# Biomass Energy Financing and Electricity Generation in Nigeria

**Lawal, Ibrahim Ozomata[1*], Bernard Ojonugwa Anthony[2], Mustapha Muktar[3], Alfa Yakubu[4], Moses G. Danpome[5]**

**[1,4,5]Department of Economics, Nigerian Defence Academy,**

**[2]Department of Economics and Statistics, Kampala International University, Uganda,**

**[3]Department of Economics, Bayero University, Kano**

**[*]Corresponding Author**

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## ABSTRACT

This research examines the impact of financial allocations for biomass energy on Nigeria's electricity output, a vital element for the country's economic growth. Using an ex-post facto research design, the analysis employs a chronological series of data from 1986 to 2022, sourced from the Central Bank of Nigeria's Statistical Bulletin, various national agencies, and the World Development Indicators. The Autoregressive Distributed Lag (ARDL) method is used to analyse both long-term and short-term relationships between electricity production and several explanatory variables, including biomass energy funding, government spending on the power sector, energy financing from commercial banks, energy-related foreign aid, and electricity consumption. The results reveal that, over the long term, investment in biomass energy, government commitments to the electricity industry, and renewable energy financing from commercial banks all significantly influence Nigeria's electricity generation. Conversely, foreign aid for renewable energy does not show a statistically significant effect. In the short term, only electricity consumption has a strong and significant causal effect on generation capacity, while the other factors do not exhibit immediate influence. The ARDL Bounds test confirms a stable, cointegrated long-run relationship among all variables, and the error correction term indicates that any deviations from this equilibrium are corrected at an annual rate of 52.2%, demonstrating a considerable level of stability within the model. Overall, the findings highlight the importance of targeted biomass energy funding as a practical solution to Nigeria's electricity generation challenges, underscoring the need for strategic policy reforms to improve investment and development in the country's renewable energy sector.

**Keywords:** Biomass, Energy Finance, Electricity Generation, Autoregressive Distributed Lag, Nigeria.

## INTRODUCTION

The importance of energy in the development and growth of a nation cannot be overemphasized. Economic development, growth and human prosperity are heavily dependent on adequate supply, security, and efficient use of energy (Abdallah, et al. 2015). Lior (2012) suggested that energy resources and consumption are intimately related to environmental quality and other vital resources, such as water and food. Lior (2012) proposed that Africa's energy deserves a close look and development to synergistically advance the quality of life of its populace and sell global-capacity energy to the rest of the world.

The need to shift away from the long-term use of fossil fuels has been prompted by the global energy crisis and the threat of global warming. It has been acknowledged that the environment would continue to be in danger and there would be an energy crisis in the absence of alternative energy sources. Clean, sustainable, and renewable energy sources are examples of alternative energy sources. Exploration into wind, solar, biomass, hydropower, ocean, and geothermal energy sources is being done in order to find an alternative energy source. Every one of these resources has advantages and disadvantages. According to Abolhosseini et al. (2014), the three primary motivators that stimulate the growth of renewable energy technologies include electricity security, economic growth, and reduction in carbon dioxide emission.

Nigeria is endowed with vast renewable energy resources and confronts a persistent challenge in satisfying its escalating electricity demands amidst a rapidly expanding population and industrial sector (International Energy Agency (IEA, 2021). In this context, the exploration of alternative energy sources emerges as a critical imperative, with biomass energy standing out as a promising avenue. Biomass energy, derived from organic materials such as agricultural residues, forest waste, and urban solid waste, offers a sustainable solution to Nigeria's energy needs, while simultaneously mitigating environmental concerns associated with fossil fuel dependency (Oladiran et al., 2020).

However, the widespread adoption of biomass energy for electricity generation in Nigeria encounters multifaceted hurdles, foremost among them being the insufficient availability of financing mechanisms (Renewable Energy Policy Network for the 21st Century [REN21], 2020). Access to finance is recognized as a cornerstone for the development and deployment of renewable energy projects, including biomass energy initiatives. The inadequacy of financial resources hampers the scaling up of biomass energy projects, limiting their contribution to the national electricity grid (Oladiran et al., 2020).

While funding for renewable energy projects in Nigeria has increased, the actual output in electricity generation hasn't fully aligned with these financial commitments. This brought about a growing concern among researchers; Giartkasari and Nikensari (2022), Rashed, et al (2022), Onabote et al. (2021), Idoko (2021), Mesagan, et al (2021), Onayemi, et al (2020). This incongruence necessitates a thorough examination of the efficacy of financial investments, specifically in solar energy, to advance Nigeria's electricity generation landscape.

This article aims to delve into the intricate relationship between biomass energy finance and electricity generation in Nigeria, examining the impact of financial mechanisms such as loans, grants, and subsidies on the development and implementation of biomass energy projects (REN21, 2020). By analyzing the current state of biomass energy finance in Nigeria, identifying existing challenges, and exploring opportunities for improvement, this study seeks to elucidate the pivotal role that finance plays in shaping the trajectory of biomass energy development in the country.

Through a comprehensive understanding of the dynamics of biomass energy finance, policymakers, investors, and stakeholders can devise strategies to overcome existing barriers and unlock the full potential of biomass energy as a sustainable source of electricity generation in Nigeria. By addressing the financial constraints hindering the sector's growth, Nigeria can accelerate progress towards achieving its energy access goals while advancing its broader sustainable development agenda.

