

# Energy Accessibility and Consumption Patterns: Transitioning Towards Sustainable Solutions in Keffi Town, Nasarawa State, Nigeria

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## ABSTRACT

Access to energy sources by households and institutions vary from region to region due to factors of availability, economic activities, population density and technological advancement of the region. This study has assessed the determinants of energy accessibility, use and preferences among households and institutions in Keffi Town, Nasarawa State, Nigeria. The aim and objectives of this study are to ascertain the differences in the quantities of energy sources used by households, determine the preferences of each of the sources by the households, reasons for preferences for each of the energy sources, and the problems associated with the use of each of the energy source. A purposive sampling technique and Krejcie and Morgan (1970) table were used in determining 383 respondents that participated in this survey. Primary data were collected and analyzed using descriptive statistics. The most commonly utilized energy source amongst households in Keffi is hydroelectric power (HEP), with 92 households (24.0%) relying on it. This significant figure highlighted a notable level of access to electric power, potentially reflecting infrastructure development in the area. Charcoal and fuelwood, the people's traditional energy sources, remain prevalent, being used by 63 households (16.4%). This continuous reliance may be due to factors such as affordability, availability, or cultural practices. The major reasons for the preference for LPG was because it cooks faster, and kerosene has lower chances of fire accident than LPG. For fuel wood, preference was due to fast cooking, its availability and affordability, while that of charcoal was due to reason of reduced cases of fire accident. The major constraints militating against the use of different cooking energy sources, even when they are preferred, were scarcity, cost and risk of fire outbreak for LPG and HEP, while for fuel wood and charcoal, they emit high level GHGs and the fact that they also release a lot of black soot. There is need to

implement incentive-based policies to encourage the use of LPG and HEP, through targeted subsidies and cost reduction.

**Key words:** Energy Consumption, Energy Efficiency, Consumption Preferences, Environmental Pollution, Energy Transition

## I. INTRODUCTION

Access to energy resources across the globe varies significantly from region to region due to factors such as availability, population density, economic activities, and the technological advancement of the populace. As societies evolve and transition toward modernization and development, it is expected that energy systems shift from unsustainable sources such as fuelwood, petroleum resources, and coal to environmentally friendly alternatives like hydroelectric power (HEP), liquefied petroleum gas (LPG), wind, solar, and thermal energy (Chineke & Igwiro, 2008, Ighodaro, 2010).

In Nigeria, population growth continues to soar, yet the government has largely failed to develop the abundant potential of renewable energy sources such as solar, wind, hydro, and thermal power (Oyedepo, 2012, Okafor & Joe-Uzuegbu, 2010). This reliance on unsustainable energy sources has exacerbated environmental issues, including deforestation, air pollution, ozone layer depletion, and the broader challenges of climate change (Ngala, Alkali & Aji, 2007). Recognizing these global challenges, Sustainable Development Goal (SDG) 7 calls on governments worldwide to provide cheap, affordable, and sustainable energy for all by 2030. Similarly, Africa's energy goal aims to end deforestation and transition to sustainable energy sources, including gas, HEP, solar, and wind, by 2060. These measures aim to ensure affordable energy access for cooking, heating, lighting, cooling, and transportation (United Nations, 2024).

While significant progress has been made globally towards achieving SDG 7, efforts remain insufficient to meet the 2030 target. Achieving universal energy access and decarbonized, climate-resilient energy systems requires accelerating global momentum. To achieve net-zero global emissions by mid-century, energy policy must take center stage in climate change agendas (WorldBank, 2024). This was emphasized during the United Nations Framework Convention on Climate Change (UNFCCC) COP26 held in Glasgow in November 2021, where countries were urged to enhance their nationally determined contributions (NDCs) to align with climate action goals.

In Nigeria, the unsustainable use and lack of access to quality energy sources compel many households to rely on charcoal, firewood, kerosene, petrol, and diesel for domestic needs. Hydroelectricity remains the most popular energy source nationwide (Pepple & Pokubo, 2024). However, electricity supply is highly unreliable. For instance, residents in Keffi Local Government Area experience electricity supply for an average of only 1–2 hours per month out of 72 hours. This limited access affects households and small and medium enterprises (SMEs), which depend on electricity for operations such as grinding, barbing, cooking, and charging gadgets. These outages force residents and businesses to rely on environmentally unfriendly energy sources.

