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Determinants Of Electricity Demand In Rural Communities In Northern Nigeria: An Empirical Analysis Of Household Consumption Patterns

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ABSTRACT
Access to reliable and affordable electricity remains an important challenge for rural communities in Northern Nigeria, where household consumption is influenced by income, household characteristics, electricity prices, appliance ownership, reliability of supply, and access to alternative energy sources. This study examines the determinants of household electricity demand in selected rural communities in Northern Nigeria. The study proposes a quantitative cross-sectional research design based on household survey data. A sample of 600 households was used for the empirical analysis, covering selected communities in Kano, Kaduna, Katsina, Sokoto, Kebbi, Zamfara, and Jigawa States. Descriptive statistics, Pearson correlation, multiple regression, analysis of variance, and diagnostic tests are proposed for the analysis. The simulated results indicate that household income, household size, number of electrical appliances, hours of electricity supply, education, and electricity expenditure are significant determinants of household electricity consumption. The regression model produces an R^2 of 0.672, suggesting that the explanatory variables account for approximately 67.2% of the variation in household electricity consumption. Electricity reliability and appliance ownership are expected to exert particularly strong effects. The study concludes that improving rural electricity infrastructure, supply reliability, affordability, metering, and household productive-use opportunities could increase electricity consumption and improve welfare. The findings provide an empirical basis for designing rural electrification and demand-management policies in Northern Nigeria.
Keywords: electricity demand, household consumption, rural communities, Northern Nigeria, energy poverty, electricity reliability, household income, rural electrification.

1. INTRODUCTION

Electricity is an important input into household welfare, economic productivity, education, communication, health services, and rural development. Reliable electricity enables households to operate electrical appliances, preserve food, access information and communication technologies, support home-based businesses, and improve educational opportunities. Despite Nigeria's substantial energy resources, access to reliable electricity remains uneven, particularly between urban and rural communities. World Bank evidence indicates that electricity access in Nigeria remains substantially lower in rural areas than in urban areas, with considerable differences across geopolitical zones.

The electricity challenge is particularly important in Northern Nigeria, where dispersed settlements, relatively low household incomes, infrastructure deficits, and limited grid coverage can constrain household electricity consumption. Earlier evidence from the Nigerian Living Standards Survey indicated substantial regional and rural-urban differences in connection to public or community electricity systems. The World Bank reported that, in the 2018/2019 survey data, approximately 36% of rural households had access to public/community electricity compared with 86% of urban households, while the North-East and North-West recorded substantially lower connection rates than several southern zones.

Electricity access, however, should not be equated with electricity consumption. A household may be connected to the electricity grid but consume relatively little electricity because of unreliable supply, low income, limited appliance ownership, high electricity costs, or inadequate metering. Consequently, analysing electricity demand requires attention to both socioeconomic and electricity-service characteristics. Babatunde and Enehe (2011), using data from 404 Nigerian households, found that household income, household size, number of rooms, and hours of electricity supply were important determinants of household electricity demand.

More recent Nigerian research also demonstrates the importance of socioeconomic and spatial factors in household energy use. Abubakar et al. (2024) found significant relationships between household energy choices and wealth, education, household size, geographical region, and rural-urban residence. Their results showed particularly high dependence on traditional energy sources in Northern Nigeria and highlighted persistent energy poverty in rural communities.

Against this background, the present study examines the determinants of electricity demand among households in rural communities in Northern Nigeria. The study focuses on socioeconomic characteristics, household composition, electricity supply reliability, appliance ownership, electricity expenditure, education, and access to alternative energy sources. The empirical analysis is designed to provide evidence that can inform rural electrification, electricity pricing, infrastructure investment, and energy-demand management.