The research structure comprises five sections. Section 1 provides the introduction, setting the stage for the study. Section 2 offers a concise review of the literature concerning the correlation between energy financing and electricity generation. In Section 3, we introduce the data utilized and detail our methodology for assessing the influence of renewable energy financing on electricity generation in Nigeria. Section 4 delves into the presentation and analysis of findings. Finally, Section 5 encompasses the conclusion and recommendations drawn from the study.

## LITERATURE REVIEW

### Conceptual Issues

Developing countries, including Nigeria, very often, have an abundant stock of untapped renewable energy

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resources, which have several potential uses (Ismail, et al. 2014; Orisaleye, et al. 2018; Ismail, et al. 2013; Orisaleye, et al. 2018). Piebalgs (2007) opined that developing countries are in strong positions to promote the use of renewable energies due to abundant renewable resources, which include wind, solar, geothermal, biomass, and hydro. This may, however, be with some financial and political support. It has been shown that renewable energy is an important factor that positively influences growth and economic development, through employment creation (Osiolo, 2016). In addition, using renewable energy increases the chances for energy self-sufficiency whilst preventing environmental degradation (Tun, et al. 2019; Tun & Juchelková, 2019).

Mas'ud et al. (2015) also assessed the renewable energy readiness in Nigeria and Cameroon and found that there is a high solar irradiation and excellent wind speed in the two countries. It was also stated that Africa has abundant energy resources, which can promote economic growth and provide sufficient capacity to meet future electricity demand. Ajayi (2009) suggested that the attending challenges bedevilling the development of renewable energy technologies vary from the lack of awareness to technical ineptitude.

Many developing nations, especially those in the sub-Saharan region, have vast tracts of fertile land, and agriculture plays a significant role in their economies. These areas offer a wealth of biomass resources that can be used to generate electricity. But biomass resources are frequently used in ways that are harmful to the environment and do no good. Despite this, biomass provides about 70% of the total energy consumption in some developing countries Keles et al. (2017). Keles et al. (2017) anticipate that about 823 million people in Africa will rely on biomass for cooking and heating in the developing country by 2030. Gujba et al. (2015) suggested that the introduction of advanced stoves should be prioritized to reduce the health impact of indoor pollution and also to reduce pressure on biomass resources.

Abolhosseini et al. (2014) identified that the two main solutions for reducing CO2 emissions and overcoming the climate change problem are to replace fossil fuels with renewable energy as much as possible and enhance energy efficiency. Keles et al. (2017) also noted that systematic data are still inadequate or unavailable for biomass energy planning and for developing specific energy policies for supply and demand. It is required that the biomass resources are appropriately managed and deployed for effective energy and power generation.

**Theoretical Underpinning**

This study is based on Mansur's (2023) utilization of Production theory, which traces its roots back to JeanBabtiste Say's pioneering work in economics in 1803. Production theory fundamentally concerns the conversion of inputs into outputs, a concept crucial for understanding economic behavior. This theory was further entrenched by Bernard and Adenuga (2016). It was added that production process is not only driven by current energy resources, also by the changes in the previous output of the industry. Given that electricity isn't naturally occurring but rather requires transformation from other energy forms, such as atomic, gasoline, or coal, solar, biomass, etc, this theory aptly applies. It elucidates the process of converting raw energy into usable electricity, aligning with the broader notion of production. This theory provides a theoretical framework for justifying the study's focus on electricity generation, which mirrors the production process of transforming raw materials into finished goods. Furthermore, like other economic activities, electricity production is subject to various influences, including economic influences such as financing energy commodities, social, technological, and political factors. Understanding these influences most especially the economic influence is pivotal for analyzing electricity generation in Nigeria, making Production theory highly relevant to this study.

**Empirical Literature**

Empirical research by Zhe (2024) investigated the relationship between renewable resources and electricity generation, highlighting the crucial role of low-cost energy production as a sustainable solution for Pakistan's energy crisis. Using secondary data from 1998 to 2018, the study employed correlation analysis and the Johansen co-integration test. Subsequently, it was found that a sustained, positive long-term relationship exists between renewables and electricity generation, thereby lowering production costs and improving environmental quality.

Lawal, et al (2025) eemployed the Auto Regressive Distributed Lag (ARDL) estimation techniques to explore the dynamic relationship between solar energy financing and electricity generation in Nigeria using data from 1985 to 2022. Solar energy financing by the Rural Electrification Agency of Nigeria is the primary independent variable, alongside control variables, such as government expenditure on the electricity sector, renewable energy financing by commercial banks, foreign aid for renewable energy, and labour employed in the electricity sector. The results demonstrate that increases in financing from the Rural Electrification Agency, government spending, commercial bank investments, and foreign aid positively impact electricity generation in both the short and long term. Additionally, labour employed in the sector significantly contributes to the improvement of electricity generation. These findings emphasize the importance of enhancing funding for solar energy projects, diversifying government allocations to the electricity sector, and fostering a supportive environment for foreign aid and investments. Beyond enriching existing literature and theoretical frameworks, this research offers practical insights for policymakers, industry stakeholders, and researchers aiming to promote renewable energy investments for sustainable electricity generation in Nigeria.

Similarly, in the Nigerian context, Mansur (2023) analyzed factors influencing electricity generation from 1981 to 2021. Applying Vector Autoregressive (VAR) model techniques like Impulse Response Functions (IRFs) and Variance Decomposition, the study revealed that electricity generation responds negatively to shocks from power loss and demand. Conversely, it showed a significant positive response to shocks in government funding, implying that increased investment could boost generation.

