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Energy Consumption And Nigeria's Economic Development

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ABSTRACT

This study examines the impact of energy consumption on economic development in Nigeria from 1986 to 2024, a period marked by significant energy sector reforms and persistent developmental challenges. Against the backdrop of Nigeria's paradoxical position as an energy-rich nation plagued by underdevelopment, the research investigates the distinct effects of key energy variables—electricity generation, per capita energy consumption, oil revenue, and total energy consumption—on the Human Development Index (HDI). Employing an ex-post facto research design and utilizing secondary time-series data, the study applied the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration and error correction modeling. The empirical findings reveal a complex and dysfunctional energy-development nexus: oil revenue exhibits a significant negative long-run relationship with HDI, providing strong evidence for the resource curse phenomenon. Similarly, per capita energy consumption shows a counterintuitive negative impact, indicating severe distributional inefficiencies. While total energy consumption demonstrates a positive and significant relationship with HDI, affirming its role as a driver of aggregate economic activity, electricity generation is found to have an insignificant long-run impact, starkly highlighting the critical failure of power sector infrastructure. The study concludes that Nigeria's energy sector is characterized by a triple paradox, where resource wealth undermines development, average energy access does not translate to well-being, and increased power generation fails to impact human development outcomes. It therefore recommends comprehensive policy reforms focused on oil revenue governance, equitable energy access, support for industrial energy demand, and a holistic overhaul of the electricity value chain to realign the energy sector with sustainable human development goals

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INTRODUCTION

Background to the Study

The intrinsic nexus between energy consumption and economic development is a cornerstone of modern economic theory and a empirically validated phenomenon globally. Energy, particularly electricity and petroleum products, serves as the lifeblood of industrial production, agricultural modernization, service delivery, and overall socio-economic advancement. It is a critical factor of production that powers machinery, enables technology adoption, and improves productivity and human welfare. The seminal work of Kraft and Kraft (1978) initially established a causal relationship between energy and economic growth for the United States, a finding that has been tested in various contexts, including developing economies. Nigeria, as the most populous nation in Africa and its largest economy, presents a profound and paradoxical case study.

Endowed with abundant energy resources, including vast reserves of crude oil (the mainstay of its economy for over five decades) and significant potential for renewable energy such as solar, hydro, and wind, the country's economic development trajectory has been inextricably linked to its energy sector. The period from 1986 is particularly significant as it marks the inception of the Structural Adjustment Programme (SAP), a pivotal moment of economic liberalization that fundamentally altered the nation's economic management and its relationship with the energy sector (Okonkwo, 2022). Following the oil boom of the 1970s, the Nigerian economy became overwhelmingly dependent on petroleum exports, leading to the "Dutch Disease" and the neglect of other sectors, including manufacturing and agriculture. The post-1986 era witnessed fluctuating oil prices, policy shifts, and persistent challenges in translating energy wealth into sustainable, broad-based economic development. Despite being a top oil exporter, Nigeria suffers from a chronic domestic energy crisis, characterized by inadequate electricity generation, inefficient refining capacity, and heavy reliance on imported refined petroleum products (World Bank, 2023). This paradox of "resource richness" coexisting with "energy poverty" and stunted industrial growth underscores the critical need to re-examine the impact of energy on Nigeria's economic development over this extended and dynamic period.

Statement of the Problem

Despite Nigeria's immense endowment of both fossil and renewable energy resources, its trajectory of economic development from 1986 to the present has been markedly suboptimal. This period is characterized by low and non-inclusive growth, persistently high unemployment rates, a continued decline in the manufacturing sector's contribution to GDP, and pervasive poverty. The central problem this study confronts is the persistent and puzzling disconnect between the nation's vast energy wealth and its failure to catalyze broad-based, sustainable economic development. This disconnection creates a critical research gap, which this study aims to fill by systematically investigating the distinct impacts of different energy sources, as outlined in the objectives. The first dimension of this problem is the perennial crisis in the power sector. Nigeria, with a population exceeding 200 million, has an installed grid capacity of about

13,000 MW but routinely delivers less than 4,500 MW, with actual grid supply often hovering around 4,000 MW on its best days (World Bank, 2023). This profound electricity deficit compels businesses and households to spend an estimated $14 billion annually on expensive and polluting petrol and diesel generators (International Energy Agency [IEA], 2023). This self-generation imposes a crippling cost on productive activities, severely erodes profitability, and renders Nigerian manufactured goods uncompetitive, thereby stifling the very industrialisation that is crucial for economic development (National Bureau of Statistics [NBS], 2022).

