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HOUSEHOLD COOKING ENERGY CONSUMPTION SITUATION IN GOMBE METROPOLIS, NIGERIA: A MIX OF QUANTITATIVE AND QUALITATIVE RESEARCH APPROACHES

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ABSTRACT

Household energy use accounts for one-third of worldwide primary energy demand, and has a considerable impact on the environment and human health. This study investigated the household energy consumption situation in Gombe Metropolis, Gombe State, Nigeria. The study used a mix of quantitative and qualitative research methods concurrently. Four hundred households were selected using systematic sampling technique. Questionnaire and Key Informant Interviews (KII) were used to collect data, while secondary data was obtained from the Gombe State Bureau of Statistics. Descriptive statistics was used to analyzed the quantitative data while thematic approach was used in qualitative data analysis. Result revealed that the majority of respondents obtained energy for domestic cooking from hydrocarbon sources, which are charcoal (33.2%) fuelwood (27.5%) and liquefied petroleum gas (22.9%) of the energy mix while 76.5% of respondents used a mixed of traditional (charcoal/fuelwood) and modern (LPG) energy sources. Similarly, result from the KII revealed that households in Gombe Metropolis rely heavily on traditional energy sources, such as fuelwood and charcoal, for cooking because of its affordability and availability. The choice of cooking fuel is influenced by factors such as affordability, household size, availability, and accessibility. The study recommended that Regular awareness campaigns through the media and public gatherings should be conducted to emphasize the significance of utilizing modern energy systems for domestic cooking. These efforts will encourage individuals in the study area to move away from heavily relying on hydrocarbon-based fuels towards cleaner and more sustainable energy sources.

Keywords: Household energy, Energy Consumption, Charcoal, Gombe Metropolis

INTRODUCTION

Energy consumption refers to the total amount of energy utilized for domestic (such as cooking, lighting, cooling, heating and communication), commercial and industrial activities. The proportion of energy used by household differs extensively depending on the nation's living standards, residential types, age among others (Danlami et al., 2015). Global energy production and consumption have been issues of public and environmental concern today as they are associated with the emissions of greenhouse gases resulting majorly from the combustion of fossil fuels such as oil, natural gas, and coal leading to global warming and climate change (Intergovernmental Panel on Climate Change [IPCC], 2007). Climate change is majorly triggered by energy consumption and as such sustainable energy transition can have a major impact on attaining the objective of climate change mitigation (Adom, 2015; Adom and Adams, 2018). Energy is one of the most significant components that promote human life, it is a fundamental commodity that underpins the comfort of modern life. A large amount of global energy is presently produced and expended in a way that could not be sustained (Gyawali et al. 2019). Energy consumption is said to be determined by choices of energy-powered devices (heating, cooking, and washing equipment's).

The increasing demand for energy in Nigeria alongside the epileptic supply (Bashir and Srivastava, 2020) in the country has necessitated the need for development of alternative sources of energy. There is the need to study the household energy consumption pattern in Gombe Metropolis, Nigeria to facilitate the adoption of modern energy systems. Because of the current security instabilities in the Northeastern region (Ruparelia and Abubakar, 2021), as well as the State's economic and commercial activities, the area has seen increase in population concentration in recent times which also increase the energy demand.

The current energy consumption landscape for cooking and other household activities in Gombe State is reported by the Gombe State Bureau of Statistics (GSBS) (2021) to be majorly solid forms of fuels with firewood accounting for 93.1%, followed by charcoal 4.2% and LPG 1.8%. it is also revealed that urban residence uses more charcoal 29.5% than rural ones 1%. Because of the growing concerns associated with the consumption of dirty energy, the area required a comprehensive analysis of energy in terms of consumption to provide a pathway to adopting the advanced forms of energy to minimize the risk of climate change and other environmental and health implications of consuming carbon-related fuels. The aim of the study was to ascertain the situation of household cooking energy consumption in the study area to provide a detailed information for policy implications.