Shifting the focus to a specific renewable technology, biomass co-firing has been extensively studied. A metaanalysis by IEA Bioenergy (2021) confirmed its technical feasibility at low ratios, although its economic viability heavily depends on local biomass supply chains and is enhanced by carbon pricing or subsidies. However, a critical empirical question surrounding biomass is its carbon neutrality. A comprehensive lifecycle assessment (LCA) review by Cherubini et al. (2018) concluded that while using agricultural or forest residues offers significant GHG savings, dedicated energy crops can create a substantial "carbon debt" due to land-use change, thus making residue sourcing paramount for immediate climate benefits.

Furthermore, beyond global emissions, the local air quality impact of biomass power is a significant concern. A case study by Nussbaumer et al. (2020) found that even modern plants can elevate emissions of carbon monoxide and organic compounds, potentially worsening local air pollution unless stringent emission controls and continuous monitoring are implemented.

In addition to technical and environmental factors, socio-economic elements are crucial for deployment. A mixed-methods study by Bauen et al. (2019) identified key drivers like local energy security and job creation, but also highlighted major barriers such as high capital costs and complex supply chains. Therefore, the study suggests that community involvement and localized benefits are critical for success. Moreover, the efficiency of biomass technology is evolving; a longitudinal analysis by Thrän et al. (2020) documented steady improvements in gasification efficiency, yet acknowledged that high capital costs remain a hurdle, although a positive technology learning rate indicates future cost-competitiveness.

The scale of deployment, however, is largely dictated by policy. A cross-country econometric analysis by Fouquet et al. (2022) demonstrated that stable and predictable policies, such as feed-in tariffs or renewable portfolio standards, are more critical for attracting investment than the specific type of instrument used.

Other critical sustainability metrics include water and land use. Research by Gerbens-Leenes et al. (2018) highlighted the substantial water footprint of some bioenergy pathways, warning of unsustainable water use in arid regions. Similarly, utilizing agricultural residues seems promising to avoid land-use conflicts, but a study by Hiloidhari et al. (2021) emphasized that logistical and economic constraints severely limit the technically feasible potential. Furthermore, long-term field research by Lal (2019) showed that systematic residue removal degrades soil health, thereby necessitating sustainable harvest plans to protect soil carbon and nutrients.

To address logistical challenges like low energy density, research by Chen et al. (2020) evaluated torrefaction, finding that this process improves biomass properties for transport and combustion, potentially lowering the overall cost of electricity. Finally, alongside these technical and economic factors, social acceptance is vital. A large-N survey by Upreti et al. (2022) found a clear link between public acceptance and perceived local benefits, whereas projects lacking transparency and community consultation often face strong opposition.

Narrowing the focus back to Nigeria, Idoko (2021) used an ARDL bounds testing approach to investigate the impact of government expenditure on electricity supply from 1990 to 2017. The study found significant contributions from government spending, GDP, and other macroeconomic variables, leading to a recommendation for increased power sector funding. In a similar vein, Imo, Chukwu, and Abode (2017) employed autoregressive and multiple regression models, identifying a strong positive relationship between rainfall and electricity generation, and consequently suggesting the construction of more dams.

The above literature reviewed shows that there is a lack of systematic data and specific energy policies tailored to its planning and utilization. Research has underscored the deficiency of such data and policies, crucial for effective energy planning and policymaking. While financial and political support is acknowledged as necessary for promoting renewable energy, including biomass energy, there is insufficient detailed analysis of the specific obstacles hindering biomass energy project development in Nigeria. It is imperative to conduct research aimed at identifying and addressing these challenges to facilitate investment in biomass energy projects and promote their sustainable development. Additionally, there is a dearth of comprehensive studies analyzing biomass energy financing mechanisms in Nigeria, despite recognizing the importance of financing for renewable energy projects. Research focusing on various financing models, investment opportunities, and financial incentives for biomass energy projects could offer valuable insights for policymakers, investors, and other stakeholders. Addressing these gaps through empirical research and policy analysis can contribute to the development of effective strategies for promoting biomass energy financing and electricity generation in Nigeria, ultimately advancing sustainable energy access and economic development in the country.

## METHOD

### Research Design

This study employed an Ex-post research design which is also known as retrospective research design, this type of research design involves collecting and analyzing data after the events of interest have occurred. In this approach, researchers do not have control over the variables being studied but instead analyze existing data to draw conclusions or make inferences about relationships between variables.

### Sources of Data

Data for this study was obtained from a secondary source. For the analysis, the study utilized time series data spanning from 1986 to 2022. The data for electricity generation (ELG) in Nigeria were sourced from the Central Bank Statistical Bulletin and World Development Indicator, measured in Million Kilowatts (MKw). The data for biomass energy finance was proxied by government budget allocation to the National Biotechnology

Development Agency (NABDA) proxied. Government energy financing (GEF) data were proxied by Government Expenditure on the Electricity sector, sourced from the Central Bank of Nigeria Statistical Bulletin (2021), and measured in Billion Naira (N'Billion). Energy financing from foreign aid (FAE) data was sourced from the World Bank (2021), European Union (2021), and DFID (2021), measured in Billion United States of America Dollars (US Dollars). Labour (LAB) data were proxied by the total workforce in Nigeria, sourced from the World Bank (2021) and the National Bureau of Statistics (Various Issues), measured in millions.

### Model Specification

Following the model of Mansur (2023) which was specified as

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LEGT = f (LEPL , LGFE, LELD) 1

Where: LEGT = Log of Electricity Generation in Megawatt Hours LEPL = Log of Electric Power Losses, LGFE = Log of Government Funding on Electricity, LELD = Log of Electricity Demand Transforming Equation (1) to an econometric equation he obtained the following:

LEGTt = β0 + β1 LEPLt + β2 LGFEt + β3 LELDt + μt 2

Where: LEGT, LEPL, LGFE, and LELD are defined earlier in Equation (1).