The second dimension, revolves around the profound inefficiencies and paradoxes within the oil and gas sector. As the primary source of foreign exchange and government revenue, the sector is perpetually hampered by crude oil theft, pipeline vandalism, and an acute lack of domestic refining capacity. This has resulted in the unsustainable situation where Nigeria exports crude oil but imports over 90% of its refined petroleum products, leading to massive subsidy expenditures that consumed over ₦4.3 trillion (approximately $5 billion) in 2022 alone (NNPC Limited, 2023). These subsidies have historically crowded out essential public investments in infrastructure, health, and education, thereby undermining long-term economic development and macroeconomic stability (World Bank, 2023). The third and increasingly critical dimension of the problem, concerns the quality and sustainability of the energy mix. The global transition towards a low-carbon economy poses an existential threat to Nigeria's oil-dependent fiscal and economic structure.

Despite possessing enormous solar, hydro, and wind potential, the country has been slow to diversify its energy portfolio and integrate modern renewables at scale. As of 2023, renewable sources (excluding large-scale hydro) contributed less than 2% to the national energy mix (International Renewable Energy Agency [IRENA], 2023). This lag threatens to lock Nigeria into an obsolete energy model, missing the opportunity for a more decentralized, cost-effective, and sustainable energy pathway that could power inclusive growth, as envisioned in its own Energy Transition Plan (Federal Government of Nigeria, 2023). Therefore, this study examines the relationship between energy consumption -development nexus in Nigeria. It seeks to systematically investigate, quantify, and differentiate the impacts of Nigeria's specific energy subsystems—electric power, renewable sources, and oil revenues—on economic development indicators from 1986 to 2024, thereby providing a nuanced evidence base for targeted policy intervention

Objective of the Study

The broad objective of this study is to examine the impact of energy consumption on Nigeria's economic development from 1986 to 2024. The specific objectives are:

1. To analyze the relationship between electricity generation and economic development in Nigeria.
2. To assess the relationship between per-capita energy consumption and economic development in Nigeria.
3. To evaluate the impact of oil revenue on economic development in Nigeria.
4. To evaluate the impact of total energy consumption on economic development in Nigeria.

Research Questions

The following research questions have been formulated to guide this investigation:

1. What is the relationship between electricity generation and economic development in Nigeria?
2. To what extent does per-capita energy consumption relate to economic development in Nigeria?
3. How has oil revenue impacted economic development in Nigeria?
4. To what extent does total energy consumption relate to economic development in Nigeria?

Research Hypothesis

The following null hypotheses will be tested in this study:

- **H_{01}:** There is no statistically significant relationship between electricity generation and economic development in Nigeria.
- **H_{02}:** There is no statistically significant relationship between per-capita energy consumption and economic development in Nigeria.
- **H_{03}:** Oil revenue has no statistically significant impact on economic development in Nigeria.
- **$H_0$4:** There is no statistically significant relationship between total energy consumption and economic development in Nigeria.

LITERATURE REVIEW

Conceptual Literature

Concept of Energy Consumption

Energy consumption refers to the total amount of energy utilized by a nation's economy, encompassing all primary fuels and sources for power generation, transportation, industrial processes, and residential use. In contemporary economics, it is not merely an intermediate input but a fundamental pillar of production and consumption, directly influencing productivity, technological advancement, and quality of life (Olanrewaju et al., 2023). For a developing nation like Nigeria, total energy consumption includes traditional biomass (often unrecorded in official statistics), fossil fuels (petroleum products, natural gas), and modern renewables. The structure and efficiency of this consumption are critical indicators of the level and sustainability of economic activity.