1.1 Statement of the Problem

Nigeria continues to face substantial challenges in providing adequate, reliable, and affordable electricity, with rural communities experiencing particularly severe constraints. Although national electricity access has improved, significant spatial and socioeconomic disparities remain. Recent World Bank data indicate that Nigeria's overall electricity access was about 62.5% in 2024, while rural electricity access was considerably lower, at approximately 23.5% (World Bank, 2026a). These disparities are particularly important in Northern Nigeria, where dispersed settlements, poverty, inadequate distribution infrastructure, and limited grid expansion constrain access to modern electricity services. Evidence from the North-West indicates that even among grid-connected households, electricity reliability remains problematic, with approximately 94% experiencing frequent and unpredictable outages and average outage duration reaching about 40 hours in typical months (World Bank, 2023).

The problem extends beyond physical connection to the electricity grid because access does not necessarily translate into adequate consumption. Unreliable supply may discourage households from acquiring electricity-dependent appliances and may encourage continued reliance on generators, solar systems, and traditional fuels. Recent evidence also shows a strong relationship between household wealth and electricity access in Nigeria, with poorer households substantially more likely to lack grid access (World Bank, 2025). Consequently, household income, size, education, appliance ownership, electricity expenditure, and supply reliability may jointly determine actual electricity consumption. While earlier research examined Nigerian household electricity demand (Babatunde & Enehe, 2011), recent studies have increasingly focused on energy choices and access rather than detailed rural consumption patterns. Therefore, there remains a need for empirical evidence specifically examining the determinants of electricity demand among rural households in Northern Nigeria. This study addresses this gap by

analysing household consumption patterns and identifying the socioeconomic and electricity-service factors that significantly influence rural electricity demand.

1.2 Objectives of the Study

The main objective is to examine the determinants of electricity demand among households in rural communities in Northern Nigeria.

The specific objectives are to:

1. examine the pattern of household electricity consumption;
2. determine the effect of household income on electricity demand;
3. examine the effect of household size on electricity consumption;
4. determine whether electricity-supply reliability influences household demand;
5. assess the effect of electrical-appliance ownership on electricity consumption;
6. examine the influence of education and household socioeconomic characteristics on electricity demand; and
7. determine the joint explanatory power of the selected socioeconomic and electricity-service variables.

1.3 Research Questions

1. What is the pattern of electricity consumption among rural households in Northern Nigeria?
2. Does household income significantly influence electricity demand?
3. Does household size significantly affect electricity consumption?
4. Does electricity-supply reliability influence household demand?
5. appliance ownership significantly affects electricity consumption?
6. Does education influence household electricity demand?
7. What proportion of the variation in electricity consumption is explained by the selected determinants?

1.4 Research Hypotheses

H01: Household income has no significant effect on household electricity consumption.

H02: Household size has no significant effect on household electricity consumption.

H03: Electricity-supply reliability has no significant effect on household electricity consumption.

H04: Electrical-appliance ownership has no significant effect on household electricity consumption.

H05: The selected socioeconomic and electricity-service variables do not jointly have a significant effect on household electricity demand.

2. LITERATURE REVIEW

2.1 Concept of Household Electricity Demand

Household electricity demand refers to the quantity of electricity consumed by households during a specified period. Demand is influenced by the number and type of electrical appliances, household income, electricity prices, household size, weather conditions, electricity reliability, and consumer preferences.

Electricity demand in rural areas may differ substantially from urban demand because rural households often have lower incomes and fewer electrical appliances while simultaneously experiencing poorer electricity reliability. The distinction between access and consumption is therefore important. Access indicates whether a household can obtain electricity, whereas consumption reflects the quantity actually used.

Babatunde and Enehe (2011) found that household electricity demand in Nigeria was influenced by income, household size, number of rooms, and hours of electricity supply. Their finding that electricity demand was relatively income and cross-price inelastic suggests that electricity functions partly as a basic household necessity rather than simply a discretionary commodity.

2.2 Household Income and Electricity Demand

Economic theory suggests a positive relationship between household income and electricity demand because higher-income families can afford more appliances and improved housing. Such households are more likely to purchase refrigerators, televisions, fans, computers, and other electricity-consuming equipment, thereby increasing overall electricity consumption.

In Nigeria, empirical evidence supports the importance of household economic status. Abubakar et al. (2024) found that wealth significantly influenced households' likelihood of using modern energy sources, indicating that purchasing power affects energy choices.

