



---

## Research Article

# Energy Use Practices in Households across Selected Communities in Guma Local Government Area of Benue State, Nigeria

\*Ekhuemelo D. O., Ordugh A. and Samuel C. O.

Department of Forest Production and products, University of Agriculture, Makurdi (Now Joseph Sarwuan Tarka University, Makurdi), Nigeria

\*Corresponding Author's email: [ekhuemelo.david@uam.edu.ng](mailto:ekhuemelo.david@uam.edu.ng)

---

## ABSTRACT

Household energy choices shape economic, environmental, and health outcomes, including deforestation and carbon emissions. This study assessed household energy use in selected communities of Guma Local Government Area, Benue State, Nigeria. Using a multi-stage sampling approach guided by security and proximity, 110 respondents were surveyed with structured questionnaires. Data were analysed using ANOVA, Spearman correlation, and multiple regression to examine how income, employment, and education influence energy preferences. Respondents were predominantly female (89.1%) and aged 21 - 50 years (90.8%). Over half (51.8%) reported no income, and only 2.7% earned above ₦161,000 monthly. Most households spent ₦0 - ₦4,000 (56.4%) or ₦5,000 - ₦10,000 (25.5%) on energy. Firewood (83.6%) and charcoal (81.8%) were the dominant fuels, chosen mainly for low cost (51.8%) and accessibility (25.5%). The most common energy mix was firewood, charcoal, and gas (81.8%). Firewood use declined with rising income, while gas use increased. Cooking gas and firewood were strongly negatively correlated ( $r = -0.981$ ,  $p < 0.01$ ). Firewood remained the most used fuel across employment categories, especially among the unemployed (mean =  $13.28 \pm 0.00$ ). Regression results ( $R = 1.000$ ,  $R^2 = 1.000$ ) confirmed income as a strong predictor of energy patterns. Wealthier, more educated households adopted cleaner fuels, whereas low-income and unemployed households relied on biomass. Policies improving affordability, access, and awareness of cleaner alternatives are needed to support a sustainable energy transition.

**Keywords:** Education; Employment; Energy; Household; Income

**Citation:** Ekhuemelo, D.O., Ordugh, A. & Samuel, C.O. (2026). Energy Use Practices in Households across Selected Communities in Guma Local Government Area of Benue State, Nigeria. *Sahel Journal of Life Sciences FUDMA*, 4(3): 113-131. DOI: <https://doi.org/10.33003/sajols-2026-0403-12>

---

## INTRODUCTION

Worldwide, energy utilization is a significant driver of environmental challenges. Household energy preferences in Nigeria are characterized by a complex mix of traditional and modern energy sources. Understanding the factors that influence household energy use in buildings is crucial for developing effective energy conservation policies (Olanrewaju and Adegun, 2021). Household energy consumption is a critical aspect of the socio-economic fabric of communities, particularly in developing countries like Nigeria. The Energy Ladder Model, as discussed in Adamu, Akeh, Adamu and Ade (2020), provides a framework for understanding how increasing income

levels might influence a shift towards cleaner energy sources. However, this model challenges the reality that households often use a mix of energy sources rather than completely substituting one for another. The paper underscores the persistent reliance on traditional energy sources in Nigerian households, exacerbated by rising poverty, and calls for policies to promote modern energy use (Adamu *et al.*, 2020). Access to modern energy services remains a critical challenge in developing countries, where over 2.4 billion people rely on traditional biomass fuels for cooking and heating, contributing to indoor air pollution, deforestation, and health risks (World Health Organization [WHO], 2023). The Energy

Ladder Model provides a foundational framework for understanding household energy transitions, positing that as socioeconomic status improves particularly through higher income and education. Households ascend from inferior, polluting fuels (firewood, charcoal) to cleaner, more efficient alternatives for example, kerosene, gas and electricity. However, empirical evidence from Nigeria reveals deviations through energy stacking, where households simultaneously use multiple fuels across the ladder for different tasks like cooking, heating, lighting among others, rather than complete substitution, due to affordability barriers and fuel availability (Twerefou and Abeney, 2020).

Contradictorily, while the Energy Ladder Model suggests a transition to cleaner energy with increased income, Danlami and Islam (2020) highlights that even with higher income levels, there is a significant dependence on firewood for cooking in Bauchi state, Nigeria. This suggests that factors other than income, such as energy availability and cultural preferences, may also play a crucial role in energy consumption patterns. Moreover, the positive correlation between income and energy consumption, as well as the negative relationship between energy price and consumption, indicates the complexity of energy choice dynamics in Nigerian households (Danlami and Islam, 2020; Li, Li, Zheng and Zhou, 2024).

In Nigeria, 70% of rural households depend on firewood (83% in some southwestern regions), exacerbating environmental degradation and respiratory illnesses, particularly among women and children (Bolaji-Olutunji, Banjo, Olowoyo and Obadimu, 2020). Although there is no available data on household energy consumption patterns the Guma LGA of Benue State. However, related insights can be drawn from the available research. For instance, Ancha, Shomkegh, and Onuche (2019) highlights the reliance on forest reserves for fuel wood products by communities in Ogbadibo LGA which suggests a potential pattern of energy consumption reliant on biomass in similar regions (Ancha *et al.*, 2019). Ekhuemelo, Tembe, and Abah (2019) reported charcoal production in both Makurdi and Guma LGAs, indicating that charcoal is a

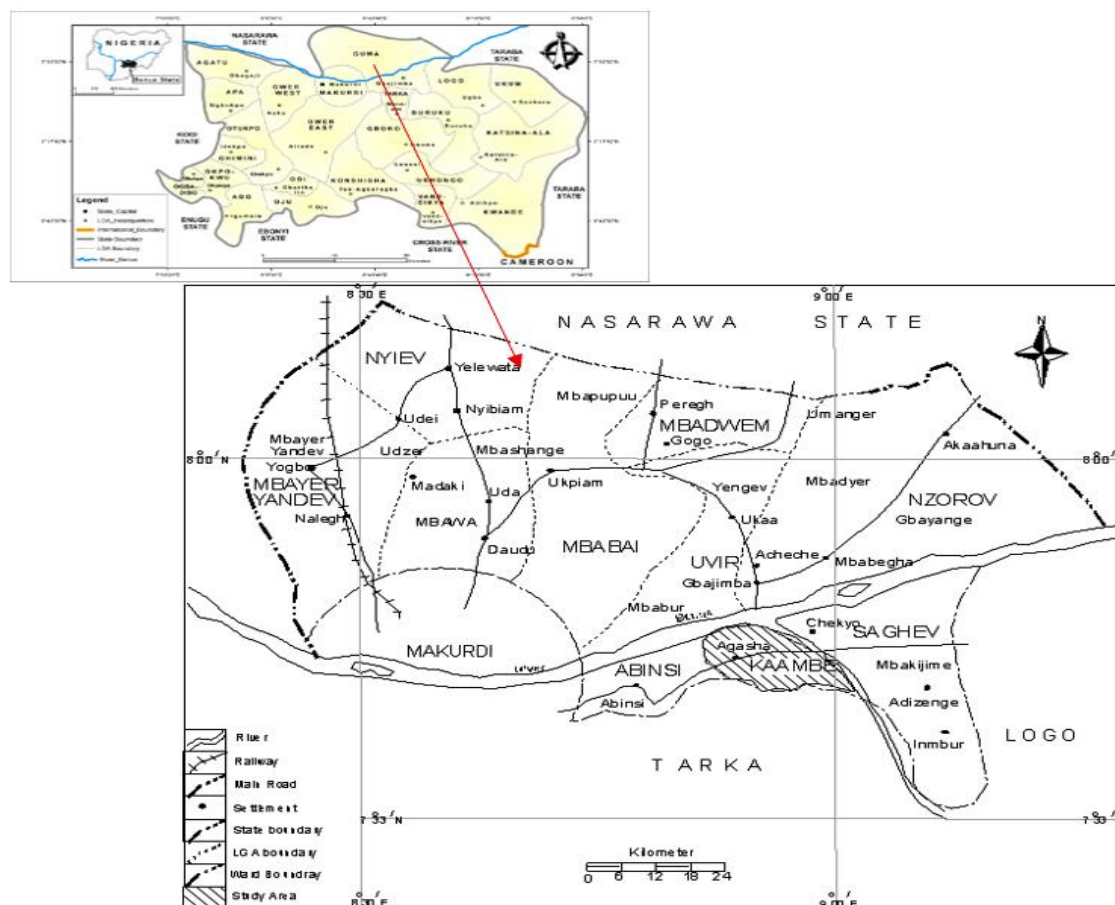
significant source of domestic cooking energy, which could imply its prevalence in household energy consumption within the Guma area.

Guma LGA in Benue State represents an ideal case study: as a predominantly agrarian rural region with significant natural gas reserves yet limited infrastructure e.g., ongoing electrification projects in Agasha-Tyulen, exemplifies energy poverty amid untapped resources. Benue's urban-rural energy substitution patterns are firewood dominant in low-income homes transitioning slowly to gas that mirror national trends but highlight localized stacking behaviours influenced by farming incomes and biomass availability (Ngutsav, Akiri and Onov, 2021). In this study, assessment of energy use practices in households across selected communities in Guma LGA, Benue State, Nigeria was carried out ascertain household preferences in the LGA.