The abundance of silicon and silicon dioxide—key raw materials for solar cell manufacturing—influenced the establishment of NASENI's solar cell manufacturing plant in Gora, Karu Local Government Area, Nasarawa State. This project, valued at ₦71.19 billion (US\$171.97 million), is West Africa's first solar factory and represents a vital step toward reducing carbon emissions. The plant is a response to the region's unsustainable annual consumption of \$50 billion worth of diesel fuel. Once fully operational, the project will boost energy access and contribute significantly to the local economy, making Nigeria a leader in climate-friendly alternative energy solutions, particularly solar energy (Punch Newspapers, 2023).

The project's total cost is US\$171.97 million (₦71.19 billion), funded by 85% external financing from the China-Africa Development Fund via the Bank of China and 15%

local counterpart funding from Nigeria. Other related projects include a \$123.99 million power transformer manufacturing plant and a \$29.91 million high-voltage testing lab, bringing the total cost to \$325.86 million, of which 85% is externally financed. With this project in place the cost of solar installation, accessibility to majority of the population in the state, electricity instability and many other issues will still persist and this will still exert serious pressure on the unsustainable energy sources in the area. It is based upon this that this study is assessing the determinants of energy accessibility, use and preferences among households and institutions in Keffi Town, Nasarawa State, Nigeria.

## II. MATERIALS AND METHOD

Keffi is both a Local Government Area and a historic town in Nasarawa State, North-Central Nigeria. Geographically, it lies between latitudes 8°51' and 8°53' North of the equator and longitudes 7°50' and 7°51' East of the Greenwich Meridian. It shares boundaries with Karu and Kokona Local Government Areas. According to Binbol and Marcus (2010), Keffi town has a landmass of about 140.47 km<sup>2</sup>, making it the least in size among all the LGAs in Nasarawa State. In comparison, it is about 20 times smaller than larger LGAs such as Awe, Doma, Karu, Lafia, and Toto, and 41 times smaller than Nasarawa LGA, the state's largest.

Keffi area has a tropical sub-humid climate (Binbol & Marcus, 2010). The temperatures are generally high, particularly during the day, due to its location in the Niger-Benue trough on the windward side of the Jos Plateau. The area serves as a climate transition zone between the humid south and the sub-humid north of Nigeria. Binbol (2007) observed that temperatures gradually rise from January to March, with the onset of rains in April bringing a noticeable decline. Average monthly temperatures range between 26.8°C and 27.9°C, with March/April being the hottest months and December/January the coldest (Binbol & Marcus, 2010). These climatic conditions influence the energy demands and consumption patterns in Keffi and its environs.