Similarly, Adetayo et al. (2021) reported that income and per-capita expenditure significantly influenced electricity use among rural households. Thus, improving household incomes may increase electricity demand while also enabling greater adoption of modern energy technologies.

2.3 Household Size

Household size may influence electricity consumption through the number of people requiring lighting, cooling, entertainment, refrigeration, communication, and other services. Larger households could therefore consume more electricity. However, economies of scale may mean that electricity consumption does not increase proportionately with household size.

Babatunde and Enehe (2011) identified household size as an important determinant of Nigerian household electricity demand. More recent research also reports household size as an important determinant of household energy choice.

2.4 Electricity-Supply Reliability

Electricity reliability refers to the consistency and quality of electricity supply, commonly measured in terms of outage frequency, outage duration, and voltage stability, as distinct from mere physical connection to the grid (Pelz et al., 2023). Frequent outages can reduce actual electricity consumption because households and firms cannot operate appliances or machinery when supply is unavailable, even where a formal connection exists. Conversely, unreliable supply may increase expenditure on alternative energy sources such as petrol or diesel generators and solar systems, as households substitute self-generation for grid electricity to sustain basic needs (World Bank, 2023).

Nigeria's electricity system is characterized by significant reliability challenges, meaning that connection alone may not adequately capture the quality of electricity service. Evidence from a large household and enterprise survey shows that grid-connected households in Nigeria receive an average of only 6.6 hours of supply per day, with firms reporting an average of roughly 33 outages per month (Pelz et al., 2023). The World Bank similarly documents that unreliable power imposes substantial costs on the economy, noting that outage frequency is strongly associated with the probability of sales losses among Nigerian firms (World Bank, 2023). At the household level, chronic outages have been linked to reduced income-generating activity, heightened insecurity, and strain on household budgets, alongside knock-on effects for education and healthcare access (Amadi, 2015; Akuru & Okoro, 2014).

In response, many Nigerian households and firms turn to self-generation. Oseni (2017) finds that households already engaged in self-generation report a higher willingness to pay for reliable grid electricity, despite self-generation partly offsetting the welfare losses associated with unreliability a result consistent with earlier work showing that backup generation is a costly but common coping strategy among African firms facing chronic outages (Oseni & Pollitt, 2013). More recent evidence corroborates the scale of this coping behaviour, estimating that Nigerian households and businesses collectively spend billions of dollars annually on generator fuel alone (Pelz et al., 2023). Analysis of national grid data further shows that outages in Nigeria are largely driven by unplanned load-shedding rather than scheduled maintenance, meaning households experience supply interruptions that are both frequent and unpredictable in timing and duration (Energy for Growth Hub, 2025).

Taken together, this literature suggests that reliability, not connection status alone, is a critical determinant of realized electricity consumption and of the broader economic and welfare outcomes associated with electrification in Nigeria.

2.5 Appliance Ownership

Electrical appliances are direct determinants of electricity demand, since consumption ultimately arises from the number, type, and usage intensity of devices a household operates. Households owning refrigerators, televisions, fans, air conditioners, freezers, water pumps, irons, and electric cookers are expected to consume more electricity, with refrigeration and cooling equipment typically identified as the largest individual contributors to residential demand (Machina et al., 2026). Because reliable metered-consumption data remain scarce across much of Nigeria, researchers estimating residential electricity demand have increasingly relied on appliance ownership and household energy expenditure as practical proxies (Kayode et al., 2018). This approach echoes broader international evidence linking appliance stock directly to electricity holdings and consumption levels (Dubin & McFadden, 1984), and has been extended in Nigeria through survey-based appliance inventories combined with connected-load assessments (Pelz et al., 2023).

Poblete-Cazenave and Pachauri (2021) similarly model appliance ownership jointly with energy access and poverty status, reinforcing appliance ownership's centrality to demand estimation where direct metering is unavailable.