## **MATERIALS AND METHODS**

### **Study Area**

This research was conducted in Guma Local Government Area (LGA), situated in the northern part of Benue State, Nigeria, covering a landmass of 2,882 square kilometers. Guma is located between latitude 7°30' - 8°03'E and longitude 8°04' - 9°02'N (Amuta and Houmsou, 2014). It shares borders with Tarka and Logo LGAs to the east, Makurdi LGA to the south, and Nasarawa State to the north (Figure 1). The area comprises isolated villages and towns that are gradually expanding into urban settlements, characterized by scattered rural settlement patterns. The settlement distribution is largely influenced by land speculation and agricultural needs, as households require extensive farmland for cultivation. According to the 2006 census, the population of Guma LGA was 191,599. The LGA consist of 10 council wards namely: Abinsi, Kaambe, Mbabai, Mbadwem (or Mbadwen), Mbawa, Mbayer/Yandev, Nyiev, Nzorov, Saghev, and Uvir. Many of the inhabitants are Tiv people, primarily engaged in farming activities, producing grains such as rice, maize, and ground nuts. Additionally, the area hosts a small number of Fulani herdsmen, who are visitors, and their primary occupation is cattle rearing.



**Figure 1: Map of the Study Area**

Source: Terwase (2013)

### Experimental design

A multistage sampling technique was used to select 110 households in Guma LGA, Benue State, Nigeria. Although the LGA comprises 10 council wards, only four wards Mbawa, Mbabai, Nyiev, and Nzorov (Table 1) were included because persistent insecurity, including attacks by armed herders and the displacement of residents, made the remaining wards inaccessible for fieldwork.

In the first stage, the four accessible Wards were purposively selected based on security and accessibility. In the second stage, five communities were identified within these Wards: Daudu (Mbawa), Ukpam (Mbabai), Ortese and Yelewata (Nyiev), and Gbajimba (Nzorov). These communities constituted the sampling frame for household selection, and 22 households were proportionally allocated to each community, giving a total sample size of 110 households.

At the third stage, household lists were generated through field enumeration in each selected community. Households were then selected using systematic random sampling, with the first household determined randomly by bottle spin and subsequent households chosen at a fixed interval of every fifth household until the required quota was obtained.

At the fourth stage, one eligible adult respondent was randomly selected from each sampled household. Eligible respondents were defined as household heads or spouses aged 18 years and above. Where the selected household or respondent was unavailable, refused to participate, or did not meet the eligibility criteria, the next eligible household or respondent in the predetermined sampling sequence within the same community was selected as a replacement. This procedure ensured that the target sample size was maintained while preserving the structure and transparency of the sampling process.

**Table 1: Names of Council Wards and communities sampled Guma LGA**

| Name of Council ward | Name of Community | Frequency (F) | Percentage (%) |
|----------------------|-------------------|---------------|----------------|
| Mbawa                | Daudu             | 22            | 20             |
| Mbabai               | Ukpam             | 22            | 20             |
| Nyiev                | Ortese            | 22            | 20             |
| Nzorov               | Yelewata          | 22            | 20             |
| Total                | Gbajimba          | 110           | 100            |

#### Data collection method

Data for the study was collected using a structured questionnaire administered through face-to-face household interaction conducted by the researcher across selected communities. The questionnaire was in five-section and captured comprehensive data on geographic location: (Section A) was socio-economic characteristics, (Section B) was household energy consumption patterns, (Section C), energy preferences by income and employment status, (Section D), and energy preferences by educational level with quantitative consumption estimates (Section E). Ethical approval was obtained from village heads and councils of community elders in the various selected wards prior to data collection. Informed consent was verbally secured from all participants after explaining the study's purpose, voluntary participation, and right to withdraw, while confidentiality was ensured through anonymization of responses and secure data storage.

#### Data Analysis

Data collated and analysed with Microsoft excel to perform frequencies, percentages, and means captured respondent demographics, income levels, energy expenditures, source preferences, accessibility perceptions, usage reasons, daily frequency, influencing factors, and consumption volumes across weekly and monthly periods and shown in Tables and Charts. Furthermore, Statistical Package for the Social Sciences (IBM SPSS Statistics 27) was used

#### Unit of Analysis

This study analyzed household energy preferences in Guma LGA, Nigeria, using household-level observations (n=110 respondents) to test socioeconomic influences via ANOVA with Duncan post-hoc, Spearman correlations, and multiple regression, with stated null hypotheses ( $H_0$ ) for each inferential test linking energy usage to income, employment, and education factors.

#### ANOVA

##### i. Income Levels on Energy Preference

Dependent variable (DV) = mean energy source usage scores (firewood, charcoal, gas, kerosene, electricity); factor = income brackets

$H_0$ : Group means are equal

One-way ANOVA model:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij} \quad \text{.....} \quad (1)$$

Where:

$Y_{ij}$ = energy usage score for household  $j$  in income group  $i$

$\mu$ = overall mean

$\tau_i$ = effect of income group  $i$

$\varepsilon_{ij}$ = random error term,  $\varepsilon_{ij} \sim N(0, \sigma^2)$

Null hypothesis:

$$H_0: \mu_1 = \mu_2 = \dots = \mu_k \quad \text{.....} \quad (2)$$

#### Correlation (Spearman)

Spearman's rank correlation coefficient:

$$\rho_s = 1 - \frac{6 \sum d_i^2}{n(n^2-1)} \quad \text{.....} \quad (3)$$

Where:

$d_i$ = difference between paired ranks

$n$ = number of observations

#### Regression

Multiple Regression Models

$$Y_i = \beta_0 + \beta_1 D_{1i} + \beta_2 D_{2i} + \beta_3 D_{3i} + \beta_4 D_{4i} + \varepsilon_i \quad \text{.....} \quad (4)$$

Where:

$Y_i$ = energy preference score for household  $i$

$D_{ki}$ = dummy variables for income categories

$\beta_0$ = intercept (reference income group)

$\varepsilon_i \sim N(0, \sigma^2)$

Model null hypothesis:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

#### RESULTS

##### Demographics and Energy Patterns

The results revealed a predominantly female population (89.1%), with a significant age concentration between 31 – 40 years (43.6%). Education levels indicated that 43.6% attained secondary education, while 27.3% had informal education. Farming emerged as the primary

occupation (59.1%), reflecting the agrarian nature of the region. Christianity was the dominant religion (95.5%), and marital status was largely comprised of married individuals (70%). Family sizes were

moderate, with 40.9% having 4-6 members. Housing conditions showed a nearly equal distribution between one-room apartments (31.8%) and duplexes (31.8%), with 16.4% living in flats (Table 2).

**Table 2: Demographic characteristics of respondents**

| Variables                 | Frequency | %         |
|---------------------------|-----------|-----------|
| <b>Sex</b>                |           |           |
| Male                      | 12        | 1.90      |
| Female                    | 98        | 89.1      |
| <b>Age</b>                |           |           |
| 0 – 20                    | 2         | 1.8       |
| 21 – 30                   | 26        | 23.6      |
| 31 – 40                   | 48        | 43.6      |
| 41 - 50                   | 26        | 23.6      |
| 51 – 60                   | 8         | 7.30      |
| <b>Level of Education</b> |           |           |
| Primary                   | 21        | 19.1      |
| Secondary                 | 48        | 43.6      |
| Tertiary                  | 11        | 10.0      |
| Informal                  | 30        | 27.3      |
| <b>Occupation</b>         |           |           |
| Civil servants            | 4         | 3.60      |
| Farming                   | 65        | 59.1      |
| Business                  | 31        | 28.2      |
| Student                   | 8         | 7.30      |
| Private Employment        | 2         | 1.80      |
| <b>Religion</b>           |           |           |
| Christianity              | 105       | 95.5      |
| Islam                     | 5         | 4.50      |
| <b>Marital status</b>     |           |           |
| Single                    | 11        | 10.0      |
| Married                   | 77        | 70.0      |
| Divorced                  | 4         | 3.60      |
| Widow                     | 17        | 15.5      |
| Widower                   | 1         | 0.90      |
| <b>Family Size</b>        |           |           |
| 1 - 3                     | 37        | 33.6      |
| 4 - 6                     | 45        | 40.9      |
| 7 – 10                    | 23        | 20.9      |
| 11 - 15                   | 5         | 5.50      |
| <b>Type of house</b>      |           |           |
| Thatch house              | 11        | 10.0      |
| One room apartment        | 35        | 31.8      |
| Flat                      | 18        | 16.4      |
| Duplex                    | 35        | 31.8      |
| Self-contained            | <b>11</b> | <b>10</b> |

Source: Field work, 2023

**Monthly Income Distribution and Household Energy Expenditure Patterns in Guma LGA, Nigeria**

Results of monthly income and household energy expenditure patterns of respondents in selected

communities of Guma LGA reveal that a majority (51.8%) of respondents reported no income, highlighting economic challenges in the region (Figure 2). A further 14.5% earned between ₦51,000 -

₦100,000, while higher-income brackets (₦161,000 and above) represented only 2.7% of the population. Household energy expenditure was predominantly low, with 56.4% spending ₦0 - ₦4,000 monthly and 25.5% allocating ₦5,000 - ₦10,000 on household energy. Only a minimal percentage (1.8%) reported energy expenditures exceeding ₦21,000 (Figure 3).