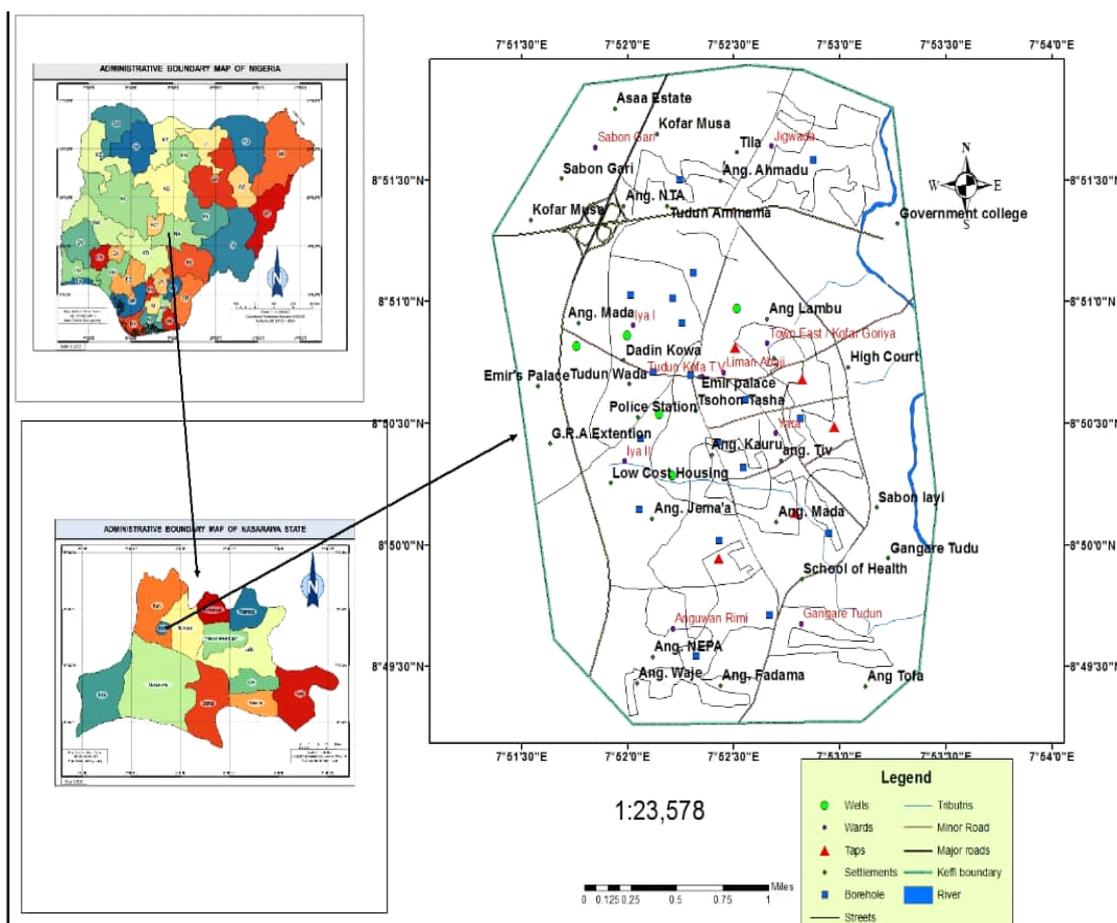


Figure 1: Map of Keffi, the Study Area

Source: GIS Unit, Department of Environmental Management, Bingham University Karu (2025)

Keffi town was selected for this study due to issues of hike in energy prices across the urban centers, the high rate of urbanization, and the widespread informal settlements. Rapid urbanization is closely linked with the development of informal settlements and their associated service delivery issues in Sub-Saharan Africa (Binbol & Marcus, 2010). To ensure equitable respondent selection, a multi-stage sampling technique was employed. to ensure a high level of inclusivity in areas covered during data collection.

The target population comprised the electricity subscribers who are the households (particularly household heads) within the study area. The selection process for the sampled population was based on electoral wards. Keffi Local Government Area (LGA) consists of 10 electoral wards as delineated by the Independent National Electoral Commission (INEC). Five wards within the town were randomly selected for sampling, considering the population's homogeneity regarding their experiences on energy sources access and the prevalence of use of charcoal, firewood and biomass for heating, cooling and cooking.

Subsequently, locations within these wards were also randomly selected. Male and female household heads were included in the study to ensure that diverse respondent experiences were captured. Households were systematically selected to ensure fair and unbiased representation within each settlement. The sample size for the administered questionnaire was determined using Krejcie and Morgan's (1970) sample size table. For a population size exceeding 75,000 but less than 100,000, at a 95% confidence level and a 5% margin of error, the required sample size is 383 respondents. The projected population for the study was estimated at 57,540 individuals. Given this projection, a total of 200 household heads were sampled due to limited time and resources. Additionally, since the water vendor population was unknown, 50 water vendors were conveniently sampled due to the mobile nature of their activities.

A set of semi-structured questionnaires, incorporating both closed-ended and open-ended questions, were designed and administered to the households. The questionnaires were administered on household with the help of five trained

research assistants. These assistants were trained on the techniques of data collection and the questionnaires administration to effectively enhance their abilities to deliver on the mandate. The educated respondents were left with the questionnaires for a minimum of seven days to allow for sufficient time for proper execution. For those who are either illiterate or semi-literate, the research assistants helped to filled out the instruments based on the answers obtained during interviews conducted in the local language of the respondents. The data collected from the field were carefully categorized by type and recorded. Descriptive statistics were employed for data analysis and these generated outputs that characterized the households and energy use and the results were presented in percentages, tables, bar graphs and pie charts.

### III. RESULTS AND DISCUSSION

Electricity supply in Keffi Local Government Area (LGA) is characterized by significant fluctuations due to various factors, including power shortages and outages, seasonal variations in river levels, billing and pricing challenges, equipment malfunctions, and the diversion of energy to

corporate consumers. These issues collectively impact the reliability of electricity in the area.

A notable practice by the Abuja Electricity Distribution Company (AEDC) involves sporadically providing electricity, often towards the end of the month, followed by an aggressive bill distribution drive and disconnection of households for non-payment. This practice raises concerns among consumers, as those who pay for electricity often experience prolonged periods of power outages. These outages result in substantial losses for small-scale enterprises such as refrigerator-dependent businesses, small grinding operations, barbing salons, and ice block production facilities. Consequently, the electricity consumers in Keffi LGA bear the economic burden of unreliable service and its associated losses.

This discussion highlights the pressing need for improved electricity infrastructure, transparent billing practices, and equitable energy distribution to enhance the quality of life and economic activities in the region. Addressing these challenges would ensure a more sustainable and reliable energy supply for households and small businesses in Keffi LGA.