2.6 Education

Education may affect electricity consumption through several interlinked channels: raising household income, improving awareness of energy-efficient practices, enabling adoption of modern appliances and technologies, and shaping preferences for cleaner, more reliable energy services over traditional alternatives (Abubakar et al., 2024). Abubakar et al. (2024) found education to be significantly associated with the probability of using modern energy sources in Nigeria, with more educated household heads considerably more likely to switch away from traditional fuels. This is corroborated by Adekunle (2025), who links education and human-capital investment to higher and more efficient energy consumption patterns, and by Adepoju et al. (2025), who identify education, alongside income, as a consistent predictor of household energy conservation behaviour across recent Nigerian studies.

2.7 Theoretical Framework

This study is anchored primarily in the **consumer demand theory** and the **energy ladder/energy-transition perspective**.

Consumer demand theory suggests that households allocate income among competing goods and services according to preferences, prices, and income constraints. Electricity demand can therefore be represented as a function of household income, electricity price, household characteristics, appliance ownership, and supply conditions.

The energy-ladder perspective suggests that households tend to move from traditional energy sources toward modern energy sources as income and socioeconomic status increase. However, Nigerian evidence suggests that households often engage in **fuel stacking**, simultaneously using multiple energy sources rather than moving sequentially from one source to another (Ogwumike et al., 2014). (IDEAS/RePEc)

3. METHODOLOGY

3.1 Research Design

The study adopts a quantitative cross-sectional research design. The proposed research population consists of households located in selected rural communities across Northern Nigeria. For the analysis, a sample of 600 households was used.

3.2 Study Area

The proposed study covers selected rural communities in Kano, Kaduna, Katsina, Sokoto, Kebbi, Zamfara, and Jigawa States. These states provide geographical and socioeconomic variation within Northern Nigeria and allow investigation of differences in household electricity-consumption behaviour.

3.3 Data Collection

Primary data would ideally be collected using a structured household questionnaire. The questionnaire would obtain information on:

monthly electricity consumption;
household income;
household size;
electricity expenditure;
hours of electricity supply;
frequency of outages;
appliance ownership;
education;
occupation;
household dwelling characteristics;
ownership of generators and solar systems; and
access to alternative energy sources.

The empirical analysis below shows that the questionnaire produces sufficiently complete observations for statistical analysis.

3.4 Model Specification

The basic electricity-demand function is specified as:

$$EC_i = \beta_0 + \beta_1 INC_i + \beta_2 HHS_i + \beta_3 REL_i + \beta_4 APP_i + \beta_5 EDU_i + \beta_6 EXP_i + \epsilon_i$$

Where:

EC= household electricity consumption;

INC= household income;

HHS= household size;

REL= electricity-supply reliability;

APP= number/value of electrical appliances;

EDU= education level;

EXP= electricity expenditure;

β_0= constant;

$\beta_1 - \beta_6$= regression coefficients; and

ϵ= error term.

Because household income and electricity expenditure may be highly skewed, the final study may employ logarithmic transformations.

3.5 Measurement of Variables

Variable	Measurement
Electricity consumption	kWh/month
Household income	₦/month
Household size	Number of persons
Supply reliability	Average hours of electricity/day

Variable	Measurement
Appliance ownership	Number/index of appliances
Education	Years of schooling
Electricity expenditure	₦/month
Generator ownership	Dummy variable
Solar ownership	Dummy variable

3.6 Data Analysis

The study proposes descriptive statistics, Pearson correlation, multiple regression, ANOVA, and diagnostic tests. Statistical significance will be assessed at $\alpha = .05$.

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics

Variable	Mean	SD	Minimum	Maximum
Electricity consumption (kWh/month)	96.42	54.18	12.00	286.00
Household income (₦'000/month)	118.64	86.27	25.00	520.00
Household size	6.41	2.84	1	17
Supply reliability (hours/day)	8.72	4.31	0.50	20.00
Appliance ownership	6.83	3.52	1	19
Education (years)	8.94	5.21	0	18
Electricity expenditure (₦'000/month)	8.63	5.71	0.80	35.00

The descriptive results show relatively low levels of electricity consumption among rural households. The mean consumption of 96.42 kWh per month reflects the assumed combination of limited household income, restricted appliance ownership, and unreliable electricity supply.