#### **Household Energy Source Preferences and Fuel Combination Patterns in Guma LGA, Nigeria**

Among single household energy sources, charcoal was the most preferred, used by 81.8% of respondents, while gas usage accounts for only 14.5%. Firewood and kerosene are the least used single energy sources (1.8% each). For double combinations, firewood and charcoal dominate with 83.6%, while other combinations like firewood and kerosene and electricity and kerosene have minimal adoption (2.7% and 1.8%, respectively). Among triple combinations, the preference for fuel wood, charcoal, and gas is overwhelmingly high at 81.8%, indicating a significant reliance on multiple energy sources for household needs (Figure 4).

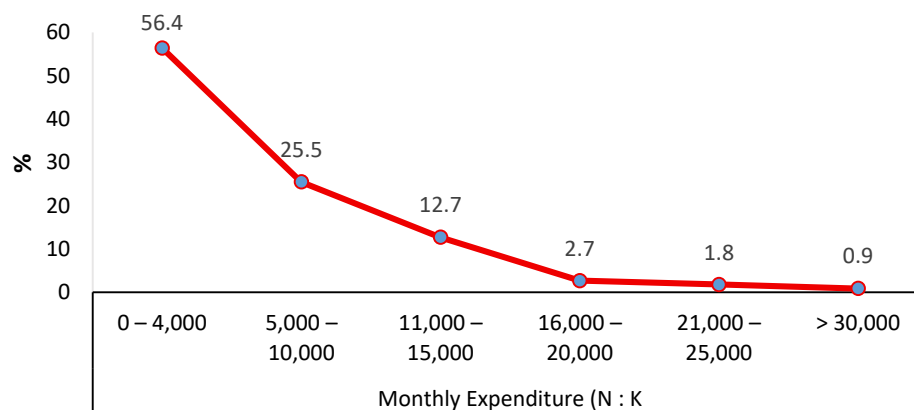
#### **Respondents perceived accessibility of household energy use in Guma LGA**

Respondents rated their experiences on the accessibility of different types of energy with charcoal, firewood, electricity, gas, and kerosene

based on ease of access. The results indicate that traditional fuels, particularly firewood (88.2%) and charcoal (80.9%), were perceived as the most accessible and convenient energy sources. Conversely, kerosene is difficult to access (60.9%), electricity and gas were partially difficult to access with 48.26 and 50% of respondents, respectively (Figure 5). Kerosene had the highest proportion of respondents (25.5%) rating it as very difficult to access.

#### **Effect of income levels on household energy preference in Guma LGA**

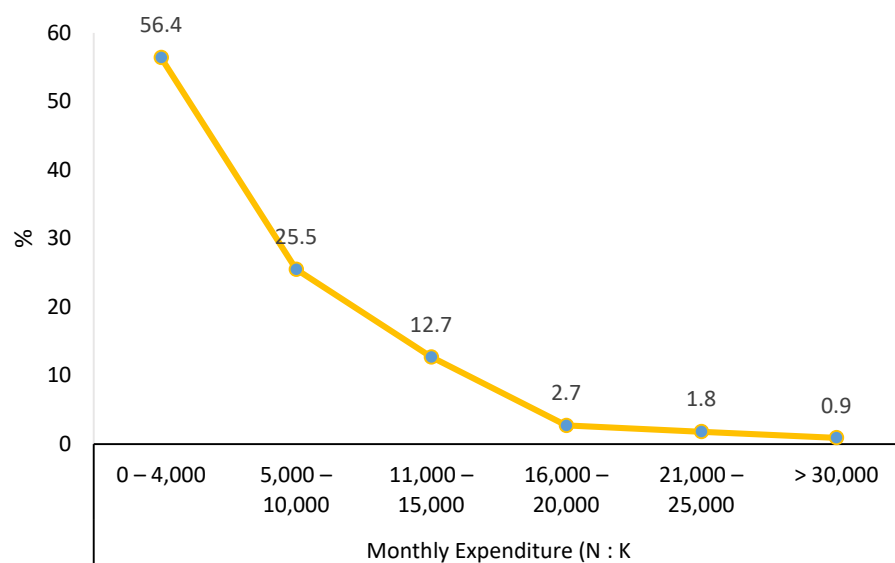
Low cost (51.8%) and ease of accessibility (25.5%) were the primary reasons for household energy preference in Guma, while convenience accounts for 21.8%. Most respondents (72.8%) utilize energy solely for domestic purposes, with a smaller proportion (27.3%) using it for both domestic and business activities. Energy use is consistently frequent throughout the day, with all respondents (100%) using energy in the morning, afternoon, and evening. Among the factors influencing household energy choices, income (37.3%) emerged as the most significant, followed by family size (21.8%) and location (20%). Seasonal variations and the cost of petroleum products had a lower but notable impact at 4.5% and 16.4%, respectively (Table 3).



**Figure 2: Monthly income on Household energy of respondents**

**Legend:** All monetary values in this manuscript are reported in Nigerian Naira (₦)

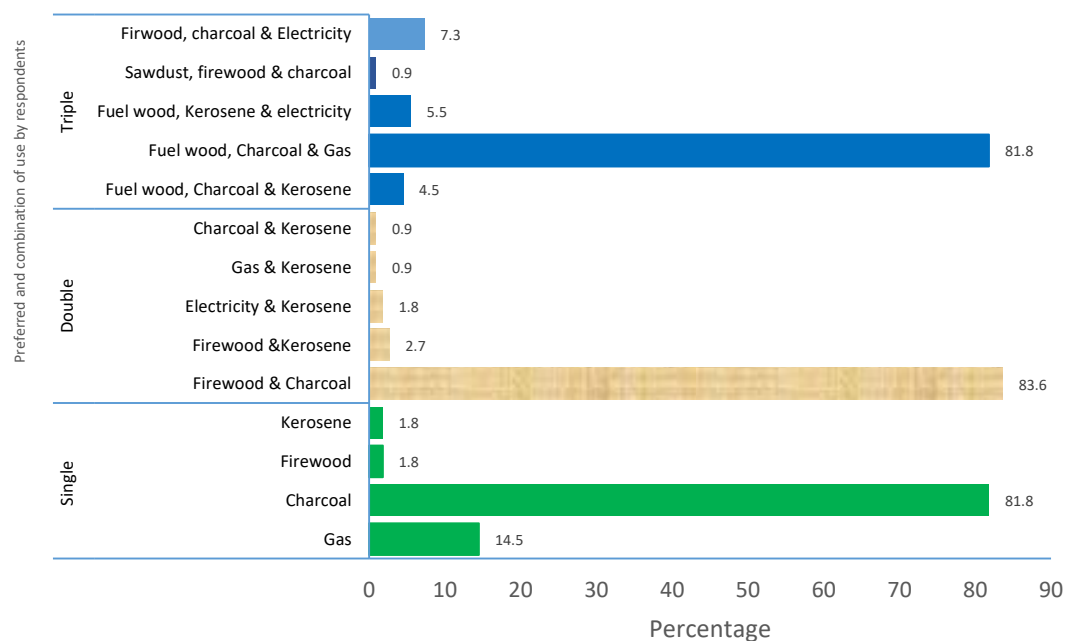
Source: Field work, 2023



**Figure 3: Monthly expenditure on Household energy of respondents**

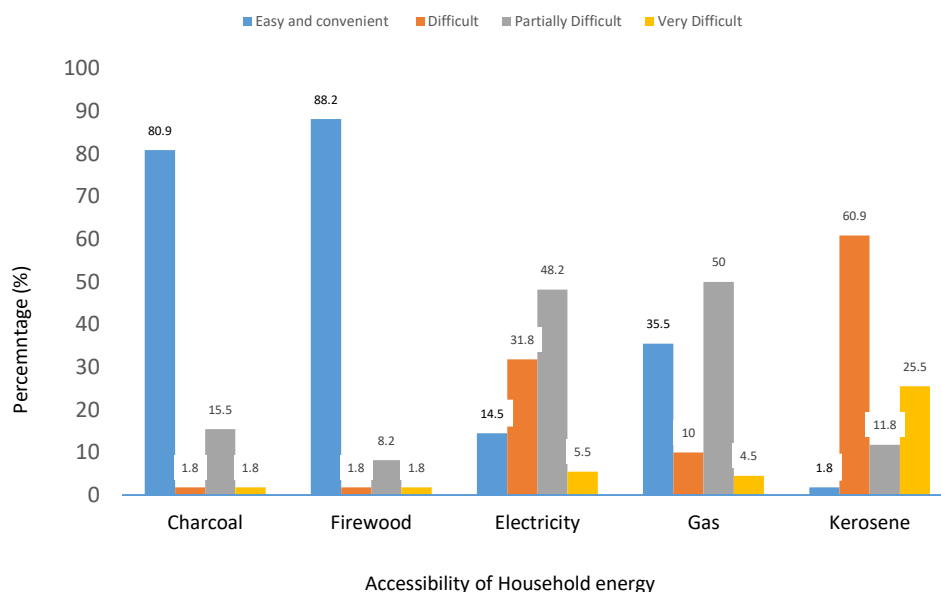
**Legend:** All monetary values in this manuscript are reported in Nigerian Naira (₦)