Table 1: Identification of Energy Sources in Keffi

Energy Source	Category	Number (NO)	Percentage (%)
<b>Household</b>			
Charcoal/Fuelwood	Household	63	16.4
Diesel	Household	61	15.9
Premium Motor Spirit	Household	59	15.4
Liquefied Petroleum Gas	Household	62	16.2
Electricity (HEP)	Household	92	24.0
Biogas/Bio digester	Household	25	6.2
Solar Panels	Household	31	8.1
<b>Institutional</b>			
Biogas/Bio digester	Institutional	21	5.5
Diesel	Institutional	125	32.6
Premium Motor Spirit	Institutional	74	19.3
Electricity (HEP)	Institutional	131	34.2
Solar Panels	Institutional	17	4.4
Liquefied Petroleum Gas	Institutional	15	3.9
<b>Total</b>		<b>383</b>	<b>100</b>

Source: Field Survey, 2024

The most commonly utilized energy source amongst households in Keffi is electricity (hydroelectric power, HEP), with 92 households (24.0%) relying on it. This significant figure highlights a notable level of access to electric power, potentially reflecting infrastructure development in the area. Charcoal and fuelwood, traditional energy sources, remain prevalent, being used by 63 households (16.4%). This continued reliance may be due to factors such as affordability, availability, or cultural practices.

Diesel and premium motor spirit (PMS) are used by 61 households (15.9%) and 59 households (15.4%), respectively, primarily for powering generators and vehicles. These figures indicate a considerable dependence on these sources for electricity generation during power outages. Liquefied petroleum gas (LPG) is utilized by 62 households (16.2%), showing a relatively widespread adoption for cooking and possibly heating purposes.

For institutional energy usage, electricity (HEP) is the predominant source, with 34.2% of institutions relying on it.

Diesel is the second most common source, used by 32.6% of institutions, reflecting its importance in powering machinery and generators. Premium motor spirit accounts for 19.3% of institutional energy usage, suggesting moderate reliance on this source.

Biogas and biodigesters, along with solar panels, are the least utilized energy sources among institutions, with adoption rates of 5.5% and 4.4%, respectively. These low percentages suggest limited integration of renewable energy

technologies in institutional settings. In contrast, liquefied petroleum gas (LPG) exhibits minimal adoption, at just 3.9%. These figures emphasize the need for enhanced advocacy and investment in renewable energy sources to promote sustainability in institutional energy consumption.

The results highlight a heavy dependence on conventional energy sources by households and institutions, underscoring the need for policies and interventions aimed at transitioning to cleaner and more sustainable energy options.