Modifying equations 1 and 2 to include biomass energy finance variable gave rise to the model used in this study. Therefore, the model of this study is thus specified as:

$$ELG_t = f(BEF_t, GOE_t, CEF_t. FEF_t, ELC_t) \qquad 3$$

$$ELG_t = \beta_0 + \beta_1 BEF_t + \beta_2 GOE_t + \beta_3 CEF_t + \beta_4 FEF_t + \beta_5 ELC_t + \mu \qquad 4$$

Where ELG, BEF, GOE, CEF, FEF and ELC are Electricity generation in Nigeria, Biomass Energy Financing, Government Expenditure on Electricity Sector, Commercial Banks Energy Financing, foreign aid energy finance, and Electricity Consumption. $\beta_1$ to $\beta_5$ are the coefficients of the variables and μ is the error term and t = time period. The estimated coefficient of the variable is expected to take the form $\beta_0 > 0$, $\beta_1$ to $\beta_5 > 0$

Equations 4 was estimated using ARDL estimation techniques. The decision to employ the ARDL approach for testing the existence of a long-term relationship between variables in levels was influenced by the fractionally integrated nature of the underlying regressors, oscillating between I(0) and I(1). The bounds test confirmed the cointegration among variables, aligning with the conditions outlined by Pesaran and Smith (2001) for AutoRegressive Distributed Lags estimation.

The chosen estimation method aligns with the arguments put forth by Narayan and Smyth (2005), emphasizing the superior small sample properties of the bounds testing approach over multivariate cointegration. This approach modifies the Auto Regressive Distributed Lag (ARDL) framework, effectively addressing the challenges associated with the coexistence of I(0) and I(1) regressors in a Johansen-type framework. In line with the theoretical disposition supported by Bernard and Adenuga (2016) who opined that production process is not only driven by current energy resources, but by the changes in the previous output of the industry sector, this study therefore modified equation 4 and specified an ARDL model of the form:

$$ELG_t = \beta_0 + ELG_{t-1}\ \beta_1 BEF_t + \beta_2 GOE_t + \beta_3 CEF_t + \beta_4 FEF_t + \beta_5 ELC_t + \mu \qquad 5$$

To determine the long-run relationship and the short-run dynamics of the ARDL model In equation 5, the longrun and the short-run form of equation is specified thus:

$$\square \ln ELG_t = + \square\ \square_0\ {}_1\ln ELG_{t\,i-} + \ln\square_2 BEF_{t\,i-} + \square_3 \ln GOE_{t\,i-} + \square_4 \ln CEF_{t\,i-} + \square_5 \ln FEF_{t\,i-} + \square_6 \ln ELC_{t\,i-} + \mu \quad 6$$

$k \quad k \quad k \quad k \quad k \quad k$

$$\square \ln ELG_t = \square\ \square_0 + \square\ {}_1\square\ln ELG_{t\,i-} + \square\square_2\square\ln BEF_{t\,i-} + \square\square_3\square\ln GOE_{t\,i-} + \square\square_4\square\ln CEF_{t\,i-} + \square\square_5\square\ln FEF_{t\,i-} + \square\square_6\square\ln ELC_{t\,i-} + ect_{t-1} + \mu \quad 7$$

$i=1 \quad i=1 \quad i=1 \quad i=1 \quad i=1 \quad i=1$

Having estimated the ARDL model in equation 5, the ARDL estimation technique simultaneously estimated equation 6 and 7 that is both long-run and short-run ARDL model. Where in the short-run estimation; the error correction term (ect) was automatically generated and estimated. The estimated results of the *ect* measure the speed of adjustment needed to converge back to long-run equilibrium after a short-term shock to the model.

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# PRESENTATION AND DISCUSSION OF RESULTS

## 4.1 Data Analysis

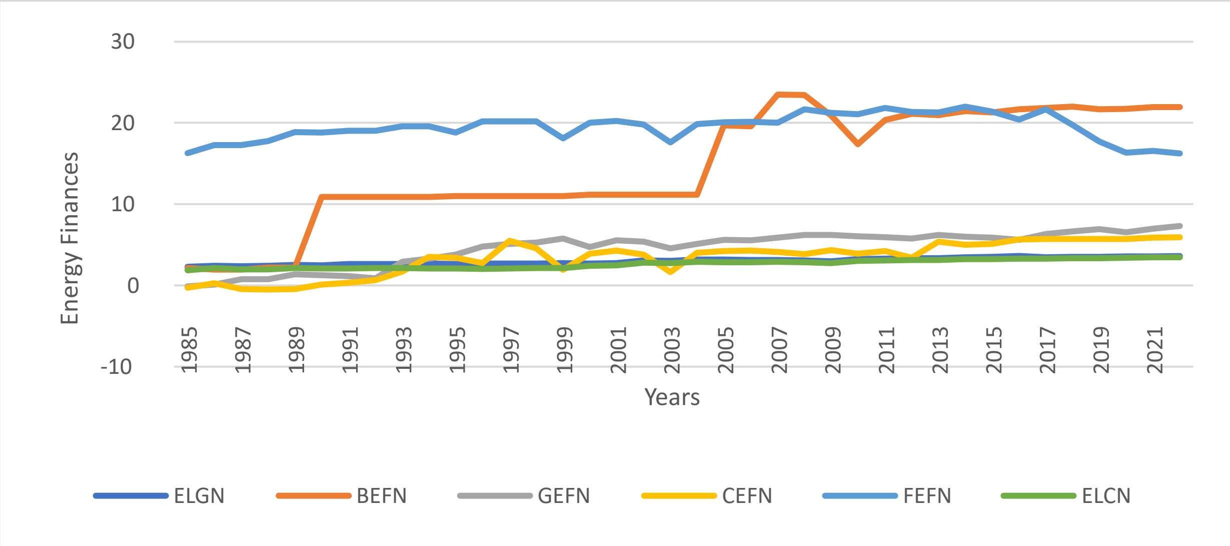


**Figure 1. The trend of Electricity Generation and Energy Finance variable in Nigeria (1985 – 2022) Source: Researcher's Computations Using Microsoft Excel.**