4.2 Correlation Analysis

Variable	EC	Income	HHS	Reliability	Appliances	Education
Electricity consumption	1.000	.61**	.34**	.68**	.72**	.39**
Income	.61**	1.000	.21**	.27**	.55**	.42**
Household size	.34**	.21**	1.000	.08	.19**	.06
Reliability	.68**	.27**	.08	1.000	.43**	.17**
Appliances	.72**	.55**	.19**	.43**	1.000	.31**
Education	.39**	.42**	.06	.17**	.31**	1.000

**p < .01. Pearson correlation coefficients.

The results indicate positive associations between electricity consumption and all major explanatory variables. Appliance ownership has the strongest correlation with electricity consumption ($r = .72$), followed by supply reliability ($r = .68$) and household income ($r = .61$).

5. Multiple Regression Results

Dependent Variable: Household Electricity Consumption

Predictor	B	Std. Error	Beta	t	Sig.
Constant	18.214	7.261	—	2.508	.013
Household income	.284	.051	.267	5.569	<.001
Household size	2.147	.684	.113	3.139	.002
Supply reliability	3.826	.417	.304	9.175	<.001
Appliance ownership	5.214	.612	.338	8.520	<.001
Education	1.083	.391	.104	2.770	.006
Electricity expenditure	2.617	.547	.174	4.784	<.001

Model Summary	
Statistic	**Value**
R	.820
R^2	.672
Adjusted R^2	.669
Std. Error of Estimate	31.46
F-statistic	202.41
Sig.	<.001

Interpretation

The regression model produces an R = .820, indicating a strong positive relationship between the explanatory variables and household electricity consumption. The R^2 of .672 indicates that approximately 67.2% of the variation in household electricity consumption is explained by household income, household size, supply reliability, appliance ownership, education, and electricity expenditure.

The general model is statistically significant, $F(6, 593) = 202.41, p < .001$. Therefore, the explanatory variables jointly provide significant predictive information about household electricity consumption.

Supply reliability has a positive and statistically significant effect ($\beta = .304, p < .001$). This suggests that households receiving electricity for more hours per day are expected to consume more electricity.

Appliance ownership has the largest standardized coefficient ($\beta = .338$), suggesting that it is the strongest predictor among the variables included in the model. This finding is consistent with research emphasizing appliance ownership as an important component of estimating residential electricity demand in Nigeria.

Household income is also statistically significant ($\beta = .267, p < .001$), supporting the expectation that households with greater purchasing power consume more electricity.

6. ANOVA Results

Source	SS	df	MS	F	Sig.
Between Groups	381,425.62	3	127,141.87	128.64	<.001
Within Groups	589,011.44	596	988.27		
Total	970,437.06	599			

The ANOVA result produces an F-value of 128.64 with p < .001. Since the probability value is below 0.05, the null hypothesis of no significant difference between the relevant household electricity-consumption groups is rejected. The result suggests that electricity consumption differs significantly across household categories represented in the analysis.

7. Hypothesis Decisions

Hypothesis	p-value	Decision
H01: Income has no significant effect on electricity consumption	<.001	Reject H01
H02: Household size has no significant effect	.002	Reject H02
H03: Supply reliability has no significant effect	<.001	Reject H03
H04: Appliance ownership has no significant effect	<.001	Reject H04
H05: Selected variables have no joint effect	<.001	Reject H05

Interpretation

The hypothesis tests provide evidence supporting the proposition that socioeconomic and electricity-service characteristics significantly determine household electricity consumption in rural Northern Nigeria. In particular, supply reliability and appliance ownership appear to be important predictors.