Concept of Electricity Generation

Electricity generation is the process of creating electric power from primary energy sources. It is a more refined and critical subset of overall energy consumption, representing the most versatile and efficient form of energy for modern industrial and service economies. Adequate and reliable electricity generation is a prerequisite for technological adoption, operational efficiency in manufacturing, and the provision of essential services like healthcare and education (Adewuyi, 2022). In Nigeria, the discourse revolves around the stark disparity between installed capacity, available capacity, and actual generation, with the latter being the true measure of the power available to drive the economy.

Concept of Renewable Energy Consumption

Renewable energy consumption entails the utilization of energy derived from naturally replenishing sources such as sunlight, wind, water (hydro), geothermal heat, and biofuels. Its conceptual importance has evolved from being a niche alternative to a central strategy for achieving energy security, reducing carbon emissions, and fostering sustainable development (IRENA, 2023). In the Nigerian context, this concept includes both large-scale hydroelectric power and non-hydro renewables like solar, wind, and biomass-based power. Its significance lies in its potential to decentralize energy access, reduce the nation's reliance on fossil fuels, and provide a cleaner path to economic development (Eleri & Onuvae, 2024).

Concept of Oil Revenue

Oil revenue constitutes the income accruing to a government and economy from the exploration and sale of crude oil. This includes taxes, royalties, profit shares from joint ventures, and proceeds from the state's equity oil. Conceptually, oil revenue is a dominant feature of "rentier states," where public finance is heavily dependent on external rents rather than domestic taxation (Uche et al., 2023). In Nigeria, oil revenue is the principal source of foreign exchange earnings and a major determinant of fiscal policy, making the economy highly vulnerable to volatile international oil prices. The "resource curse" thesis often frames the discussion, highlighting the paradox where abundant resource revenue can lead to economic instability, corruption, and the neglect of other sectors.

Concept of Economic Development

Economic development transcends narrow metrics like Gross Domestic Product (GDP) growth. It is a multidimensional concept encompassing sustained, inclusive improvements in the economic and social well-being of a populace. Key indicators include rising per capita income, reduction in poverty and unemployment, structural transformation from an agrarian to an industrial and service-based economy, and improvements in non-income dimensions of welfare such as health (life expectancy) and education (literacy rates), often captured by the Human Development Index (HDI) (UNDP, 2022). For this study, economic development is measured not just by the growth of GDP but also by

the performance of the manufacturing sector and broader human development metrics.

Energy-Development Nexus in Nigeria

The energy-development nexus in Nigeria describes the complex and often dysfunctional relationship between the country's energy sector and its socio-economic progress. Conceptually, this nexus is characterized by a dual paradox: the paradox of "poverty amidst plenty" in the oil sector and the paradox of "energy scarcity amidst abundance" in the power sector (Ayodele & Moshood, 2024). The expected virtuous cycle—where energy availability fuels productivity, which in turn generates revenue for further energy investment—is broken. Instead, the nexus is marked by a feedback loop where energy deficits constrain economic output, leading to lower investment in the energy sector, further perpetuating underdevelopment.

Theoretical Literature

The study is anchored on three interconnected theoretical frameworks:

- The Growth Theory: Modern extensions of the Solow-Swan and endogenous growth models recognize energy not just as a minor input but as a critical factor that can directly influence the total factor productivity (TFP) of an economy. Energy-efficient technologies and reliable power are seen as key drivers of technological progress, a core element of endogenous growth (Adewuyi, 2022).
- The Resource Curse Theory: Also known as the "paradox of plenty," this theory posits that countries with an abundance of natural resources, like Nigeria's oil, tend to have less economic growth and worse development outcomes than countries with fewer natural resources. The mechanisms include Dutch Disease, where the resource sector crowds out manufacturing; price volatility; and rent-seeking behavior that lead to corruption and weak institutions (Uche et al., 2023).
- The Sustainable Development Theory: This framework emphasizes the need to meet present development needs without compromising the ability of future generations to meet their own. It directly informs the analysis of renewable energy consumption, advocating for a transition from a hydrocarbon-based economy to a sustainable one that balances economic, social, and environmental objectives (Federal Government of Nigeria, 2023).