MATERIALS AND METHODS

Study Area

Gombe Metropolis is located between Latitude $10^0$17'30"N to$11^0$7'30"E and Longitude $10^0$15'0"N to$11^0$10'30"E (See Fig.1). It is the administrative headquarter of Gombe LGA with an area of 52 km² (Geohack, 2014). The study area is limited to Gombe Metropolis. Gombe is located within the

sub-Sahara climatic zone. It is characterized by two distinctive seasons, that is, dry season (November-April) and wet season (May- October). The rainfall here averages 907 mm. The vegetation of Gombe is within Sudan/Guinea savannah. This is characterized by shrubs and scattered trees with a different species of grasses. The predominant tree species include Locust bean tree, Baobab tree, Tamarin, Moringa, Date-palm, Neem trees and Azadirachtaindica. The soils in the area are highly ferruginous, formed as a result of intensive weathering of the basement rocks (Mbaya et al., 2019).

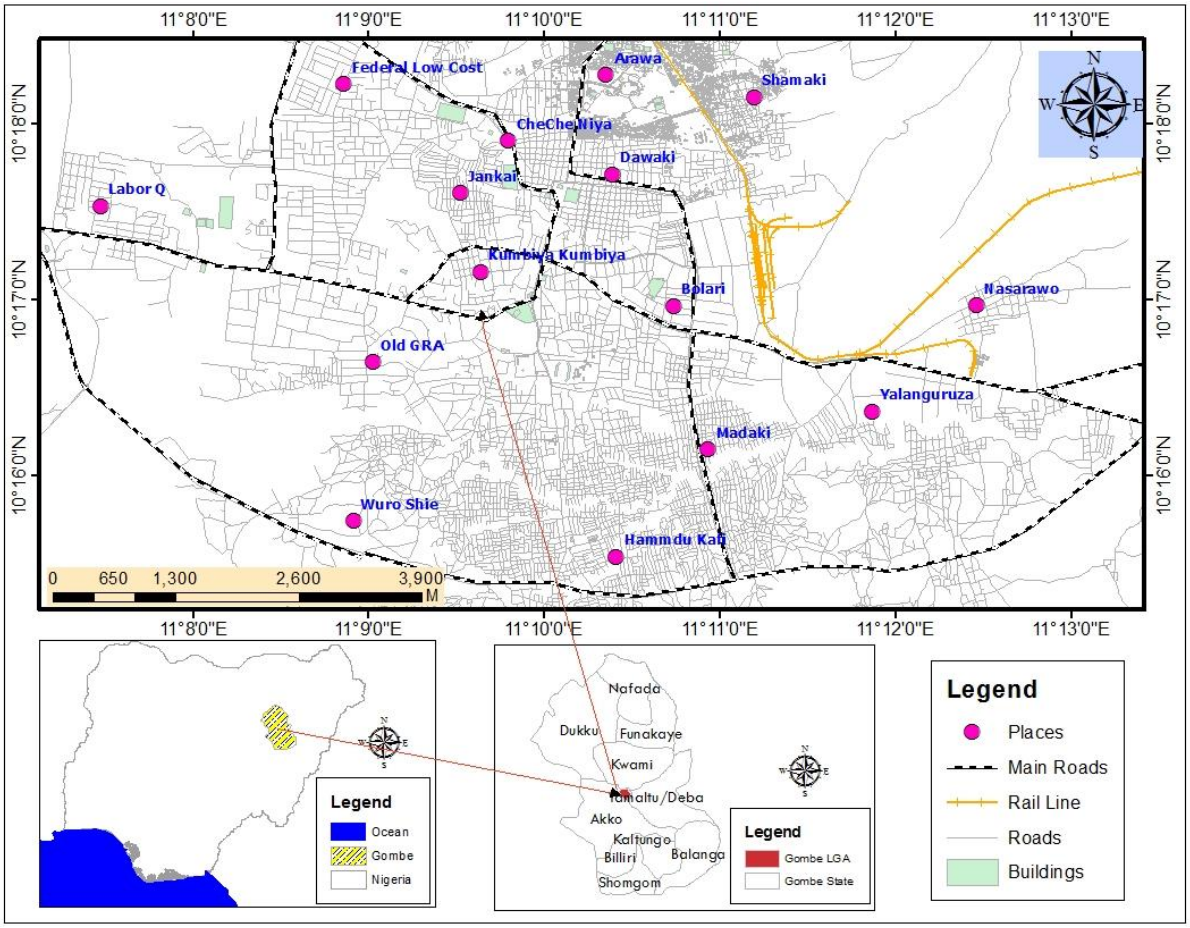

Figure 1: Map of Gombe Metropolis Showing Sampling Locations
Source: Modified from administrative Map of Gombe State (2021)

Methodology

Procedure for sampling

The study area was categorized into different residential zones based on the socio-economic status of the households, using a method partly adopted from Kiyawa and Yakubu (2017). These divisions are believed to persist, although with some changes over time. For example, in Gombe Metropolis, Federal low cost and G.R.A, which were formerly residential areas of expatriates, are now dominated by businessmen and other elites, but still retain their features as zones of high-income earners. Other areas such as State low cost and Yalanguruza are classified as middle-income earners areas. Furthermore, areas such as Pantami, Tudun-Wada, and Jekadafari are classified as areas of low-income earners. The households for this study were systematically selected across the study area (see Table 1).