Source: Field work, 2023



**Figure 4: Types, Preference and combination of household energy use by respondents**

Source: Field work, 2023



**Figure 5: Respondents perceived accessibility of household energy use in Guma LGA**

Source: Field work, 2023

**Table 3: Reasons influencing energy use by respondents**

| Variable                             | Frequency | Percentage (%) |
|--------------------------------------|-----------|----------------|
| Reason for energy preference         |           |                |
| Convenience                          | 24        | 21.8           |
| Low cost                             | 57        | 51.8           |
| Ease accessibility                   | 28        | 25.5           |
| Easy to ignite                       | 1         | 0.9            |
| Uses of energy                       |           |                |
| Domestic                             | 80        | 72.8           |
| Domestic and Business                | 30        | 27.3           |
| Frequency of energy use              |           |                |
| Morning, afternoon and Evening       | 110       | 100            |
| Factors influencing household energy |           |                |
| Season                               | 5         | 4.5            |
| Income                               | 41        | 37.3           |
| Location                             | 22        | 20             |
| Cost of petroleum products           | 18        | 16.4           |
| Family size                          | 24        | 21.8           |

Source: Field work, 2023

#### ***Effect of income levels on household energy preference in Guma LGA***

Firewood was the dominant energy source among lower-income households in Guma LGA, with significantly higher usage in income groups below N100,000, while its consumption decreases as household income rises. Charcoal serves as an intermediate energy source among respondents, peaking in the N21,000 – N100,000 income range before declining in higher-income groups. Gas usage shows a significant upward trend, becoming the most

preferred energy source in wealthier households earning above N200,000. Kerosene remains minimally utilized across all income levels, while electricity usage, though slightly increasing among high-income earners, remains significantly lower than gas, indicating possible infrastructural or cost-related constraints (Table 4). The findings underscore the need for targeted policies to improve income of low-income household in Guma to afford cleaner energy sources to reduce the environmental problems that

come result from massive utilization of biomass as energy source among low-income households.

The extremely high F-value (31107.187) and the significance level ( $p < .001$ ) indicate a very strong and statistically significant relationship between the households' income levels and energy type (Table 4). The model explains nearly all the variance in energy type (Sum of Squares Regression / Total = 29.998 / 30.000 = 99.99%), suggesting that household incomes are exceptionally powerful predictors of household energy choices.

The ANOVA results revealed that the regression model (Table 5) accounted for a total sum of squares of 3.517 with 7 degrees of freedom at a mean square value of 0.502, while the residual variance had a sum of squares of 19.538 with 102 degrees of freedom and a mean square of 0.192. The resulting F-statistic of 2.623 with a p-value of 0.016 indicates that household income levels exert a statistically significant effect on the choice of energy type ( $p < 0.05$ ). This implies that as income levels increase, there is a measurable shift in household energy preferences from traditional sources such as firewood and charcoal toward cleaner and more modern fuels like gas and kerosene. The findings underscore economic capacity as a major determinant of domestic energy consumption behavior.

However, kerosene demonstrated a moderate positive correlation with gas ( $r = 0.577$ ,  $p < 0.01$ ) but no significant relationship with electricity, suggesting that the use of kerosene was not necessarily influenced by increase in income level but on availability. Charcoal and firewood showed a moderate positive correlation ( $r = 0.519$ ,  $p < 0.01$ ), indicating their concurrent use in some households with low income (Table 6). These results provide valuable insights into the energy transition patterns in Guma LGA, highlighting the shift from traditional biomass fuels to modern energy sources as household improved. The findings have important implications for energy policy formulation which

implies that for households to switch from biomass to modern energy, households must be improved otherwise, they will rely solely on firewood and charcoal which in turn will increase deforestation and environmental pollution.

The correlation (Table 7) matrix reveals strong, statistically significant negative associations between "No fixed income" status and salaried income groups, particularly mid-range brackets ( $r = -0.412^{**}$  with ₦51,000 -100,000;  $r = -0.428^{**}$  with <₦21,000;  $p < 0.01$ ). These inverse relationships indicate mutual exclusivity households rarely occupy both informal/unstable income status and formal salary categories simultaneously. Higher income brackets exhibit weaker, mostly non-significant correlations among themselves ( $r$  ranging from -0.013 to -0.116), suggesting limited overlap in extreme income distributions. The findings highlight Nigeria's polarized income structure, where employment stability strongly differentiates low-to-middle income households from those without fixed earnings. This pattern underscores socioeconomic barriers to income progression and supports targeted interventions for informal sector formalization to enhance economic mobility and reduce vulnerability among no-fixed-salary populations.

#### **Regression Model Summary for the Relationship between Energy types and Monthly Income Levels**

Regression model results (Table 8) show a moderate correlation ( $R = 0.391$ ) and indicated that income categories explained 15.3% of the variation in energy use patterns ( $R^2 = 0.153$ ,  $p = 0.016$ ). The findings confirm that income significantly affects household energy preferences, with higher-income groups more likely to adopt cleaner sources such as gas and kerosene, while lower-income households remain dependent on traditional fuels. The study highlights the importance of integrating income-sensitive strategies into national energy policies to promote equitable access to sustainable and modern energy options.

**Table 4: Effect of income levels on household energy preference in Guma LGA**

| Energy Type | No fixed income         | Respondents' income (N : K) in comparison to Energy Choice (Means±stdv) |                         |                         |                         |                         |                         |                         |
|-------------|-------------------------|-------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
|             |                         | Less than N 21,000                                                      | N 21,000 – 50,000       | N 51,000 – 100,000      | N 101, 000 – 151,000    | N 151,000 – 160,000     | N 161,000 – 200,000     | Above N200,000          |
| Gas         | 1.83±0.01 <sup>c</sup>  | 0.90±0.00 <sup>c</sup>                                                  | 2.13±0.01 <sup>c</sup>  | 3.67±0.01 <sup>c</sup>  | 7.57±0.01 <sup>b</sup>  | 10.00±0.00 <sup>b</sup> | 16.07±0.01 <sup>a</sup> | 20.20±0.00 <sup>a</sup> |
| Kerosene    | 0.30±0.00 <sup>d</sup>  | 0.00±0.00 <sup>d</sup>                                                  | 0.30±0.00 <sup>d</sup>  | 0.30±0.00 <sup>e</sup>  | 0.30±0.00 <sup>d</sup>  | 0.60±0.00 <sup>d</sup>  | 0.90±0.00 <sup>d</sup>  | 0.30±0.00 <sup>d</sup>  |
| Charcoal    | 3.37±0.01 <sup>b</sup>  | 4.83±0.01 <sup>b</sup>                                                  | 5.77±0.01 <sup>b</sup>  | 5.80±0.00 <sup>b</sup>  | 6.07±0.01 <sup>c</sup>  | 4.23±0.01 <sup>c</sup>  | 3.93±0.01 <sup>c</sup>  | 1.23±0.01 <sup>c</sup>  |
| Firewood    | 27.83±0.01 <sup>a</sup> | 27.87±0.01 <sup>a</sup>                                                 | 25.17±0.01 <sup>a</sup> | 22.93±0.01 <sup>a</sup> | 19.40±0.00 <sup>a</sup> | 17.87±0.01 <sup>a</sup> | 12.13±0.01 <sup>b</sup> | 10.70±0.00 <sup>b</sup> |
| Electricity | 0.00±0.00 <sup>e</sup>  | 0.00±0.00 <sup>d</sup>                                                  | 0.00±0.00 <sup>e</sup>  | 0.60±0.00 <sup>d</sup>  | 0.00±0.00 <sup>e</sup>  | 0.60±0.00 <sup>d</sup>  | 0.30±0.00 <sup>e</sup>  | 1.23±0.01 <sup>c</sup>  |

**Legend:** Mean values in the same column with same alphabet are not significantly different from each other ( $P < 0.05$ )

Source: Field work, 2023

**Table 5: ANOVA Summary for the Relationship between Energy Types and Monthly Income Levels**

| Source of Variation | Sum of Squares | df  | Mean Square | F-Statistic | Sig. (p-value)     |
|---------------------|----------------|-----|-------------|-------------|--------------------|
| Regression          | 3.517          | 7   | 0.502       | 2.623       | 0.016 <sup>b</sup> |
| Residual            | 19.538         | 102 | 0.192       |             |                    |
| Total               | 23.055         | 109 |             |             |                    |

**Notes:**

- Dependent Variable: Energy Types
- Predictors: (Constant), Above N 200,000, N 161,000 – 200,000, N 151,000 – 160,000, N 101, 000 – 151,000, N 21,000 – 50,000, N 51,000 – 100,000, Less than N 21,000

Source: Field work, 2023

**Table 6: Correlation Analysis of Household Energy Choices**

| Energy Type | Gas      | Kerosene | Charcoal | Firewood | Electricity |
|-------------|----------|----------|----------|----------|-------------|
| Gas         | 1        | 0.577**  | -0.672** | -0.981** | 0.742**     |
| Kerosene    | 0.577**  | 1        | -0.154   | -0.647** | 0.186       |
| Charcoal    | -0.672** | -0.154   | 1        | 0.519**  | -0.659**    |
| Firewood    | -0.981** | -0.647** | 0.519**  | 1        | -0.706**    |
| Electricity | 0.742**  | 0.186    | -0.659** | -0.706** | 1           |