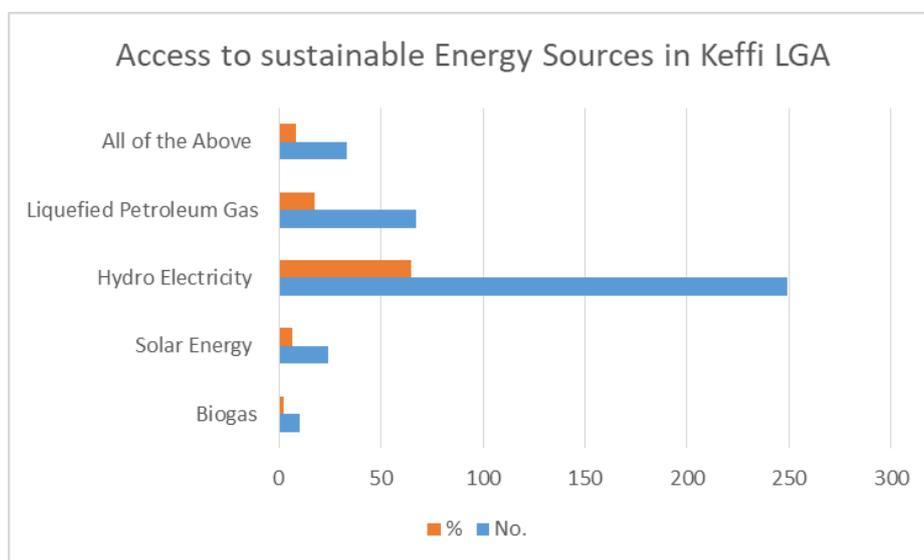


Figure 2: Access to sustainable Energy Sources in Keffi LGA

Source Field Survey, 2024

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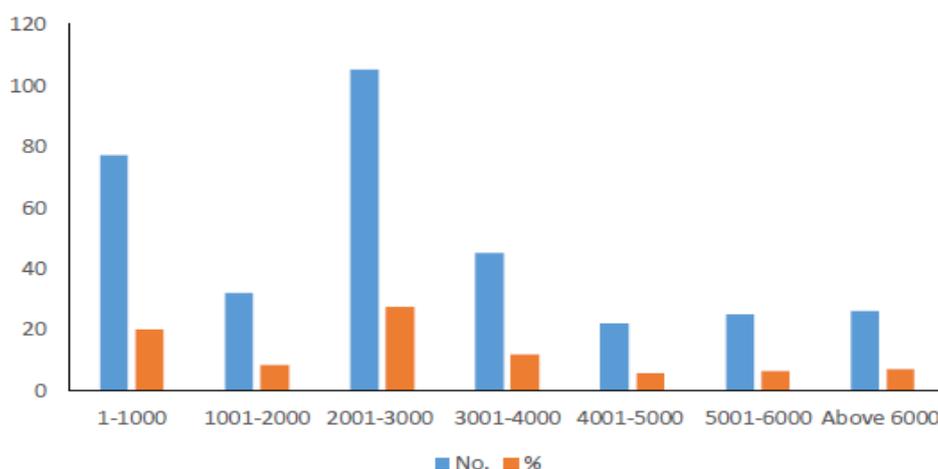


Figure 3: Cost of Clean Energy in Households and institutions (Biogas Installation Costs)

Source: Field Survey, 2025

Figure 3 showed the commonly reported cost range for biogas installation is ₹2,001– ₹3,000, with 105 respondents, representing 27.4% of the total. This suggests that a significant proportion of households and institutions are able to install biogas systems within this price range, making it a prevalent expenditure category. The second most common cost range, ₹1–₹1,000, accounts for 20.1% of the respondents. This indicated that a notable segment of the population is able to access biogas installation services at relatively low costs, highlighting affordability for some users.

The ₹3,001–₹4,000 range is reported by 11.7% of respondents, suggesting a moderate expenditure level for a considerable portion of the population. Higher cost ranges ₹4,001–₹5,000, ₹5,001– ₹6,000, and above ₹6,000 are

reported by fewer respondents, representing 5.7%, 6.5%, and 6.8%, respectively. These figures suggest that fewer households or institutions incur expenditures at these higher levels, likely reflecting budget constraints or a preference for more affordable options.

The least reported cost range is ₹4,001– ₹5,000, with only 5.7% of respondents indicating expenditures within this bracket. This comparatively lower proportion underscores reduced likelihoods of installations at this cost level relative to other ranges. These findings highlighted variations in expenditure for biogas installations across households and institutions, reflecting affordability levels and the potential for further adoption with increased accessibility and cost-efficiency measures.

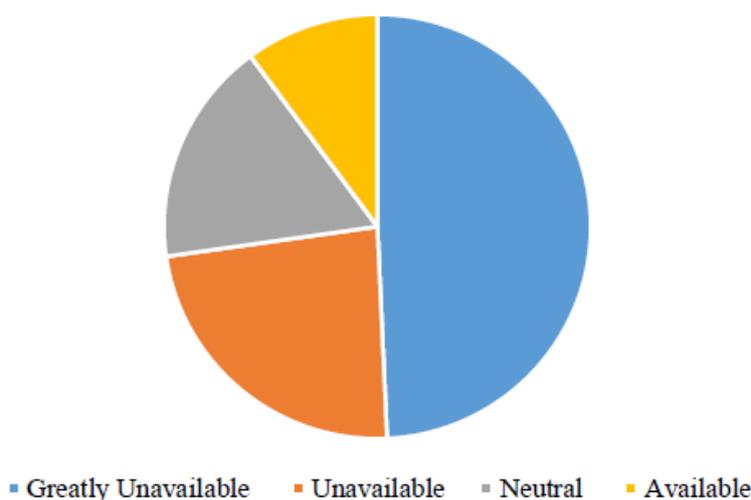


Figure 4: Availability and Access to Clean Energy Sources in Keffi

Source: Field Survey, 2024

Figure 4 showed that a significant proportion of respondents, totaling 170 (44.4%), perceived clean energy sources as greatly unavailable. This represented the most common perception, highlighting a critical barrier to clean energy access. Additionally, 81 respondents (21.1%) consider clean energy sources to be unavailable. When combined, these two categories account for 251 respondents (65.5%), underscoring a widespread belief in the lack of access to clean energy. A neutral stance was reported by 59 respondents (15.4%), indicating either a lack of strong opinions or insufficient information regarding the availability of clean energy sources.

Conversely, only 35 respondents (9.1%) believe that clean energy sources are available. This small fraction emphasizes the limited perception of accessibility to clean energy within the population. Affordability was identified as a key factor influencing energy choices, with 119 respondents (31.1%) citing it as the primary reason for reliance on unsustainable energy sources. This finding underscores the significant role of cost as a determinant in energy decision-making. These results indicated the pressing need for targeted interventions to improve the availability and affordability of clean energy sources, thereby addressing the barriers to adoption and promoting sustainable energy practices.