Table 1: Selected Residential Clusters

S/N	High income earners	Middle income earners	Low-income earners	Total Number of Residential Zones
1	Federal Low Cost	Dawaki	Arawa	3
2	Labor Quarters	Hammadu Kafi	Bolari	3
3	Old GRA	Yalanguruza	Checheniya	3
4			Jankai	1
5			Kumbiya-Kumbiya	1
6			Madaki	1
7			Nasarawo	1
8			Shamaki	1
9			Wuro Shie	1
Total	**3**	**3**	**9**	**15**

Source: Author's Computation, 2021

The researchers systematically selected households and then used a proportionate ratio of 1:1:2 to select sampled households, with an interval of 7 households in high-density areas and 4 in moderate and low-density areas. This resulted in a total of 400 households being sampled. The head of each household was selected for questionnaire administration, as per the tradition of the Hausa/Fulani land, where housewives are prohibited from contact with strangers. If the household head was not available, a male family representative was chosen. In cases where a single residential building contained multiple households, one of them was chosen conveniently. The number of households in each residential cluster was determined using a proportionate ratio by dividing the number of residential areas in each cluster by the total number of residential areas in all clusters, and multiplying by the sample size. Similarly, the number of households that completed the questionnaire in each residential area within each cluster was determined using a proportionate ratio. The selected residential zones are shown on a map (see Figure 1).

Data used and sources

For this research, primary and secondary sources of data was utilized from different sources. Table 2 lists the types and sources of data required.

Table 2: Data Used for the Study and Sources

Data Used	Sources of Data
Socioeconomic characteristics of the households	Questionnaire Survey
The population of the Study Area	National Population Commission
Current household energy sources	Gombe State Buarea of Statistics and Questionnaire
Quantity of energy consume for cooking	Questionnaire Survey
Key Informant Interview	Field Survey

Source: Author's Compilation, 2021

Procedure for data collection

The structured questionnaire was directly administered to the respondents using Kobo Collect mobile application tool because of its accuracy and reliability for data collection. Questions on the household energy type, quantity and rate of consumption, household socio-economic and demographic factors such as household size, occupation, income, level of education of the household head, and that of the wife was the main content of the questionnaire. Furthermore, key informant interviews were conducted to enable the researcher to have deeper insights on the phenomenon in question and also supplement the quantitative data while secondary data was obtained from the Gombe State Bureau of Statistics.

Computer-Assisted Personal Interview (CAPI Software): Kobo Collect mobile application was used during the questionnaire administration to the selected households. Computer-assisted interview (KoboCollect) data collector tool is a computer-oriented software used for field survey where a well-structured questionnaire is coded into the software in which questions are read from the android device, and that responses are entered directly into the device by the questionnaire administrator. Thereafter, the data was generated directly from the server immediately after the interview in an XLS format ready for analysis. The major advantage of using Kobo Collect mobile application in data collection over the traditional paper and pen method includes more data accuracy, quality, and reliability, and also time and cost-effectiveness (Randolph, Virnes, Jormanainen, and Eronen, 2006); Mao et al. (2018) and Samantara and Ratha (2020). The questionnaire admistration was carried out with the aid of research assitants for about one week throughout the study area.