Source: Field work, 2023

**Table 7: Spearman Correlation Coefficients among Household Income levels and Energy Preferences**

| Variables          | No fixed income | Less than N 21,000 | N 21,000 – 50,000 | N 51,000 – 100,000 | N 101, 000 – 151,000 | N 151,000 – 160,000 | N 161,000 – 200,000 | Above N200,000 |
|--------------------|-----------------|--------------------|-------------------|--------------------|----------------------|---------------------|---------------------|----------------|
| No fixed income    | 1.000           | -0.428**           | -0.290**          | -0.412**           | -0.270**             | -0.201*             | -0.099              | -0.141         |
| <N21,000           | -0.428**        | 1.000              | -0.116            | -0.164             | -0.108               | -0.080              | -0.040              | -0.056         |
| N21,000 - 50,000   | -0.290**        | -0.116             | 1.000             | -0.111             | -0.073               | -0.054              | -0.027              | -0.038         |
| N51,000 -100,000   | -0.412**        | -0.164             | -0.111            | 1.000              | -0.104               | -0.077              | -0.038              | -0.054         |
| N101,000 -151,000  | -0.270**        | -0.108             | -0.073            | -0.104             | 1.000                | -0.051              | -0.025              | -0.035         |
| N151,000 -160,000  | -0.201*         | -0.080             | -0.054            | -0.077             | -0.051               | 1.000               | -0.019              | -0.026         |
| N161,000 - 200,000 | -0.099          | -0.040             | -0.027            | -0.038             | -0.025               | -0.019              | 1.000               | -0.013         |
| >N200,000          | -0.141          | -0.056             | -0.038            | -0.054             | -0.035               | -0.026              | -0.013              | 1.000          |

**Legend:**

- \*\*Correlation significant at the 0.01 level (2-tailed).
- \*Correlation significant at the 0.05 level (2-tailed).

Source: Field work, 2023

**Table 8: Model Summary for the Relationship between Energy types and Monthly Income Levels**

| Model | R                  | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
|-------|--------------------|----------|-------------------|----------------------------|-----------------|----------|-----|-----|---------------|
| 1     | 0.391 <sup>a</sup> | 0.153    | 0.094             | 0.438                      | 0.153           | 2.623    | 7   | 102 | 0.016         |

**Note: Predictors:** (Constant), Above N200,000, N161,000–N200,000, N151,000–N160,000, N101,000–N151,000, N21,000–N50,000, N51,000–N100,000, Less than N21,000.

Source: Field work, 2023

***Effect of employment status on household energy preference in Guma LGA***

Firewood was the most utilized energy source across all employment groups, with the highest mean value among unemployed individuals ( $13.28 \pm 0.00$ ), followed by civil servants ( $10.64 \pm 0.00$ ) and private employees ( $10.54 \pm 0.00$ ). This suggests that traditional biomass fuels remain a dominant choice, particularly among lower-income or stable-income earners. Self-employed individuals, however, exhibit a significant shift towards electricity ( $10.72 \pm 0.00$ ), likely due to business-related energy needs or improved financial capacity. Gas consumption was highest among private employees ( $5.82 \pm 0.00$ ), indicating that those with more stable, salaried jobs prefer modern, cleaner fuels. Kerosene usage is generally low across all groups, except for self-employed respondents ( $4.36 \pm 0.00$ ), suggesting its scarcity in the area. Charcoal usage was highest among civil servants ( $4.78 \pm 0.00$ ), followed by unemployed individuals ( $3.10 \pm 0.00$ ), likely reflecting affordability and accessibility factors. The minimal reliance on electricity among unemployed ( $0.36 \pm 0.00$ ), civil servants ( $0.18 \pm 0.00$ ), and private employees ( $0.18 \pm 0.00$ ) highlights infrastructural or economic barriers to electricity adoption in the region (Table 9).

***Effect of Educational Level on household energy preference in Guma LGA***

Cooking gas usage shows a dramatic rise from  $37.30 \pm 0.00$  among those with no formal education to  $69.10 \pm 0.00$  for tertiary education holders, indicating a strong positive correlation between education and cleaner fuel adoption. Conversely, firewood use decreases sharply from  $54.50 \pm 0.00$  to  $20.90 \pm 0.00$  as education levels rise, suggesting a shift away from traditional biomass fuels. Charcoal use fluctuates slightly, peaking at  $11.80 \pm 0.00$  for those with primary education. Kerosene usage remains relatively low across all education levels, with a slight peak of  $6.40 \pm 0.00$  at the secondary education level. However, electricity adoption is minimal, only appearing at  $0.90 \pm 0.00$  for those with tertiary education (Table 10). These findings underscore the crucial role of education in shaping energy preferences, likely due to increased awareness of environmental and health impacts, as well as improved economic status associated with higher education.

Primary education shows the strongest correlations with other education levels, including a near-perfect correlation with secondary education ( $r = 0.943$ ) and a very strong correlation with tertiary education ( $r =$

$0.912$ ). Similarly, secondary education is almost perfectly correlated with tertiary education ( $r = 0.991$ ), highlighting a close association between these higher education levels. The correlation between no formal education and other education levels is slightly weaker but still substantial, with the strongest association observed with primary education ( $r = 0.884$ ) and the weakest with tertiary education ( $r = 0.624$ ) (Table 11). These findings suggest that as education levels progress, the relationships between them become increasingly linear and interdependent, particularly at higher levels of education. All correlations are significant at the 0.01 level, underscoring the robustness of these associations.

There is a perfect regression model, with an R value of 1.000 and an R Square of 1.000, indicating that 100% of the variance in the dependent variable is explained by the predictors (Table 13). Educational attainment significantly influenced energy choices and consumption patterns across various levels. Higher education, particularly tertiary education, is associated with more informed decision-making, increased awareness of sustainable practices, and a greater likelihood of adopting renewable energy sources. The transition from primary to secondary education often marks changes in behaviour and consumption patterns, potentially impacting energy use. Primary education lays the foundation for energy literacy, while energy education across all levels empowers individuals to make informed decisions about energy use and its environmental implications. The regression model's results (Table 13) provide crucial insights into the relationship between specific income levels and energy preferences in Guma LGA. With a perfect fit ( $R = 1.000$ ,  $R \text{ Square} = 1.000$ ), the model indicates that the income categories ranging from very low (No fixed income) to very high (Above N200,000) are exceptionally strong predictors of energy consumption patterns. This suggests a pronounced stratification in energy access and usage across these income levels. The findings imply that Very High income (Above N200,000) and High-Medium income (N161,000 – N200,000) households likely have preference for gas, a modern and cleaner energy source, while Medium-Low income (N 21,000 – N50,000) and Very Low income (No fixed Salary) groups might rely more heavily on firewood and charcoal. This stark divide underscores potential energy poverty issues among lower-income brackets, particularly those earning less than N21,000 or with no fixed salary. Policymakers must consider these income-based disparities when designing energy

strategies, ensuring that initiatives address the specific needs and constraints of each income group, from those earning below N21, 000 to those earning above N200, 000. The study emphasizes the importance of income-sensitive approaches in

promoting equitable access to sustainable energy sources across all socioeconomic levels in Guma LGA, considering the unique challenges faced by each income level identified in the study.

**Table 9: Effect of employment status on household energy preference in Guma LGA**

| Energy Type | Respondents' employment status versus energy choice |                         |                    |                            |                                                |
|-------------|-----------------------------------------------------|-------------------------|--------------------|----------------------------|------------------------------------------------|
|             | Unemployed (Mean±std)                               | Civil (Mean±std)        | Servant (Mean±std) | Self-Employment (Mean±std) | Private Employment (NGO and others) (Mean±std) |
| Gas         | 2.90±0.00 <sup>c</sup>                              | 3.66±0.00 <sup>c</sup>  |                    | 4.00±3.82 <sup>b</sup>     | 5.82±0.00 <sup>b</sup>                         |
| Kerosene    | 0.36±0.00 <sup>d</sup>                              | 0.74±0.00 <sup>d</sup>  |                    | 4.36±0.00 <sup>b</sup>     | 0.18±0.00 <sup>d</sup>                         |
| Charcoal    | 3.10±0.00 <sup>b</sup>                              | 4.78±0.00 <sup>b</sup>  |                    | 0.54±0.00 <sup>c</sup>     | 3.28±0.00 <sup>c</sup>                         |
| Firewood    | 13.28±0.00 <sup>a</sup>                             | 10.64±0.00 <sup>a</sup> |                    | 4.36±0.00 <sup>b</sup>     | 10.54±0.00 <sup>a</sup>                        |
| Electricity | 0.36±0.00 <sup>d</sup>                              | 0.18±0.00 <sup>e</sup>  |                    | 10.72±0.00 <sup>a</sup>    | 0.18±0.00 <sup>d</sup>                         |

Note: Mean values in the same column with same alphabet are not significantly different from each other ( $P < 0.05$ )  
Source: Field work, 2023