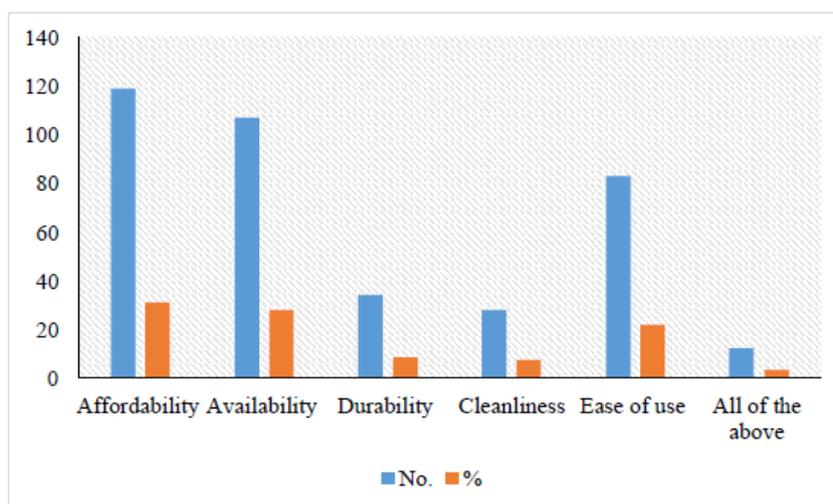


Figure 5: Reasons for use of Unsustainable Energy Source

Source: Field Survey, 2024

Figure 5, indicated that affordability is the most frequently cited reason for choosing unsustainable energy sources, with 119 respondents (31.1%) identifying it as the primary factor. This highlights the significant role that cost plays in energy decisions, as many respondents prioritize budget constraints over other considerations. Availability emerged as the second most common reason, with 107 respondents constituting 27.9% citing it as a major determinant. This underscores the importance of access to energy sources and the challenges associated with obtaining sustainable alternatives in the area.

Ease of use of energy sources and facilities is another influential factor, as noted by 83 respondents (21.7%). This indicated that the simplicity and convenience of operating certain energy sources contribute to their continued use, even though they contribute to severe environmental degradation.

Durability was mentioned by 34 respondents (8.3%), suggesting that the longevity and reliability of an energy

source hold some importance but are less significant than affordability or availability. Cleanliness was prioritized by only 28 respondents (7.3%), implying that environmental and health considerations are not the primary drivers of energy use for most individuals when selecting energy sources. This finding points to a potential gap in awareness or concerns for the broader impacts of energy choices and issues of climate change and environmental management. Finally, the “All of the above” category, chosen by 12 respondents (3.1%), showed that a small fraction of the population consider multiple factors, including affordability, availability, ease of use, durability, and cleanliness, in their decision-making process.

These findings suggest that efforts to promote sustainable energy sources must address issues of unaffordability and unavailability as primary barriers while also raising awareness about the environmental and health benefits of cleaner alternatives.