RESULTS AND DISCUSSION

Household's Sources of Energy for Domestic Cooking

According to table 3 Charcoal is the major source of energy supply mix accounting for 33.2% of the respondents, followed by fuelwood and LPG which constitutes 27.5% and 22.9% respectively. This demonstrates that the majority of respondents in the study area used energy for cooking from hydrocarbon-based energy sources (Charcoal and fuelwood 60.7%) in line with the report of Gombe State Bureau of statistics (GSBS) on household survey (2021), which stated that the majority (81%) of the households in the study area are using hydrocarbon-related energy sources to meet their cooking requirements. Moreover, the result contrast of GSBS report on liquefied petroleum gas and electricity consumption for cooking of 16.2% and 2% respectively, it is also conflicting the GSBS report of 0.8% of kerosene consumption indicating that there is a gradual energy transition going on in the area. The present result is in agreement with that of Bisu, Kuhe, and Iortyer (2016) whose findings revealed that because of availability and affordability of hydrocarbon fuel, households in Bauchi metropolis widely used it as the primary source of energy for cooking. Similarly, the findings is in consistent with that of Akinola et al. (2017) whose findings demonstrated that hydrocarbon-based energy sources such as fuelwood and charcoal are majorly used as energy for cooking by households in Ekiti State. In the same line, Anugwom et al. (2020) and Muazu and Ogujiuba (2020) revealed that the higher proportion of Nigerian households are largely dependent on traditional fuels (firewood, charcoal) and other hydrocarbon-based fuels for cooking requirements. The basis for these similarities may be attributed to the facts that hydrocarbon energy sources were readily available, affordable and easily accessible at all the times in the study areas.

This assertion is supported by the KII responses thus;

Fuelwood Key Informant stated as follows:

> *We supply sell fuelwood for cooking and commercial activities in Gombe Metropolis. We are selling more than 30 trucks of fuelwoods daily to the households for cooking, bread bakers and rice producers among others. Households alone are buying at least 10 trucks of fuelwood daily out of the aforementioned figure supplied to Gombe Metropolis of which each truck contains at least 1100 bundles of fuelwoods - (KI1). This is equivalent to the weight of 101,300 kg capable of generating estimated energy of 1, 641,060 MJ.*

In the same way the Charcoal Key informant reported as follows:

> *We are supplying selling charcoal for cooking and commercial activities in Gombe Metropolis. Households are using charcoal for cooking and heating of rooms especially during rainy and harmattan season, poultry owners are also using*

charcoal for heating, and blacksmiths are also using charcoal for their fabrication's activities. We supply more than 3 trailers of charcoal to Gombe Metropolis in which at least a trailer is consumed on daily basis by the households alone, each trailer contains about 700 bags of charcoal - (KI2). This is equivalent to the weight of 86,331 kg capable of generating estimated energy of 2,589,930 MJ.

Supply of modern energy in the area have been reported by key informants thus;

Key Informant of LPG reported as follows:

We sell LPG for domestic cooking and commercial activities in Gombe Metropolis. We have 4 existing LPG plants in Gombe Metropolis which are responsible for LPG supply for domestic cooking and commercial needs in the Metropolis. Each of these plants sell 2 trucks of LPG monthly in which each truck contains 30,000Kg of LPG. It means each month Gombe State consumes 240,000kg among which households consume 8,000 kg daily of LPG capable of generating estimated energy of 396,000 MJ - (KI3).

Likewise, Key Informant of Electricity Distribution Company stated as follows:

We supply electricity to the household in Gombe Metropolis and the whole state for domestic and commercial activities. Of course, some people are using this energy for cooking at the household level while on the other hand, some cannot afford to use it for cooking because of the high electricity tariff. We supply approximately 7million kWh equivalent to 25,200,000 MJ (total energy consumed per hour per month) monthly to Gombe Metropolis - (KI4).

Also, Key Informant of kerosene suppliers reported as follows:

We supply kerosene for domestic cooking and commercial activities in Gombe Metropolis. We sell 90,000 Liters of kerosene monthly to the people of Gombe State among which households use at least 3000 Liters daily capable of generating estimated energy of 183,000 MJ - (KI5).

An assertion by Key Informants in relation to the major findings of this section reported thus:

Households in Gombe Metropolis are mostly using fuelwood for cooking more especially during the dry season, we do sell dry woods to them and they buy it in larger quantities to satisfy their domestic cooking needs because it is cheaper and available than LPG and Electricity. We are more engaged in felling trees during the dry season, because the demand is high at that period as the majority of the households that cannot afford to use modern energy systems for cooking, thus they switching to charcoal instead because it is easier to use in the rainy season and it doesn't burn within a short time - (KI1).