Empirical Literature

A substantial body of empirical work has investigated aspects of the energy-growth nexus in Nigeria, with mixed findings. On electricity generation, numerous studies confirm its critical role. A study by Adeleye et al. (2023) employing an ARDL model from 1980-2020 found a significant long-run relationship between electricity access and GDP growth, but also identified the infrastructure gap as a major binding constraint. Their findings align with earlier work but emphasize the deteriorating situation in the post-privatization era. Regarding oil revenue, the evidence largely supports the resource curse hypothesis. Research by Okonkwo (2022) demonstrated a strong positive correlation between oil revenue and government expenditure, but a weak and often negative relationship with HDI, citing mismanagement and corruption as

key transmission channels of the curse. Similarly, a World Bank (2023) report highlighted how fuel subsidies, funded by oil revenue, have created massive fiscal burdens, crowding out productive public investment. The literature on renewable energy is emerging but growing. A recent study by Olanrewaju et al. (2023) used a multivariate framework to show that while the current contribution of non-hydro renewables to GDP is minimal, investment in renewables has a strong potential for future job creation and decentralized power generation. Eleri and Onuvae (2024) provided a qualitative analysis, arguing that Nigeria's Energy Transition Plan is theoretically sound but practically hampered by inadequate financing and policy implementation, limiting the measurable impact of renewable consumption on development so far.

However, many existing studies suffer from limitations. Several focus on a narrow time frame, ending before critical recent developments like the PIA (2021) and the full impact of the COVID-19 pandemic. Furthermore, many studies treat "energy" as a monolithic variable or focus on only one sub-sector (e.g., only electricity or only oil), failing to provide a comparative analysis of the distinct impacts of different energy sources as proposed in this study.

Summary of Literature and Gap

The extant literature firmly establishes the theoretical significance of energy for development and provides substantial empirical evidence of Nigeria's energy crises and their adverse economic effects; however, a clear gap exists in the scarcity of comprehensive, updated studies that simultaneously model and compare the impact of electricity generation, renewable energy consumption, and oil revenue on multi-dimensional economic development indicators over the policy-rich period from 1986 to 2024, which this study aims to fill through a holistic econometric analysis to provide nuanced insights for targeted policy formulation.

METHODOLOGY

Research Design

This study will employ an ex-post facto research design utilizing a quantitative approach. This design is appropriate because the research involves investigating phenomena that have already occurred and where the variables cannot be manipulated by the researcher. The study will use secondary time-series data from 1986 to 2024 to establish relationships and test the stated hypotheses.

Sources of Data

This study will utilize secondary annual time-series data from 1986 to 2024, sourced from reputable national and international institutions: the Central Bank of Nigeria (Statistical Bulletin, 2023) for oil revenue and real GDP data; the World Bank (World Development Indicators, 2024) for GDP per capita and electricity generation; the International Renewable Energy Agency (Data & Statistics, 2024) for renewable energy consumption metrics; and the National Bureau of Statistics (2024) for complementary socio-economic indicators, ensuring a robust and comprehensive dataset for analysis.

Model Specification

To achieve the objectives of this study, multiple econometric models will be specified. The core models are adapted from the work of Adeleye et al. (2023) and Olanrewaju et al. (2023) and specified as follows:

$$\mathbf{HDI_t = \beta_0 + \beta_1 ELECGEN_t + \beta_2 PCENERC_t + \beta_3 OILREV_t + + \beta_4 TENRCt + \varepsilon_t}$$

Where: HDI_t represents Economic Development, proxied by Human Capital Development Index in year t, $ELECGEN_t$ represents Electricity Generation (GWh) in year t, $PCENERC_t$ represents Per-Capita Energy Consumption (KWh) in year t, $OILREV_t$ represents Oil Revenue (as a percentage of total government revenue) in year t, and $TENRC_t$ represent Total Energy Consupmtion ε_t is the stochastic error term, β_0 is the constant intercept, and β_1, β_2, β_3 are the coefficients to be estimated.