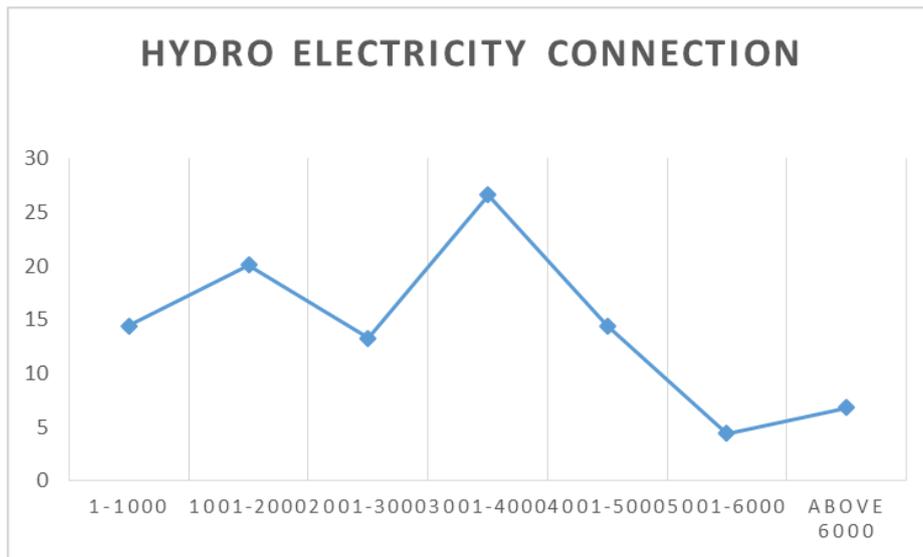


Figure 6: Hydro Electricity Connection by Residents of Keffi Town

Source: Field Survey, 2024

Figure 6 showed that survey results revealed that the cost range ₦3001-4000 is the most common for hydroelectricity usage, with 26.6% of respondents falling within this category. This indicates that a significant portion of the population incurs moderate expenses for hydroelectric power. The second most common cost range is ₦1001-2000, representing 20.1% of respondents. This suggests that a notable proportion of individuals access hydroelectricity at relatively lower costs, which may reflect variations in energy consumption or regional pricing structures.

Conversely, the ₦5001-6000 range is the least common, with only 4.4% of respondents reporting expenses in this

bracket. This indicates that relatively few households or institutions experience higher costs for hydroelectricity. Additionally, the category of those with tariff above ₦6000 accounts for 6.8% of respondents, highlighting that while not predominant, some users incur significantly higher expenses, potentially reflecting higher consumption levels or other contributing factors. These findings emphasized the variability in hydroelectricity costs and the financial implications for households and institutions in the study area.

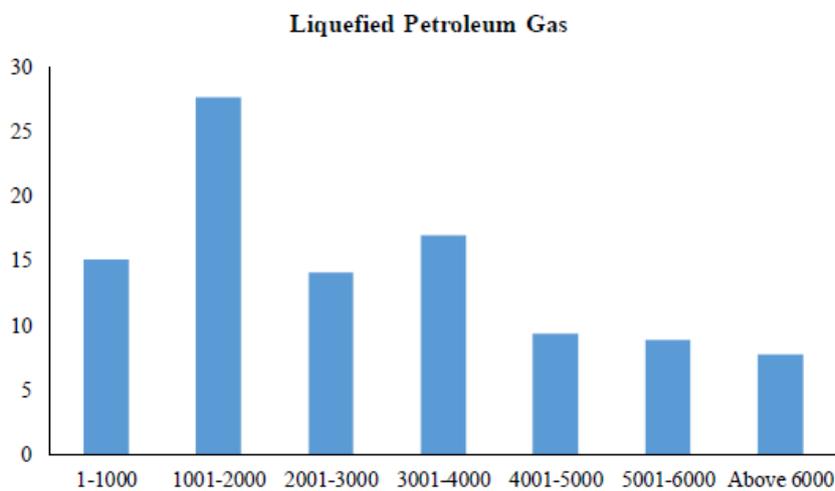


Figure 7: Liquefied Petroleum Gas

Field survey, 2024

Figure 7 indicated that 27.7% of respondents fall within the 1001-2000-unit consumption range for LPG, indicating that the majority of households are moderate users of this energy source. A significant proportion of respondents are also distributed within the 1-1000-unit range (15.1%) and the 2001-3000-unit range (14.1%). This demonstrated a balanced distribution among low, moderate, and relatively higher levels of LPG consumption. However, as LPG consumption exceeds 3000 units, the proportion of respondents began to decline. For instance, 17% of

respondents fall within the 3001-4000-unit range, but this percentage decreases steadily with higher consumption levels. Only 7.8% of respondents reported that LPG usage above 6000 units, highlighting that fewer households fall into the highest consumption categories.

This gradual decline in the percentage of households as LPG consumption increases suggests that while moderate usage is prevalent, higher consumption levels are less common, likely due to cost or usage patterns.