The graph illustrates trends in various energy finance metrics in Nigeria from 1985 to 2022, with the y-axis showing energy finance values and the x-axis representing years. Electricity Generation (ELG) Began near 10MKw in 1985, increased to about 20MKw by the early 1990s, remained stable until around 2007, and then declined to below 15MKw by 2022. Biomass Energy Finance (BEF): Started at 0, rose to around N10 billion by the early 1990s, surged past N20 billion around 2000, and stayed around N20 billion with minor fluctuations until 2022. Federal Government Electricity Sector Finance (GEFN): Gradually increased, peaking slightly above N5 billion in 2005 and reaching about N7 billion by 2022. Commercial Banks' Energy Financing (CEFN): Remained flat until the mid-1990s, then gradually rose to around N5 billion by 2006, and stabilized between N3 billion and N5 billion until 2022. Energy Finance from Foreign Aid (FEFN): Stayed nearly flat, slightly below N5 billion throughout the period. Electricity Consumption: Remained constant from 1985 to 2022. All series show an upward trend, indicating potential non-stationarity. Thus, a unit root test is needed to determine the order of stationarity of the series.

### Stationary Test

**Table 1: Unit Root Test (ADF Test Result)**

| Variables | ADF Levels | Critical Values | ADF 1st Diff | Critical Values | Order of Integration |
|---|---|---|---|---|---|
| LnELG | -3.141 | -3.536 | -7.359 | -3.540 | I(1) |
| LnBEF | -2.394 | -3.537 | -6.267 | -3.540 | I(1) |
| LnGEF | -1.937 | -3.537 | -6.994 | -3.540 | I(1) |
| LnCEF | -3.492 | -3.537 | -7.431 | -3.540 | I(1) |
| LnFEF | -6.866 | -2.946 | -1.489 | -3.537 | I(0) |
| LnELC | -2.369 | -3.537 | -8.402 | -3.540 | I(1) |

**Source: Researcher's Computations Using Eviews 10.**

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The ADF results in Table 1 reveal that the variables exhibit stationarity at the first difference, except for the FEF variable, which appears to be stationary at the level. Both the dependent and explanatory variables present a combination of I(0) and I(1) series. Consequently, these variables possess the characteristics suitable for the ARDL model, suggesting a potential existence of a long-run relationship among them.

**Optimal Lag Selection**

**Table 2:** Lag Length Selection Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -233.0345 | NA | 0.023577 | 13.27969 | 13.54361 | 13.37181 |
| 1 | -78.30593 | 249.2849* | 3.32e-05* | 6.683663* | 8.531101* | 7.328468* |
| 2 | -44.39660 | 43.32859 | 4.44e-05 | 6.799811 | 10.23077 | 7.997307 |

**Source: Researcher's Computations Using Eviews 10.**

Table 2 shows different criteria from which a lag length of our model variables was selected. All four criteria: FPE, AIC, HQIC, and SBIC indicate the selection of a maximum of four (1) lags in our model as shown by the asterisk (* ) along the fourth lag. The AIC lag length was selected to estimate the ARDL model.

**ARDL Result**

**ARDL Bounds Test**

Estimating the ARDL model in its first difference reveals the possibility of the variable deviating from the longrun equilibrium. Therefore, to ascertain the possibility of the existence of a long-run relationship among variables necessitated the ARDL Bounds test for cointegration. The result is presented in Table 3.

**Table 3. ARDL Bounds Test for Cointegration.**

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| F-statistic | 15.93427 | 10% | 2.08 | 3 |
| K | 5 | 5% | 2.39 | 3.38 |
| | | 2.5% | 2.7 | 3.73 |
| | | 1% | 3.06 | 4.15 |

**Source: Author's computation using Eviews 10.**

The ARDL Bounds test in Table 3 shows an F-statistic of 15.93, exceeding the upper bound, indicating cointegration and a long-run relationship among the variables. Consequently, it is essential to estimate and interpret the long-run model and the relationships between the independent and dependent variables. Additionally, the short-run estimate of the ARDL model is necessary to determine how the model adjusts to short-term shocks.