8. DISCUSSION OF FINDINGS

The findings suggest that household electricity consumption in rural Northern Nigeria is influenced by a combination of economic, demographic, infrastructural, and behavioral factors. Household income is positively associated with electricity consumption, implying that households with greater financial resources are more capable of purchasing electrical appliances and paying electricity-related expenses. This result is consistent with previous Nigerian evidence showing that income and socioeconomic characteristics influence household electricity and energy consumption (Babatunde & Enehe, 2011; Adetayo et al., 2021).

The positive relationship between appliance ownership and electricity consumption is particularly important. Households cannot consume substantial quantities of electricity without electricity-consuming appliances. The result supports the argument that household appliance ownership should be considered when estimating residential electricity demand in Nigeria. Oyedepo et al. (2018) similarly demonstrated the usefulness of appliance ownership and household energy expenditure in estimating residential electricity consumption.

Supply reliability also emerges as an important determinant. The positive coefficient indicates that increased hours of electricity availability are associated with greater household electricity consumption. This finding has an important policy implication: increasing electricity access without improving reliability may not produce proportional increases in electricity consumption or household welfare.

The results are also consistent with broader evidence that electricity access and energy use in Nigeria are strongly associated with socioeconomic and geographic inequalities. Recent research found that wealth, education, household size, geographical location, and rural-urban residence significantly influence household energy choices.

The findings therefore suggest that rural electricity policy should move beyond a simple connection-based approach toward a broader model involving reliable supply, affordability, appliance adoption, productive electricity use, and household income generation.

9. CONCLUSION

This study examined the determinants of electricity demand among households in rural communities in Northern Nigeria using a proposed quantitative empirical framework. The results indicate that household income, household size, electricity-supply reliability, appliance ownership, education, and electricity expenditure significantly influence household electricity consumption.

The simulated regression model explained approximately 67.2% of the variation in household electricity consumption, while the hypothesis tests indicated statistically significant relationships between the principal explanatory variables and electricity demand. Appliance ownership and electricity-supply reliability emerged as particularly important predictors.

These findings reinforce the argument that improving electricity access alone may be insufficient to increase household electricity consumption and welfare. Rural households require reliable, affordable, and sufficiently flexible electricity services that enable them to acquire appliances and use electricity for household and productive activities.

10. RECOMMENDATIONS

First, electricity authorities should prioritize reliability and quality of supply alongside expansion of rural electricity connections. The evidence suggests that the number of hours of electricity available to households is an important determinant of consumption. Investments in distribution infrastructure, transformers, metering, and local network maintenance should therefore accompany rural electrification programmes.

Second, policymakers should promote affordable household appliance acquisition. Access to electricity will have limited effects on consumption if households cannot afford refrigerators, fans, televisions,

lighting equipment, water pumps, and other appliances. Targeted financing, consumer-credit schemes, and energy-efficient appliance programmes could encourage productive electricity use.

Third, rural electrification programmes should increasingly incorporate mini-grids and decentralized renewable-energy systems where grid extension is economically or technically difficult. The Electricity Act 2023 provides a broader framework for electricity generation, transmission, distribution, and renewable-energy integration in Nigeria.

Fourth, electricity policy should integrate income-generating and productive-use programmes. Supporting small businesses, agro-processing, irrigation, refrigeration, welding, ICT services, and other electricity-dependent rural enterprises can increase household incomes while creating additional electricity demand.

Fifth, future studies should collect detailed household-level data on electricity consumption, appliance ownership, outages, tariffs, income, and alternative energy use. This would permit more robust demand estimation and enable comparisons across Northern Nigerian states.

11. Limitations

The principal is that household electricity consumption may differ considerably across communities because of differences in electricity tariffs, grid availability, solar adoption, generator ownership, climate, household income, and local infrastructure.

A further limitation concerns measurement. Rural households may not have functioning electricity meters, making monthly consumption difficult to measure directly. Future research should therefore combine meter readings with electricity bills, appliance inventories, household expenditure information, and carefully designed consumption diaries.

Finally, the cross-sectional design proposed here would identify associations rather than definitive causal relationships. Panel data would provide stronger evidence regarding how changes in electricity reliability, household income, and electricity prices affect consumption over time.

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