**Table 10: Effect of Educational Level on household energy preference in Guma LGA**

| Energy Type | Respondents' educational level versus to energy choice (Means±stdv) |                         |                         |                         |
|-------------|---------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|
|             | No formal education                                                 | Primary Education       | Secondary Education     | Tertiary Education      |
| Gas         | 37.30±0.00 <sup>b</sup>                                             | 49.10±0.00 <sup>a</sup> | 60.90±0.00 <sup>a</sup> | 69.10±0.00 <sup>a</sup> |
| Kerosene    | 0.90±0.00 <sup>d</sup>                                              | 3.60±0.00 <sup>d</sup>  | 6.40±0.00 <sup>d</sup>  | 1.80±0.00 <sup>d</sup>  |
| Charcoal    | 7.30±0.00 <sup>c</sup>                                              | 11.80±0.00 <sup>c</sup> | 8.20±0.00 <sup>c</sup>  | 10.00±0.00 <sup>c</sup> |
| Firewood    | 54.50±0.00 <sup>a</sup>                                             | 35.50±0.00 <sup>b</sup> | 24.50±0.00 <sup>b</sup> | 20.90±0.00 <sup>b</sup> |
| Electricity | 0.00±0.00 <sup>e</sup>                                              | 0.00±0.00 <sup>e</sup>  | 0.00±0.00 <sup>e</sup>  | 0.90±0.00 <sup>e</sup>  |

Note: Mean values in the same column with same alphabet are not significantly different from each other ( $P < 0.05$ )  
Source: Field work, 2023

**Table 11: Spearman Correlation Coefficients between Education Levels**

| Education Level     | No Formal Education | Primary Education | Secondary Education | Tertiary Education |
|---------------------|---------------------|-------------------|---------------------|--------------------|
| No Formal Education | 1                   | 0.884**           | 0.692**             | 0.624**            |
| Primary Education   | 0.884**             | 1                 | 0.943**             | 0.912**            |
| Secondary Education | 0.692**             | 0.943**           | 1                   | 0.991**            |
| Tertiary Education  | 0.624**             | 0.912**           | 0.991**             | 1                  |

Note: \*\* indicates correlation is significant at the 0.01 level (2-tailed)  
Source: Field work, 2023

**Table 12: Summary Regression Model: Educational based Household Energy Preferences**

| Model | R                  | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change           | df1 | df2 | Sig.  | F Change |
|-------|--------------------|----------|-------------------|----------------------------|-----------------|--------------------|-----|-----|-------|----------|
| 1     | 1.000 <sup>a</sup> | 1.000    | 1.000             | .000                       | 1.000           | 70589335852197.120 | 4   | 20  | 0.000 |          |

<sup>a</sup> Predictors: (Constant), Tertiary Education, No formal education, Secondary Education,  
Source: Field work, 2023

**Table 13: Regression Model Summary: Income-Based Energy Preferences**

| Model | R                  | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change  | df1 | df2 | Sig. | F Change |
|-------|--------------------|----------|-------------------|----------------------------|-----------------|-----------|-----|-----|------|----------|
| 1     | 1.000 <sup>a</sup> | 1.000    | 1.000             | .016                       | 1.000           | 31107.187 | 4   | 10  | .000 |          |

<sup>a</sup> Predictors: (Constant), No fixed Salary, less than N 21,000, N 21,000 – N50,000, N 51,000 – N100,000, N101, 000 – N151,000, N151,000 – N160,000, N161,000 – N200,000 and Above N200,000

### Consumption pattern of firewood (bundle) as household energy in Guma LGA

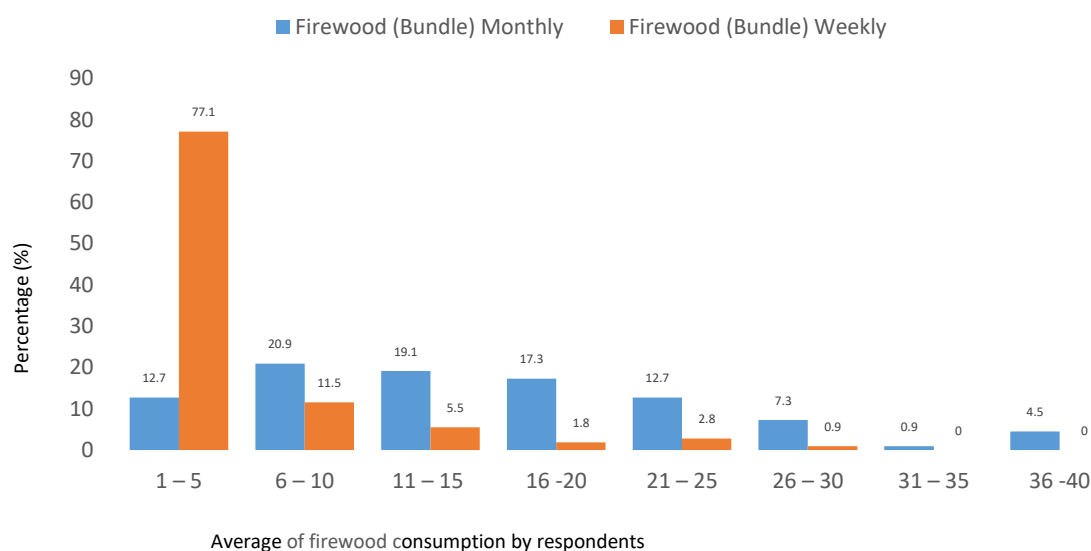
Figure 6 presents result on the average weekly and monthly consumption of firewood bundles as household energy in Guma LGA. The result is differences in consumption patterns between weekly and monthly timeframes. On a weekly basis, most households (77.1%) consume between 1-5 bundles of firewood. There was a sharp decline in the percentage of households consuming larger quantities weekly, with only 11.5% using 6-10 bundles and 5.5% using 11-15 bundles. Very few households consume more than 15 bundles per week, with percentages dropping to 1.8% for 16-20 bundles and 2.8% for 21-25 bundles. No households report using more than 30 bundles per week. Monthly consumption patterns show a more even distribution across the lower to middle ranges. The highest percentage of households (20.9%) consume 6-10 bundles per month, followed closely by 19.1% using 11-15 bundles and 17.3% using 16-20 bundles. There was a gradual decrease in the percentage of households consuming larger quantities monthly, with 12.7% using both 1-5 and 21-25 bundles. A small percentage of households (4.5%) report high monthly consumption of 36-40 bundles.

Figure 7 reveals distinct patterns in charcoal usage between weekly and monthly timeframes. On a weekly basis, most households (80.9%) consume 25kg of charcoal or less. There was drop in consumption for

larger quantities, with only 6.4% of households using 1 bag, 7.3% using 2 bags, and 5.5% using 3 bags per week. Notably, no households report using 4 or 5 bags of charcoal on a weekly basis. Monthly consumption patterns show a more distributed usage across different quantities. The highest percentage of households (35.8%) consume 0.5 bags or less per month, followed by 28.4% using 1 bag. There's a gradual decrease in the percentage of households consuming larger quantities monthly, with 15.6% using 2 bags, and roughly equal percentages (6.4% to 7.3%) using 3, 4, or 5 bags per month.

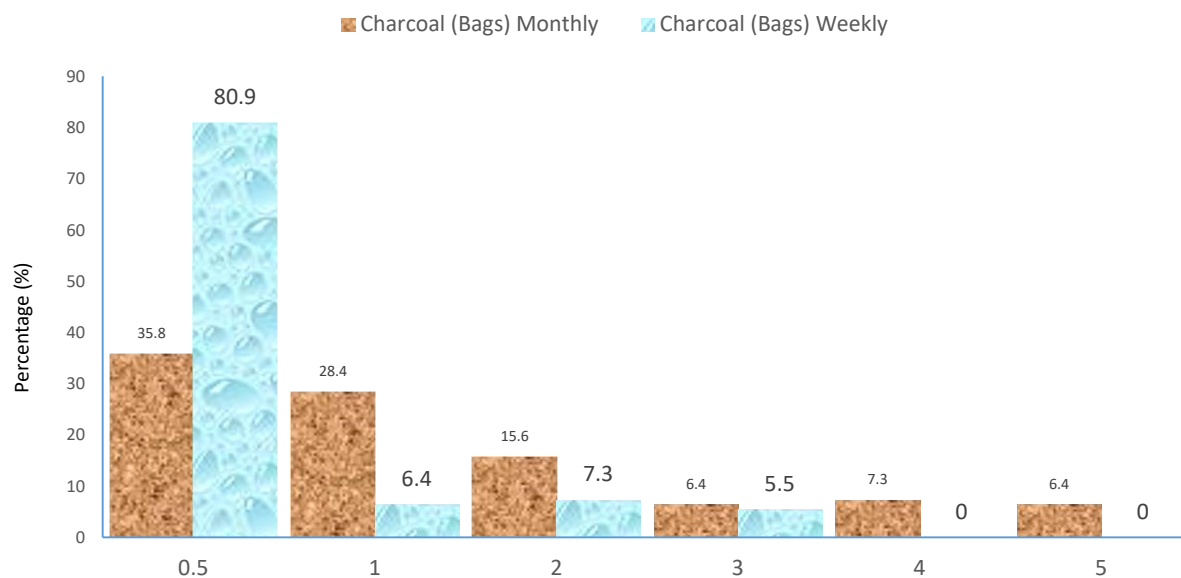
### Average weekly and monthly consumption of Kerosene as household

The majority (93.6%) of households reported no use of kerosene, both on a weekly and monthly basis. This indicates that kerosene was not a primary or even common energy source in this area (Figure 8). For monthly consumption, there is a small but notable percentage (3.6%) of households that use between 21-25 liters of kerosene. Equal percentages (0.9%) of household's report using 1-5 liters, 6-10 liters, and 15-20 liters per month. This suggests that among the few households that do use kerosene, there is a range of consumption patterns, with a slight preference for larger quantities monthly. Weekly consumption patterns show similarly low usage, with 2.8% of households using 1-5 liters and 3.7% using 6-10 liters. However, no households report using more than 10 liters of kerosene per week.