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**Table 4. ARDL Long Run Result**

| Levels Equation | | | | |
|---|---|---|---|---|
| Case 2: Restricted Constant and No Trend | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LNBEF | 0.010696 | 0.003063 | 3.492293 | 0.0251 |
| LNGEF | 0.002467 | 0.011219 | 0.219872 | 0.8367 |
| LNCEF | 0.036900 | 0.010978 | 3.361321 | 0.0283 |
| LNFEF | 0.030478 | 0.004443 | 6.859487 | 0.0024 |
| LNELC | 0.625573 | 0.026063 | 24.00266 | 0.0000 |
| C | 0.733796 | 0.113965 | 6.438791 | 0.0030 |

**Source: Author's computation using Eviews 10.**

The long-run results reveal a critical narrative about the drivers of electricity generation in Nigeria, where the significance and magnitude of the coefficients point to the underlying effectiveness of different financial sources. The most powerful driver is electricity consumption (LNELC), with a coefficient of 0.626, which is highly significant (p-value = 0.0000). This indicates a strong, positive long-run relationship where a 1% increase in electricity consumption is associated with a 0.63% increase in generation, reflecting a demand-driven expansion of the power sector. Among the financial variables, foreign aid (LNFEF) shows a significant and positive longrun impact with a coefficient of 0.030 (p-value = 0.0024), suggesting that sustained aid flows do contribute to capacity building over time. Similarly, commercial banks' energy finance (LNCEF, coefficient = 0.037, p-value = 0.0283) and biofuel finance (LNBEF, coefficient = 0.011, p-value = 0.0251) also demonstrate significant, though smaller, positive long-run effects.

However, the stark exception is government expenditure on the electricity sector (LNGEF), which, despite a positive coefficient of 0.002, is statistically insignificant (p-value = 0.8367). This insignificance, especially when contrasted with the effectiveness of commercial finance and foreign aid, strongly suggests that the problem is not a lack of funding but rather how funds are managed. The ineffectiveness of government expenditure can be directly attributed to deep-seated institutional and governance failures. These include pervasive issues like corruption, which diverts funds from their intended purposes; political interference, which prioritizes projects based on patronage rather than economic viability; and chronic inefficiency in public project management, leading to cost overruns and abandoned initiatives. Consequently, government financial input fails to translate reliably into tangible physical assets and increased generation capacity.

Furthermore, the relative success of foreign aid and commercial finance highlights the role of better governance structures. Commercial finance (LNCEF) is subject to market discipline, profitability analysis, and stricter oversight, which forces more efficient allocation and use of capital. Foreign aid (LNFEF), while sometimes hampered by donor-driven agendas, often comes with its own project management frameworks and oversight mechanisms that can, to some extent, bypass the most corrupt layers of domestic bureaucracy. This allows it to have a significant long-run impact where purely government-managed funds fail. In conclusion, the coefficients tell a story where the source and governance of financing are paramount. For Nigeria, policy must focus not only on mobilizing capital but, more critically, on implementing institutional reforms—such as enhancing transparency, strengthening public financial management, and reducing political interference to ensure that all financial investments, especially public expenditure, can effectively catalyze long-term growth in electricity generation.

Following the establishment of these long-run relationships, the study also estimated the short-run dynamics of the ARDL model to determine the speed of adjustment to long-run equilibrium after a short-term shock. The short-run ARDL model results are presented in Table 5.

**Table 5. ARDL Error Correction Regression**

| | | | | |
|---|---|---|---|---|
| Dependent Variable: D(LNELG) | | | | |
| Included observations: 37 | | | | |
| ECM Regression | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 0.254331 | 0.060585 | 4.197917 | 0.0003 |
| D(LNBEF) | 0.001930 | 0.004353 | 3.851638 | 0.6613 |
| D(LNGEF) | 0.624324 | 0.203771 | 3.063851 | 0.2438 |
| D(LNCEF) | 0.313810 | 0.110893 | 2.829845 | 0.2166 |
| D(LNFEF) | 0.001820 | 0.010774 | 0.168886 | 0.8672 |
| D(LNELC) | 0.607157 | 0.104311 | 5.820664 | 0.0000 |
| ECT(-1)* | -0.522310 | 0.119324 | -4.377250 | 0.0002 |
| R-squared | 0.689388 | Mean dependent var | | 0.030850 |
| Adjusted R-squared | 0.627266 | S.D. dependent var | | 0.092789 |
| S.E. of regression | 0.056649 | Akaike info criterion | | -2.735220 |
| Sum squared resid | 0.096274 | Schwarz criterion | | -2.430452 |
| Log likelihood | 57.60157 | Hannan-Quinn criter. | | -2.627775 |
| F-statistic | 11.09728 | Durbin-Watson stat | | 2.120744 |
| Prob(F-statistic) | 0.000002 | | | |

**Source: Author’s Computation using Eviews 10.**

The short-run dynamics of the ARDL model in Table 5 reveal a stark contrast between the influence of financial inputs and real economic activity on electricity generation. While the coefficients for government expenditure (0.624), commercial banks' energy finance (0.313), and electricity consumption (0.607) are sizeable, their statistical significance diverges sharply. Electricity consumption is the only variable with a robust and immediate impact, being highly significant (p-value = 0.0000). This indicates that in the short run, the grid responds directly to demand pressures. In contrast, the substantial but statistically insignificant coefficients for government spending and commercial finance (with p-values of 0.2438 and 0.2166, respectively) suggest that while these funds are theoretically important, their translation into actual generation is highly unreliable and subject to other mediating factors.

The persistent insignificance of foreign aid, with a negligible coefficient of 0.002 and a high p-value of 0.8672, underscores profound institutional and logistical barriers. This result indicates that foreign aid does not function as a quick stimulus for the power sector. The failure to achieve significance, even with a positive sign, can be attributed to several governance-related bottlenecks. Aid projects are often ensnared in complex procurement rules, lengthy feasibility studies, and bureaucratic approval processes, causing significant implementation delays. Furthermore, this "project-based" nature of aid means funds are often tied to specific, long-gestation

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infrastructure projects (like building new power plants) rather than addressing immediate operational bottlenecks. Consequently, the financial inflow is not felt in the short-term generation capacity.