Estimation Procedure

The estimation procedure will follow a systematic econometric approach beginning with testing the stationarity of the time-series variables using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests to determine their order of integration and avoid spurious regression. Following this, if variables are integrated of order one, I(1), the Autoregressive Distributed Lag (ARDL) bounds testing approach will be employed to examine cointegration, valued for its flexibility with small samples and mixed integration orders. Once a long-run relationship is established, the long-run coefficients will be derived from the ARDL model, while short-run dynamics and the speed of adjustment to equilibrium will be captured through an Error Correction Model (ECM). The model will then undergo diagnostic checks for serial correlation, heteroscedasticity, functional form, and normality, with coefficient stability verified using CUSUM and CUSUMSQ tests, culminating in hypothesis testing where the null hypotheses (H_{01}, H_{02}, H_{03}) will be evaluated using t-tests on the relevant long-run coefficients at a 5% significance level, with all analyses conducted in EViews 13.

RESULT AND DISCUSSION

Data Presentation, Analysis and Interpretation

Data Presentation

This section provides an overview of the data and methodology used to examine the factors influencing energy consumption on economic development in Nigeria from 1986 to 2024. The analysis focuses on five key variables, each representing a critical dimension of Nigeria's economic and social landscape. The dependent variable, the Human Development Index (HDI), is a composite statistic of life expectancy, education, and per capita income indicators, used to rank countries into tiers of human development. It serves as the primary measure of societal well-being in this study. The independent variables include Electricity Generation (ELECGEN) in GWh, which represents the total domestic power generation. Reliable electricity is a fundamental infrastructure that impacts health, education, and economic activities, directly influencing human development. Per Capita Energy Consumption (PCENERC) in kWh measures

the average energy use per person, serving as a proxy for access to modern energy services and overall standard of living.

Oil Revenue (OILREV) in billions of Naira captures the government's earnings from the petroleum sector. As the mainstay of the Nigerian economy, oil revenues are crucial for public spending on health, education, and other social services that drive HDI. Finally, Total Energy Consumption (TENRC) in thousand tonnes of oil equivalent reflects the aggregate energy demand of the economy, indicating the level of industrial and economic activity which can create the conditions for improved human development. This data presentation analyzes Nigeria's development trajectory from 1986 to 2024, tracing the evolution of the Human Development Index (HDI) which shows a steady climb from 0.385 to 0.538, against key economic indicators: Electricity Generation (ELECGEN) surged from 9,500 to 30,000 GWh, Total Energy Consumption (TENRC) more than doubled from 980 to 2170, while Per Capita Energy Consumption (PCENERC) remained stagnant and Oil Revenue (OILREV) exhibited significant volatility, fluctuating dramatically between 52.8 and 88.2 billion Naira, collectively painting a picture of macroeconomic growth with uneven distribution of benefits across the 38-year period.

Augmented Dickey-Fuller Test (Unit Root Test)

To ensure the validity of the regression estimates and avoid spurious results, the stationarity properties of the variables were tested using the Augmented Dickey-Fuller (ADF) test at the 5% significance level. The results are summarized in Table 4.1.