**Figure 6: Average weekly and monthly consumption of firewood (bundle) as household energy in Guma LGA**

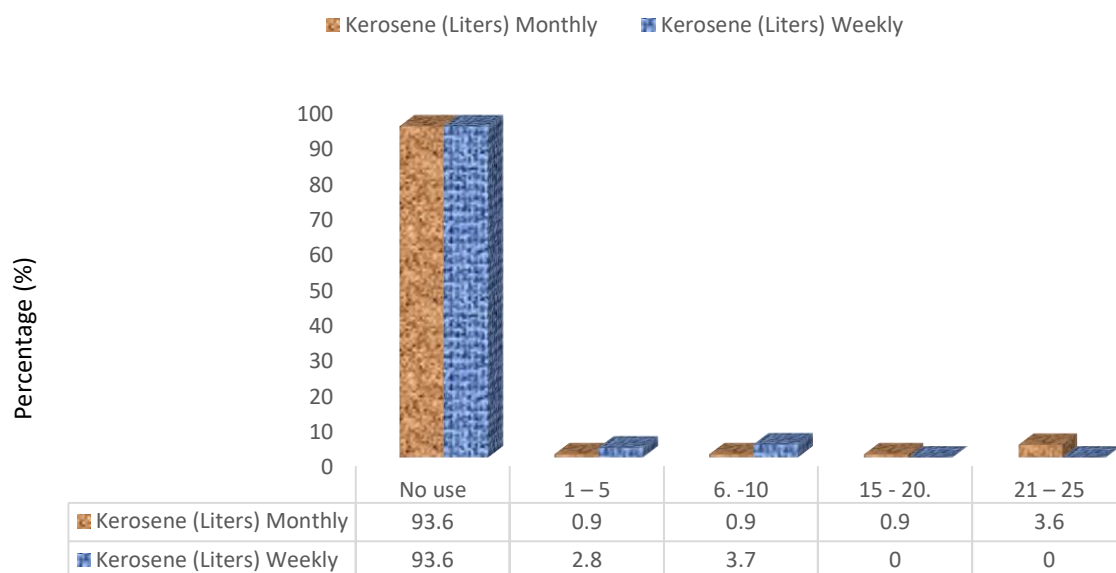
Source: Field work, 2023



Average charcoal (50 kg bag) consumption by respondents

**Figure 7: Average weekly and monthly consumption of charcoal as household**

Source: Field work, 2023



Average consumption of kerosene by respondents

**Figure 8: Average weekly and monthly consumption of Kerosene as household**

Source: Field work, 2023

## DISCUSSION

This study examined household energy use practices in selected communities within Guma LGA revealed a predominant reliance on traditional energy sources, with a significant role played by women in energy-

related activities. This might be since gender roles influence energy preferences, with women prioritizing product quality and cooking traits. This finding aligns with broader patterns observed in various regions where gender roles significantly

influence household energy decisions. Teeken, *et al.* (2018) reported the traditional division of labour where women are more involved in food preparation and household tasks. In many communities, women are primarily responsible for cooking and managing household energy needs. This responsibility often leads them to collect and utilize traditional biomass fuels such as firewood and charcoal. A study in Uganda highlighted that gender role differentiation significantly affects household energy transition decisions, with women's control over financial resources increasing the likelihood of adopting modern cooking fuels by (Katutsi *et al.*, 2020; Elasu, *et al.*, 2024). However, both men and women influence household energy decisions in Nigeria, although women appear to have a more direct role in choosing and using household energy, particularly for cooking. This is likely due to traditional gender roles that assign domestic responsibilities primarily to women.

In single household energy sources, charcoal was the most preferred while it was firewood and charcoal for double combinations. According to Ozoh *et al.* (2018), charcoal was the second most common in a study conducted in Lagos while kerosene was the most used cooking fuel. Łaska and Ige (2023) estimates that in 2021, Nigerians consumed 23,745,458 tons of firewood and 4,828,689 tons of charcoal, making these the most consumed domestic solid fuel sources in the country. Contrary to the finding of this study, Łaska and Ige (2023) reports suggests that firewood, rather than charcoal, was more preferred option nationwide. Wiedinmyer *et al.* (2017) notes that rural households rely primarily on wood, while urban households are more likely to use charcoal and LPG (Wiedinmyer *et al.*, 2017). This implies that wood might be more prevalent in rural areas of northern Nigeria. Studies in Northern Sudan, found that firewood and charcoal combined were used by 63.4% of respondents, but it does not specify which of the two was more preferred (Mperejekumana *et al.*, 2021).

Also in this study, low cost, ease of accessibility and convenience to energy were the primary reasons for household energy preference in Guma LGA. Although these might not be the sole determinants of household energy preferences in Nigeria. Anugwom *et al.* (2020) revealed that the adoption of clean energy sources, for example, Solar Home Systems (SHS), was constrained by factors beyond cost and accessibility. This study indicated that income levels of respondents strongly influenced household energy preference in Guma communities. Basically,

household income is a key determinant of energy choices and consumption patterns across African countries. Higher-income households tend to use gas, a cleaner and more modern energy source, while lower-income households rely more on traditional firewood, biomass fuels (Makonese *et al.*, 2017; Wassie *et al.*, 2021). Ismail and Khembo (2015) noted that in South Africa, household expenditure patterns were found to be an important factor explaining the state of energy in households. The wealth effect on energy consumption expenditure was found to be positive across countries, confirming that energy consumption increases with household wealth improvement (Piao and Managi, 2023). On the contrary, Uhunamure *et al.* (2017) and Wassie *et al.* (2021) reported that cultural norms, values, education level, and location also play important roles in determining energy preferences. As observed in this study, as income increased, there was a general preference for gas, a cleaner energy sources which indicated that higher income levels were associated with increased affordability of gas. Dioha and Emodi (2019) noted that even with increased income, the benefits of modern energy access have been limited in Nigeria due to poor financing and low overall income levels. This suggests that income alone was not sufficient to drive a complete shift to cleaner energy sources.

Educational attainment strongly influenced household energy preferences in the Guma communities. Respondents with higher levels of education were more likely to use modern energy sources, particularly gas and electricity, whereas those with lower levels of education tended to depend more on traditional fuels such as firewood and charcoal. This finding is consistent with previous studies showing that educated households are more likely to adopt modern cooking fuels and electricity (Anugwom *et al.*, 2020; Ogbeide-Osaretin, 2020). Similarly, Adamu *et al.* (2020) reported that households generally shift towards cleaner energy sources as their income and educational levels increase. Employment status was also closely associated with household energy choice, largely because it reflects differences in income and economic security. Respondents in more stable or financially secure forms of employment, particularly the self-employed and privately employed, showed a greater preference for gas and electricity and less reliance on firewood and charcoal. In contrast, unemployed respondents and civil servants depended more heavily on traditional biomass fuels. Thus, the more secure and comfortable the

employment situation, the more likely households were to adopt cleaner energy sources. Conversely, households with limited employment opportunities were more likely to rely on firewood and charcoal.

These findings support the observations of Nwaka *et al.* (2020) and Ogbeide-Osaretin (2020), who found that increased employment opportunities were associated with reduced poverty and greater adoption of cleaner household energy sources. Overall, the results suggest that employment status, income, and education jointly shape household energy decisions in the study area. The widespread use of firewood and charcoal also raises environmental and public-health concerns, including deforestation, indoor air pollution, and related health risks. There is therefore a need for targeted energy policies that make cleaner fuels more accessible and affordable, particularly for unemployed and economically vulnerable households. Subsidies or incentives for gas and electricity, together with improvements in electricity reliability and distribution infrastructure, could encourage the transition to cleaner energy sources and strengthen household energy security across all employment groups.

## CONCLUSION

This study on household energy preference in Guma LGA showed strong correlation between income levels and the transition to modern energy sources. Households with higher income levels are more likely to adopt cleaner energy alternatives like gas and electricity. This trend suggests that financial constraints prevent lower-income households from accessing modern energy, highlighting the need for interventions that enhance affordability and accessibility of cleaner fuels. Unemployed individuals were more likely to rely on firewood, emphasizing the link between economic stability and energy preferences. Also, education level played a crucial role in influencing energy transitions. Households with higher education levels tend to move away from traditional biomass fuels towards modern energy sources, possibly due to increased awareness of health and environmental impacts, higher incomes, or better access to infrastructure. While most households use small amounts of firewood weekly, monthly consumption varies significantly, possibly due to stockpiling or fluctuating energy needs. Firewood, on the other hand, was primarily used as a supplementary energy source rather than a primary one. Its consumption patterns suggest that charcoal remains the dominant fuel while firewood serves specific cooking or backup energy purposes.