The highly significant Error Correction Term (ECT) of -0.522 confirms a strong self-correcting mechanism in the system, with 52.2% of any disequilibrium being corrected within one period. This rapid adjustment underscores that the long-run relationships are the primary drivers, while short-run financial shocks have limited lasting effect. The collective evidence suggests that the effectiveness of all financial investments—whether domestic or foreign—is critically mediated by the institutional environment. Weak governance, characterized by corruption, inefficient bureaucracy, and poor project management, acts as a filter that dilutes the potency of capital. Money is absorbed by procedural delays, mismanagement, or a lack of complementary infrastructure, preventing it from quickly translating into increased power output. Therefore, for Nigeria, policy must focus not just on mobilizing finance but on strengthening the institutional foundations, streamlining regulations, enhancing transparency, and improving project execution to ensure that both short-run disbursements and long-run investments can effectively bridge the electricity gap.

The summary statistics of the short-run ARDL model revealed R-squared value of 0.689, indicating that approximately 69% of the variability in electricity generation is explained by the model. After accounting for the number of predictors, the adjusted R-squared is 0.627. The standard error of regression is 0.057, suggesting that observed values deviate from the regression line by nearly 6%. The F-statistic value of 11.08 with a p-value of around 0.00 shows the model is statistically significant at the 5% level. The Durbin-Watson statistic of approximately 2.12 suggests no serial correlation among the residuals.

**Diagnostic Test on the Estimated ARDL Model**

A diagnostic test was conducted to examine the reliability of the ARDL model. The study employed the JarqueBera Normality test, the Breusch-Godfrey serial correlation test and the Breusch-Pagan-Godfrey heteroskedasticity test to test the underpinning assumption of the disturbance term. The results of the diagnostic test are presented in Table 6, 7 and 8, respectively.

**Table 6. Jarque-Bera Normality Test**

| | | | |
|---|---|---|---|
| Jarque-Bera Statistic | 0.261 | Prob. | 0.877 |

**Source: Author's computation using Eviews 10.**

**Table 7. Breusch-Godfrey Serial Correlation LM Test:**

| | | | |
|---|---|---|---|
| F-statistic | 0.136627 | Prob. F(2,21) | 0.8731 |
| Obs*R-squared | 0.462417 | Prob. Chi-Square(2) | 0.7936 |

**Source: Author's computation using Eviews 10.**

**Table 8.**

| **Heteroskedasticity Test: Breusch-Pagan-Godfrey** | | | |
|---|---|---|---|
| F-statistic | 2.525037 | Prob. F(11,24) | 0.0680 |
| Obs*R-squared | 19.31254 | Prob. Chi-Square(11) | 0.0557 |
| Scaled explained SS | 12.45096 | Prob. Chi-Square(11) | 0.3307 |

**Source: Author's computation using Eviews 10.**

The diagnostic test results show that the probability values for the Jarque-Bera normality test, the serial correlation test, and the heteroskedasticity test are all greater than 0.05 or 5 percent significance level. This indicates that the disturbance term in the ARDL model is normally distributed, uncorrelated, and homoscedastic. To further examine the model's stability, the study employed the Cusum-Sum of Squares test. The result, shown in Figure 2, indicates that the trend lies within the 5 percent boundary. This demonstrates that the estimated ARDL model is stable for policy formulation.