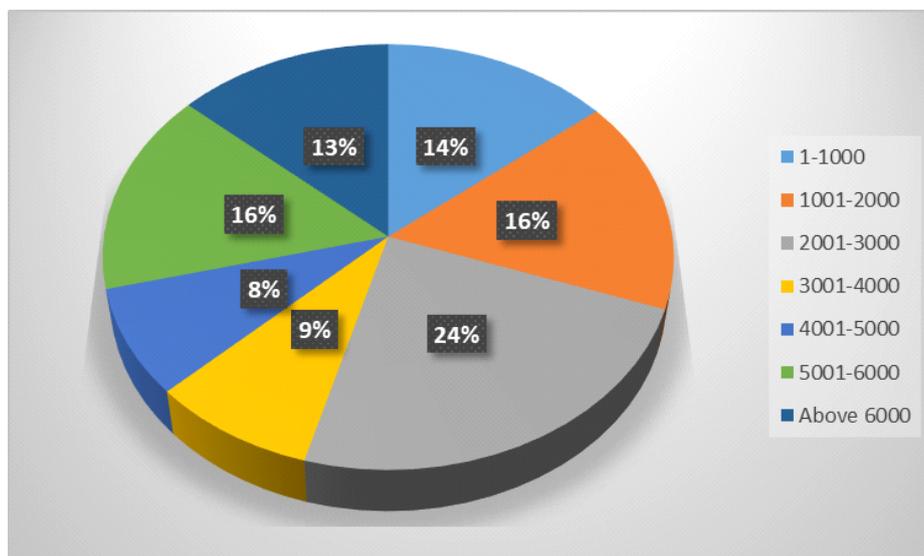


Figure 8: Access to Clean Energy Sources in Keffi Town

Source: Field Survey, 2024

Access to clean modern energy services is a significant challenge facing the African continent, as energy is fundamental to socioeconomic development and poverty eradication. Presently, 60% to 70% of Nigeria's population lacks access to electricity, creating a major hindrance to development. Result in Figure 8 indicated diverse energy consumption patterns, particularly in LPG usage. For instance, the largest proportion of respondents (24%) fall within the 2001–3000 consumption range, followed by 1001–2000 (16%) and 3001–4000 (16%). In contrast, lower and higher consumption categories such as 1–1000 (13%), 4001–5000 (9%), 5001–6000 (8%), and above 6000 (13%) show a less significant proportion of users, emphasizing disparities in energy accessibility.

These findings underscored the urgent need for Nigeria to diversify its energy sources across domestic, commercial, and industrial sectors. The adoption of new and efficient technologies to reduce energy wastage and minimize costs is critical. A comprehensive review of energy policy interventions can significantly contribute to sustainable economic, environmental, and social development in Nigeria, Africa's most populous country. Expanding access

to clean energy will not only address current challenges but also catalyze long-term development.

#### IV. CONCLUSION

This study underscores the critical state of energy access and consumption among households and institutions in Keffi, Nasarawa State. Findings revealed a heavy dependence on unsustainable energy sources, including charcoal, fuelwood, diesel, and premium motor spirit (PMS), driven by limited, erratic and unreliable electricity supply. The widespread reliance on these conventional sources exacerbates environmental degradation and imposes significant economic burdens on users. Electricity from HEP, though widely used, is unreliable, pushing households and institutions toward alternative sources like diesel and PMS generators. Additionally, the continued use of fuelwood and charcoal contributes to deforestation and environmental harm. Renewable energy adoption, such as solar panels and biogas systems, remains minimal, reflecting a pressing need for interventions to facilitate the transition to clean energy.

The establishment of initiatives like the NASENI solar cell manufacturing plant in Karu LGA near Keffi LGA represents progress but is insufficient to address the broader challenges. Achieving sustainable energy access requires targeted policies, infrastructure investments, and widespread public awareness campaigns to bridge the gap between current practices and sustainable energy adoption.

## V. RECOMMENDATIONS

### Expansion of Renewable Energy Infrastructure

- Develop large-scale renewable energy projects, such as solar farms, wind turbines, and biogas plants, to diversify the energy mix.
- Provide incentives, including subsidies and grants, to encourage the installation of solar panels and biogas plants in homes and institutions.

### Policy and Institutional Reforms

- Formulate and implement policies to prioritize renewable energy adoption and phase out reliance on environmentally harmful sources like fuelwood and charcoal.
- Strengthen regulations to ensure fair electricity distribution and transparent pricing mechanisms.

### Awareness and Capacity Building

- Launch public awareness campaigns on the economic, environmental, and health benefits of renewable energy sources.
- Train technicians and engineers to support the deployment and maintenance of renewable energy systems.

### Investment in Research and Development

- Fund innovative projects focused on developing effective renewable energy technologies tailored to local contexts.
- Collaborate with universities and research institutions to explore energy-efficient solutions and improve existing technologies.

### Upgrading Electricity Infrastructure

- Modernize the national grid to enhance reliability and reduce energy losses.
- Invest in smart grid technologies to enable better energy management and distribution.

### Support for Local Businesses and Communities

- Provide financial aid and technical support to small-scale enterprises adopting renewable energy technologies, reducing dependence on diesel and PMS.

- Promote community-owned renewable energy initiatives to empower rural areas and reduce energy poverty.

### Affordability and Accessibility Measures

- Subsidize renewable energy systems to make them affordable for low-income households.
- Establish financing schemes, such as low-interest loans, for the adoption of clean energy solutions.

By addressing affordability, infrastructure, and public awareness, Nigeria can significantly improve energy accessibility and transition to sustainable practices. These efforts will contribute to environmental conservation, reduce carbon emissions, and enhance socioeconomic development, aligning with global sustainable energy goals.

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