income and additional operational costs among small businesses in Nigeria, and aligns with Mmbaga et al. (2023), who concluded that high energy prices negatively affect economic growth and emphasized the need for energy price stability. The finding also agrees with Tubotamuno and Oladosu (2025), who found that electricity tariff exerts a significant negative effect on industrial output in Nigeria.

The findings additionally showed that access to clean fuels and technologies exerts a positive but non-significant effect on Human Development Index in Nigeria in both the short run and long run. This implies that although access to clean fuels and modern energy technologies has the potential to improve living standards, the current level of adoption and utilization in Nigeria remains inadequate to produce statistically significant development outcomes. This finding aligns with Ekone and Amaghionyeodiwe (2020), who found that renewable energy consumption exerts an insignificant effect on economic growth in Nigeria, and with Temitope et al. (2024), who emphasized that poor households face difficulties accessing clean and modern energy technologies due to poverty conditions. The result similarly corroborates Afaha and Ifarajimi (2021), who reported that traditional and unsafe energy sources remain predominant in Nigerian households, thereby limiting the benefits of modern clean energy adoption.

The study also established that renewable energy consumption exerts a positive and significant effect on Human Development Index in Nigeria in the long run. This implies that renewable energy development contributes to improvements in education, healthcare and income dimensions of human development over time. This finding is consistent with Haliru (2023), who found that renewable energy positively and significantly contributes to green growth in Nigeria, and agrees with Amadi et al. (2022), who found that renewable energy consumption positively influences the Human Development Index in Nigeria. However, the result contradicts Ekeocha et al. (2020) and Ekone and Amaghionyeodiwe (2020), who reported negligible or insignificant effects of energy consumption on economic growth in Nigeria, a disparity that may be attributable to differences in proxies, estimation methods and periods of analysis.

5 Conclusion and recommendations

5.1 Conclusion

This study examined the effect of energy poverty on economic development in Nigeria, proxying energy poverty by access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption, and economic development by Human Development Index. Theoretically, the study found that energy plays a central role in the economic development of resource-rich but energy-poor nations such as Nigeria, which depends heavily on reliable energy access to drive productivity, industrialization and human welfare. Empirically, the study showed that access to electricity, electricity tariff, access to clean fuels and technologies and renewable energy consumption have a joint significant effect on Human Development Index in Nigeria. Based on the findings, the study concludes that energy poverty has a significant effect on economic development in Nigeria.

5.2 Recommendations

Based on the above findings and conclusion, the following recommendations are made:

1. The Nigerian government should prioritize expanding access to reliable electricity supply through increased investment in power generation, transmission and distribution infrastructure. Greater attention should also be given to rural electrification and decentralized energy systems such as mini-grids and solar-powered solutions to reduce regional energy inequality.
2. Government and regulatory authorities, such as the Nigerian Electricity Regulatory Commission, should implement electricity tariff reforms that balance cost recovery with affordability for households and businesses. Tariff increases should be gradual, transparent and accompanied by service delivery improvements, with subsidies or targeted support programs introduced for low-income households and small businesses.
3. The government should intensify policies that promote access to clean fuels and modern energy technologies across urban and rural communities, including incentives for clean cooking technologies, tax relief for renewable energy equipment, and public awareness campaigns on the socioeconomic benefits of modern energy use.
4. The Nigerian government should strengthen investment in renewable energy development and local renewable energy industries such as solar, wind, biomass and small hydropower projects, while encouraging private sector participation, research and development, and local manufacturing of renewable energy technologies to ensure sustainable economic development.

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