**Stability Test of the ARDL Estimated Model**

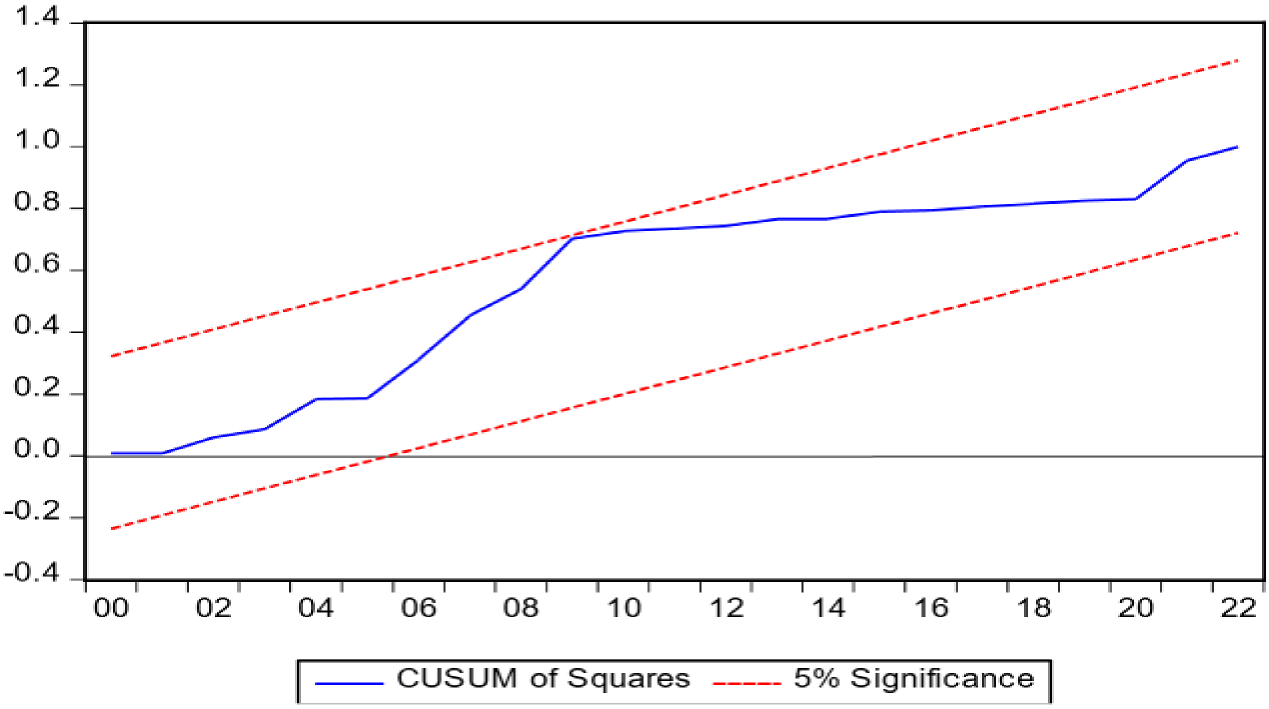


**Figure 2: Cusum of Squares test for Stability**

**Source: Author’s computation using Eviews 10.**

**Policy Implications of findings**

The strong and significant short-term influence of electricity consumption on electricity generation indicates that energy demand is a crucial determinant of electricity generation in Nigeria. This highlights a pressing need for electricity generation companies in Nigeria to increase their capacity to meet the rising demand.

The lack of notable short-term effects from biofuel energy finance, government expenditure on electricity, commercial banks' energy finance, and foreign aid energy finance suggests that these funding sources may not be effectively contributing to electricity generation in the immediate future.

The substantial error correction term suggests that although short-term impacts are limited, there is a significant mechanism adjusting towards long-term equilibrium. Consequently, policies aimed at promoting long-term electricity generation through renewable energy financing should be encouraged.

## CONCLUSION AND RECOMMENDATIONS

The role of electricity in the growth and development of an emerging economy like Nigeria cannot be overemphasized. Recognizing this role, and understanding the various sources of electricity, categorized into renewable and non-renewable sources are essential. However, these sources cannot be effectively harnessed without adequate financing. Given the challenges faced by the Nigerian electricity sector, including erratic supply, significant shortfalls in meeting demand, and funding difficulties, this study examines the impact of biomass energy financing on electricity generation in Nigeria, leveraging the country's abundant renewable energy resources.

As an agrarian nation with prominent animal production, Nigeria has substantial potential to utilize biomass from agricultural activities for electricity generation. Despite extensive research on the determinants of electricity generation in Nigeria, specific aspects of renewable energy financing, particularly biomass energy finance, have not received sufficient attention in energy economics research. Addressing this gap, this study investigates the significance of biomass energy financing on electricity generation in Nigeria.
Other variables examined include government expenditure on electricity, commercial banks' renewable energy finance, and energy finance from foreign aid. Additionally, the influence of electricity consumption on electricity generation is considered. Pre-estimation tests, including unit root tests to assess the stochastic properties of the series, revealed that the series are integrated of order I(0) and I(1) and are cointegrated. This necessitated the use of the Autoregressive Distributed Lag (ARDL) model estimation technique.

findings from the ARDL long-run model indicate that past values of electricity generated, biomass energy financing, government expenditure on the electricity sector, and commercial banks' renewable energy finance significantly influence electricity generation in Nigeria in the long run. In contrast, renewable energy finance from foreign aid does not have a significant influence on electricity generation. Furthermore, the study concludes that electricity consumption significantly influences electricity generation in both the short run and long run. Overall, energy finance variables have the potential to influence electricity generation in the long run.

Based on the findings, this study provides the following policy recommendations:

The empirical findings from the ARDL analysis provide a clear roadmap for revitalizing Nigeria's electricity sector, pointing squarely to the need for a fundamental shift in policy approach. The core insight is that the sector's problem is not a scarcity of funds but a critical failure in how those funds are absorbed and converted into reliable generation capacity. To address this, policy must first aggressively enhance private-sector participation through market-oriented reforms. Given the proven long-run effectiveness of commercial banks' energy finance and the consistent failure of direct government expenditure, the government's role should transition from being a primary funder to a strategic facilitator. This can be achieved by implementing transparent, competitive procurement processes for power purchase agreements and by fundamentally reforming the distribution companies to improve their commercial viability. By creating a market where private investments can flourish, the sector can leverage the efficiency, innovation, and capital that the private sector brings, moving away from the inefficient model of government-led funding.

Furthermore, to overcome the stark short-run ineffectiveness of all financial variables, a comprehensive risk mitigation framework is essential. The fact that even substantial short-run inflows from government and commercial banks show no significant impact reveals a sector perceived as high-risk. To unlock immediate investment, a dedicated Partial Risk Guarantee Fund, backed by the government and international partners, should be established to cover off-taker payment risks and mitigate political interference. Concurrently, strengthening the regulatory environment to ensure contract enforcement and tariff stability is crucial to provide investors with the long-term predictability needed to commit capital. This framework would directly address the hesitation behind the insignificant short-run coefficients, transforming potentially idle finance into productive, immediate investment.

Ultimately, these efforts must be underpinned by an unwavering commitment to institutional capacity-building and governance reform. The insignificance of government expenditure and the delayed impact of foreign aid are direct symptoms of weak institutions, characterized by bureaucratic delays, corruption, and poor project management. A dedicated initiative to strengthen public financial management within the power sector, using digital tracking and independent audits, is needed to ensure public funds are used effectively. Additionally, creating a specialized project management unit can fast-track the implementation of both foreign-aided and public projects, ensuring they move swiftly from approval to completion. By building a foundation of transparency, accountability, and technical competence, Nigeria can ensure that all financial inflows, whether

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public, private, or foreign are no longer diluted by governance failures but are effectively channelled to bridge the nation's electricity gap.

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