Kerosene's very low usage rates suggest that it was either unavailable or too costly. Generally, these findings consistently emphasize the critical role of affordability, accessibility, and socio-economic factors in shaping household energy consumption patterns. The findings underscore the urgent need for targeted policy interventions that promote cleaner, more affordable, and sustainable energy solutions.

## REFERENCES

- Adamu M.B, Akeh G.I, Adamu H., Ade S.M. (2020). Household Energy Consumption in Nigeria: A Review on the Applicability of the Energy Ladder Model. *Journal of Applied Sciences and Environmental Management*, 24(2):237-244. doi:10.4314/jasem.v24i2.7
- Adamu, M., Adamu, H., Ade, S., and Akeh, G. (2020). Household energy consumption in Nigeria: A review on the applicability of the Energy Ladder model. *Journal of Applied Science and Environmental Management*, 24(2), 237–244. <https://doi.org/10.4314/jasem.v24i2.7>.
- Amuta, E., and Houmsou, R. (2014). Prevalence, intensity of infection and risk factors of urinary schistosomiasis in pre-school and school aged children in Guma Local Government Area, Nigeria. *Asian Pacific Journal of Tropical Medicine*, 7(1), 34–39. [https://doi.org/10.1016/s1995-7645\(13\)60188-1](https://doi.org/10.1016/s1995-7645(13)60188-1)
- Ancha, P. U., Shomkegh, S. A., and Onuche, P. (2019). Contribution of Odoba Forest Reserve to livelihoods of the rural people in Ogbadibo Local Government Area, Benue State, Nigeria. *Asian Journal of Environment and Ecology*, 1–12.
- Anugwom E.E, Anugwom K.N and Eya O.I. (2020). Clean energy transition in a developing society: Perspectives on the socioeconomic determinants of Solar Home Systems adoption among urban households in southeastern Nigeria. *African Journal of Science, Technology, Innovation and Development*, 12(5):653-661. doi:10.1080/20421338.2020.1764176.
- Bolaji-Olutunji, K.A., Banjo, A. A., Olowoyo, F. B. and Obadimu, O. (2020). Energy consumption pattern of households in rural southwestern Nigeria. *Ethiopian Journal of Environmental Studies and Management* 13(2): 138 – 152. [ejesm.org/wp-content/uploads/2020/05/ejesm.v13i2.2.pdf](https://ejesm.org/wp-content/uploads/2020/05/ejesm.v13i2.2.pdf)
- Danlami, A. H., and Islam, R. (2020). Explorative analysis of household energy consumption in Bauchi State, Nigeria. In *Intech Open eBooks*. <https://doi.org/10.5772/intechopen.89597>
- Dioha M.O. Emodi N.V. (2019). Investigating the Impacts of Energy Access Scenarios in the Nigerian

- Household Sector by 2030. *Resources*, 8(3):127. doi:10.3390/resources8030127
- Ekhuemelo, D., Tembe, E. T., and Abah, M. (2019). Investigation of charcoal production in Makurdi and Guma Local Government Areas of Benue State, Nigeria. *SAFER*, 7(1). <https://doi.org/10.7770/safer-v0n0-art1557>
- Elasu, J., Ntayi, J. M., Adaramola, M. S., Buyinza, F., Atukunda, R., and Ngoma, M. (2024). Gender-based roles and energy transition in Ugandan households: Evidence from panel data analysis. *Research Square*. <https://doi.org/10.21203/rs.3.rs-4582288/v1>.
- Ismail Z. and Khembo P. (2015). Determinants of energy poverty in South Africa. *Journal of Energy in Southern Africa*, 26(3):66-78. doi:10.17159/2413-3051/2015/v26i3a2130
- Katutsi, V., Dickson, T. and Migisha, A. (2020) Drivers of Fuel Choice for Cooking among Uganda's Households. *Open Journal of Energy Efficiency*, 9, 111-129. doi: [10.4236/ojee.2020.93008](https://doi.org/10.4236/ojee.2020.93008).
- Łaska G. and Ige A. A. (2023). Review: Assessment of Domestic Solid Fuel Sources in Nigeria. *Energies*, 16(12): 4722. doi:10.3390/en16124722
- Li, H., Li, Y., Zheng, G., and Zhou, Y. (2024). Interaction between household energy consumption and health: A systematic review. *Renewable and Sustainable Energy Reviews*, 189, 113859. <https://doi.org/10.1016/j.rser.2023.113859>
- Makonese T., Ifegbesan A.P. and Rampedi I.T. (2021) Household cooking fuel use patterns and determinants across southern Africa: Evidence from the demographic and health survey data. *Energy and Environment*, 29(1):29-48. doi:10.1177/0958305x17739475
- Mperejekumana, P., Li, H., Elshareef, H., Dong, R., Wu, R., Tursunov, O., Nepo, N. J., Gaballah, M. S., Zhou, Y., and Lu, J. (2021). Determinants of Household Energy Choice for Cooking in Northern Sudan: A Multinomial Logit Estimation. *International Journal of Environmental Research and Public Health*, 18(21), 11480. <https://doi.org/10.3390/ijerph182111480>
- Ngutsav, A. S., Akiri S.E. and Onov G. A. (2021). Substitution of Energy Products in Benue State Urban Households. *International Journal of Innovative Finance and Economics Research* 9(2):52-62. <https://www.seahipublications.org/wp-content/uploads/2025/05/IJIFER-J-6-2021.pdf>
- Nwaka I.D., Uma K.E. and Ike G.N. (2020). Determinants of household fuel choices among Nigerian family heads: are there gender-differentiated impacts? *Environmental Science and Pollution Research*, 27(34):42656-42669. doi:10.1007/s11356-020-09554-x.
- Ogbeide-Osaretin E. N. (2020) Analysing energy consumption and poverty reduction nexus in Nigeria. *International Journal of Sustainable Energy*, 40(5):477-493. doi:10.1080/14786451.2020.1815744.
- Olanrewaju, S. D., and Adegun, O. B. (2021). Household energy consumption within a low-income neighbourhood in Akure, Nigeria. *IOP Conference Series. Materials Science and Engineering*, 1036(1), 012025. <https://doi.org/10.1088/1757-899x/1036/1/012025>
- Ozoh, O. B., Okwor, T. J., Adetona, O., Akinkugbe, A. O., Amadi, C. E., Esezobor, C., Adeyeye, O. O., Ojo, O., Nwude, V. N., and Mortimer, K. (2018). Cooking Fuels in Lagos, Nigeria: Factors Associated with Household Choice of Kerosene or Liquefied Petroleum Gas (LPG). *International Journal of Environmental Research and Public Health*, 15(4), 641. <https://doi.org/10.3390/ijerph15040641>
- Piao X., and Managi S. (2023). Household energy-saving behavior, its consumption, and life satisfaction in 37 countries. *Scientific Reports*, 13(1). doi:10.1038/s41598-023-28368-8
- Shi, X., Cheong, T. S., Yu, J., and Liu, X. (2021). Quality of life and relative household energy consumption in China. *China and World Economy*, 29(5), 127–147. <https://doi.org/10.1111/cwe.12390>
- Teeken, B., Olaosebikan, O., Haleegoah, J., Oladejo, E., Madu, T., Bello, A., Parkes, E., Egesi, C., Kulakow, P., Kirscht, H., and Tufan, H. A. (2018). Cassava Trait Preferences of Men and Women Farmers in Nigeria: Implications for Breeding. *Economic botany*, 72(3), 263–277. <https://doi.org/10.1007/s12231-018-9421-7>
- Terwase S. (2013). "Determination of Resource Use Efficiency of Rice Farmers in Kaambe District of Guma Local Government Area of Benue State, Nigeria." *World Journal of Agricultural Research* 1, 143-148. doi: 10.12691/wjar-1-6-9.
- Twerefou, D. K., and Abeney, J. O. (2020). Efficiency of household electricity consumption in Ghana. *Energy Policy*, 144, 111661. <https://doi.org/10.1016/j.enpol.2020.111661>
- Uhunamure S.E, Nethengwe N.S. and Musyoki A. (2017). Driving forces for fuelwood use in households in the Thulamela municipality, South Africa. *Journal of Energy in Southern Africa*. 2017;28(1):25. doi:10.17159/2413-3051/2017/v28i1a1635
- Wassie Y.T., Rannestad M.M. and Adaramola M.S. (2021). Determinants of household energy choices in

rural sub-Saharan Africa: An example from southern Ethiopia. *Energy*, 221:119785. doi: 10.1016/j.energy.2021.119785

World Health Organization (WHO). (2023). Household air pollution and health. *who.int/news-room/fact-sheets/detail/household-air-pollution-and-health*

Wiedinmyer, C., Coffey, E., Hannigan, M., Alirigia, R., Piedrahita, R., Kanyomse, E., Dickinson, K., and Oduro, A. (2017). Rural–urban differences in cooking practices and exposures in Northern Ghana. *Environmental Research Letters*, 12(6), 065009. <https://doi.org/10.1088/1748-9326/aa7036>.