Table 4.1 Analysis of Augmented Dickey Fuller Test at 0.05 Significance Level

Parameters	ADF Test Statistic	5% Critical Value	Integration Order	Conclusion
HDI	1.747023	-2.941145	I(1)	Ho Not Rejected
ELECGEN	1.292604	-2.941145	I(1)	Ho Not Rejected
PCENERC	-6.297376	-2.943427	I(0)	Ho Rejected
OILREV	-0.976035	-2.945842	I(1)	Ho Not Rejected
TENRC	1.514010	-2.941145	I(1)	Ho Not Rejected

Source: Result Output, 2025

The ADF test results in Table 4.1 indicate that Per Capita Energy Consumption (PCENERC) is stationary at level, denoted as I(0). However, Human Development Index (HDI), Electricity Generation (ELECGEN), Oil Revenue (OILREV), and Total Energy Consumption (TENRC) all contain unit

roots at their levels but become stationary after first differencing, hence they are integrated of order one, I(1). Given that the variables are a mixture of I(0) and I(1), the Auto-Regressive Distributed Lag (ARDL) model is the most appropriate estimation technique for this study.

Data Analysis

Bound Test for Auto-Regressive Distributed Lag Co-integration

The ARDL bounds test was conducted to investigate the existence of a long-run relationship between HDI and the explanatory variables. An ARDL(3, 2, 4, 3, 4) model was selected based on the Akaike Information Criterion (AIC). The result of the F-bounds test is presented below.

Table 4.2 ARDL Bounds Test for Cointegration

Test Statistic	Value	Significance	I(0) Bound	I(1) Bound
F-statistic	**4.474173**	5%	2.947	4.088

Source: Result Output, 2025

The F-statistic of 4.474173 is compared with the critical value bounds at the 5% significance level. Since the calculated F-statistic lies between the lower I(0) bound (2.947) and the upper I(1) bound (4.088), the result is inconclusive based on the asymptotic critical values. However, using the approximate critical values for a sample size of 35, the F-statistic exceeds the 5% I(0) bound (2.947), suggesting evidence of a long-run relationship. For robustness, we proceed under the conclusion that a stable long-run relationship exists among the variables.

Estimated Long-Run Coefficients

The estimated long-run coefficients derived from the ARDL model are presented in Table 4.3. These coefficients explain the sustained impact of the independent variables on Nigeria's HDI.

Table 4.3 ARDL Long-Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ELECGEN(-1)	0.00000155	0.000000862	1.7996	0.0820
PCENERC(-1)	-0.0000146	0.00000396	-3.6825	0.0009
OILREV(-1)	-0.001096	0.000447	-2.4518	0.0203
TENRC(-1)	0.0000679	0.0000127	5.3603	0.0000
C	0.579692	0.092412	6.2729	0.0000

Source: Result Output, 2025

The long-run results reveal insightful dynamics:

Electricity Generation (ELECGEN) has a positive but marginally insignificant effect on HDI in the long run (p-value = 0.0820). This suggests that while increased power generation may contribute to human development, the effect is not strongly statistically definitive at the 5% level.

Per Capita Energy Consumption (PCENERC) exhibits a negative and statistically significant relationship with HI (coefficient = -0.0000146, p-value = 0.0009). This counterintuitive result may indicate inefficiencies in energy use or that the benefits of energy consumption in Nigeria are not effectively translating into improved health and education outcomes.

Oil Revenue (OILREV) also shows a negative and significant long-run impact on HDI (coefficient = -0.001096, p-value = 0.0203). This finding supports the "resource curse" hypothesis, suggesting that oil revenues in Nigeria may not have been effectively channeled into human capital development and may even be associated with governance challenges that hinder social progress.

Total Energy Consumption (TENRC) has a positive and highly significant effect on HDI (coefficient = 0.0000679, p-value = 0.0000). This implies that a broader increase in the nation's total energy consumption, which reflects overall economic and industrial activity, is strongly associated with improvements in human development.

Short-Run Dynamics (Error Correction Model)

The short-run dynamics of the model, captured by the Error Correction Model (ECM), are presented in Table 4.4. The ECM describes how the variables adjust in the short term towards their long-run equilibrium.

Table 4.4 ARDL Error Correction Representation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ(-1)	-0.551841	0.091426	-6.0359	0.0000
D(HDI(-1))	-1.313919	0.250276	-5.2499	0.0000
D(HDI(-2))	-0.851730	0.195544	-4.3557	0.0003
D(ELECGEN)	-0.00000402	0.000000591	-6.7985	0.0000
D(OILREV)	0.000745	0.0000895	8.3171	0.0000
D(TENRC)	0.0000811	0.0000301	2.6995	0.0142

Source: Result Output, 2025

The key finding from the ECM is the highly significant and negative error correction term, COINTEQ(-1), with a coefficient of -0.5518 (p-value = 0.0000). This implies that approximately 55.18% of any disequilibrium from the long-run relationship is corrected within one year, indicating a moderately speedy adjustment back to equilibrium. In the short run: Changes in Electricity Generation (D(ELECGEN)) have a significant negative immediate impact, which contrasts with its positive long-run effect. Changes in Oil Revenue (D(OILREV)) have a strong positive immediate effect (coefficient = 0.000745), contrasting with its negative long-run effect. This may reflect temporary boosts in government spending. Changes in Total Energy Consumption (D(TENRC)) have a positive and significant short-run effect, consistent with its long-run impact.

Hypothesis Testing

The ARDL long-run estimates presented in Table 4.3 are used to test the study's hypotheses at the 5% significance level ($\alpha = 0.05$).

- Hypothesis 1 (H_{01}): Electricity generation does not have a significant long-run impact on HDI in Nigeria.
  Decision: Fail to Reject H_{01}. The p-value of 0.0820 is greater than 0.05.
  Conclusion: There is insufficient evidence to conclude a statistically significant long-run relationship between electricity generation and HDI at the 5% level, though the positive coefficient suggests a potential weak relationship.
- Hypothesis 2 (H_{02}): Per capita energy consumption does not have a significant long-run impact on HDI in Nigeria.
  Decision: Reject H_{02}. The p-value of 0.0009 is less than 0.05.
  Conclusion: There is a statistically significant negative long-run relationship between per capita energy consumption and HDI. This suggests that increases in per capita energy use have not translated into proportional improvements in human development.
- Hypothesis 3 (H_{03}): Oil revenue does not have a significant long-run impact on HDI in Nigeria.
  Decision: Reject H_{03}. The p-value of 0.0203 is less than 0.05.
  Conclusion: There is a statistically significant negative long-run relationship between oil revenue and HDI. This finding lends support to the resource curse phenomenon in the context of human development.
- Hypothesis 4 (H_{04}): Total energy consumption does not have a significant long-run impact on HDI in Nigeria.
  Decision: Reject H_{04}. The p-value of 0.0000 is less than 0.05.
  Conclusion: There is a strong and statistically significant positive long-run relationship between total energy consumption and HDI. This indicates that the overall scale of economic activity, as reflected in energy use, is a key driver of human development.

Diagnostic and Stability Tests

To validate the reliability of the ARDL model, diagnostic tests were conducted.

- Serial Correlation Test: The Breusch-Godfrey LM test yields an F-statistic of 0.4656 with a p-value of 0.6386, indicating no evidence of serial correlation in the residuals.
- Heteroskedasticity Test: The Breusch-Pagan-Godfrey test gives an F-statistic of 0.5577 with a p-value of 0.8866, suggesting that the residuals are homoscedastic.
- Normality Test: The Jarque-Bera statistic (from the provided figure) indicates that the residuals are approximately normally distributed. These tests confirm that the model is well-specified, with no major issues of serial correlation or heteroskedasticity, and the residuals are normally distributed.

Discussions of Findings

The empirical findings reveal a complex energy-development nexus in Nigeria, where the significant negative long-run impact of oil revenue on HDI empirically validates the resource curse thesis advanced by Okonkwo (2022), while the paradoxical insignificance of electricity generation's relationship with HDI quantitatively confirms Adeleye et al.'s (2023) identification of critical infrastructure gaps, with the counterintuitive negative effect of per capita energy consumption highlighting severe distributional inefficiencies that extend Olanrewaju et al.'s (2023) analysis, though the strong positive relationship between total energy consumption and HDI reaffirms fundamental growth theory, collectively providing a comprehensive empirical foundation that addresses the literature gap by simultaneously evaluating multiple energy subsystems and their distinct developmental impacts.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

This study examined the impact of energy consumption on economic development in Nigeria from 1986 to 2024, using the Human Development Index (HDI) as a proxy and employing the ARDL approach. The analysis incorporated key energy variables including electricity generation (ELECGEN), per capita energy consumption (PCENERC), oil revenue (OILREV), and total energy consumption (TENRC). The findings are summarized below:

1. Oil Revenue Effect: Oil revenue has a negative and statistically significant long-run relationship with HDI in Nigeria.
2. Per Capita Energy Consumption Effect: Per capita energy consumption has a negative and statistically significant long-run relationship with HDI in Nigeria.
3. Total Energy Consumption Effect: Total energy consumption has a positive and statistically significant long-run relationship with HDI in Nigeria.
4. Electricity Generation Effect: Electricity generation was found to have an insignificant long-run relationship with HDI in Nigeria.

Conclusion

This study set out to investigate the impact of various energy dimensions on Nigeria's economic development, proxied by the Human Development Index, over the period 1986 to 2024. Against the backdrop of Nigeria's paradoxical position as an energy-rich nation plagued by underdevelopment, the analysis sought to disentangle the distinct effects of its energy subsystems. The empirical findings reveal a profound disconnect. The significant negative impact of oil revenue starkly illustrates the "resource curse," where vast petroleum wealth has not translated into improved human welfare but has instead been associated with detrimental outcomes. Similarly, the negative relationship with per capita energy consumption points to critical inefficiencies and inequities in how energy benefits are distributed among the population. While the positive effect of total energy consumption affirms the fundamental role of aggregate economic activity in development, the most telling finding is the statistical insignificance of

electricity generation. This conclusively demonstrates that simply increasing power generation is insufficient if systemic failures in transmission, distribution, and cost prevent reliable electricity from reaching households and businesses to improve health, education, and livelihoods. The study therefore concludes that Nigeria's energy-development nexus is not merely broken but is characterized by a triple paradox: wealth from oil undermines development, average energy access does not translate to well-being, and increased power generation fails to impact human development outcomes.

Recommendations

In light of the study's key findings, the following policy recommendations are proposed to realign Nigeria's energy sector with sustainable human development:

1. Remedy the Negative Impact of Oil Revenue through Governance and Strategic Investment: Given the significant negative long-run relationship between oil revenue and HDI, policy must prioritize strict governance reforms in the oil and gas sector. This includes transparent management of oil earnings and the establishment of a sovereign wealth fund mandated to channel a defined portion of revenues into direct investments in human capital development, such as public health and education infrastructure.
2. Transform the Negative Per Capita Consumption Trend into Equitable and Productive Use: To counteract the paradoxical negative impact of per capita energy consumption on HDI, policy must shift from a supply-only focus to one that ensures equitable access and efficient usage. This involves promoting energy-efficient technologies, incentivizing productive energy use in small and medium-sized enterprises, and implementing targeted subsidies to guarantee that clean, modern energy reaches low-income households, thereby directly linking consumption to poverty reduction.
3. Leverage the Positive Impact of Total Energy Consumption by Supporting Industrial and Economic Activity: The strong positive relationship between total energy consumption and HDI underscores the importance of a robust energy base for the overall economy. Policy should therefore ensure that the energy needs of key industrial and manufacturing sectors are met reliably and affordably to sustain the job creation and economic output that underpin broader developmental progress.

Bridge the Electricity Generation Insignificance by Fixing the Value Chain: To address the critical finding that electricity generation has no significant impact on HDI, policy must urgently target the entire power value chain. This requires massive investment in modernizing transmission and distribution infrastructure to reduce losses, coupled with regulatory reforms to ensure financial viability and fair pricing, thereby ensuring that generated power is reliably delivered and directly contributes to improving lives and livelihoods.

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