Households in Gombe Metropolis are majorly using charcoal for cooking because it is cheaper than fuelwood and it has a longer burning period than fuelwood. Currently, most of the households are suffering from high cost of living therefore they cannot afford to adopt modern energy systems for cooking as such charcoal is the most alternative form of energy because it does not generate smoke like the other types of traditional energy systems. Moreover, households use to consume charcoal for cooking mostly during the rainy season because it is easier to use. In addition, charcoal is mostly consumed by the middle-income class while high-income earners consume both LPG and charcoal sometimes and the low-income class consumes fuelwood for cooking activities - (KI2).

According to our observations currently about 20-30% of households in Gombe have shifted from consuming hydrocarbon energy sources like fuelwood for cooking to LPG because it is cheaper, easy to use, and faster and perhaps user friendly. However, due to the recent high cost of LPG, some households that are using LPG for cooking are backsliding to the traditional sources of energy for cooking in Gombe metropolis especially charcoal because of its user friendly than fuelwoods after LPG. Just of recent 1kg of LPG is sold between 270-300 naira but now as I am talking to you it is about 600 naira - (KI3).

In Gombe Metropolis, we have two categories of households that are consuming electricity for lighting, heating, cooking and other activities. Some households are using prepaid meter while some are on direct connection because they are not metered. These households that are not using prepaid meter consumes much energy because we cannot get their exact bill as such, they don't have way of managing their energy consumption. These people are mostly using electricity for cooking because they don't pay for it. For those that are using prepaid meter, it usually monitors their consumption and therefore they don't use it often for cooking unlike those households that are on direct connection, simply because the more the consumption the higher the tariff - (KI4).

Summarily, the KII revealed that fuelwood and charcoal are widely used for cooking and commercial activities in Gombe Metropolis. The supply of fuelwood amounts to over 30 trucks daily, with households alone purchasing at least 10 trucks, each containing 1100 bundles of fuelwoods, weighing 56,100kg. Similarly, charcoal supply involves over 3 trailers, with at least one trailer consumed daily by households, and each trailer holding around 700 bags of charcoal, weighing 42.560 kg. Regarding modern energy sources, LPG is sold through four existing plants, with each plant selling 2 trucks monthly, totaling 240,000 kg where a total daily sell amounting to 8000 kg. Electricity is supplied to households and the state, but high tariffs discourage its use for cooking. Approximately 7 million kWh of electricity is supplied monthly to households in Gombe Metropolis. Kerosene is also supplied, with 90,000 liters sold monthly, and households using at least 3,000 liters daily for cooking.

Key informants highlight that households predominantly use fuelwood and charcoal for cooking due to their availability and affordability, especially during the dry season. Charcoal is preferred due to its longer burning period and lack of smoke generation. Additionally, middle-income households consume more charcoal, while high-income households occasionally use both LPG and charcoal. Observations show that 20-30% of households have shifted from fuelwood to LPG due to its cost-effectiveness and convenience. However, recent price increases have led some households to revert to charcoal. In terms of electricity usage, unmetered households consume more energy, including for cooking, while households with prepaid meters regulate their usage to manage costs.

Table 3: Household Sources of Energy

Energy Sources	Frequency	Percent
Fuel Wood	215	27.50
Charcoal	259	33.20
Kerosene	26	3.30
LPG	179	22.90
Electricity	102	13.10
Total	781	100.00

Source: Field Survey, 2021
Note: Multiple responses were allowed

Estimated Quantity of Energy Consumed for Cooking by the Respondents Per Month

Households consumes energy from different sources and at different quantities depending on the energy requirement for individual households. Table 4 shows the distribution of monthly amount spent on energy for cooking by the respondents. Energy conversion method was employed for the conversion of the raw data collected into energy units to determine the quantities of energy consumed in various households (see table 4).

Table 4: Energy Conversion Method

Energy Type	Energy Equivalent
Electricity	3.6MJ/1kWh
LPG	49.50 MJ/Kg
Kerosene	36.60 MJ/L
Charcoal	30.0 MJ/Kg
Fuel Wood	16.20 MJ/Kg

Source: IOR Energy, "List of common conversion factors (2010)"

Table 5 the estimated quantity of energy for cooking by the respondents per month, majority (33.2%,) of the respondents consumed charcoal and fuelwood (27.5%,) amounting to (1,230.25 Kg, 36,907.5 MJ) and (2,521.95 Kg, 40,855.59 MJ) respectively for cooking signifying a high rate of hydrocarbon fuel- related consumption in the area, similarly, considerable proportion of the respondents consumes energy for domestic cooking from cleaned sources with electricity (13.1%), LPG (22.9%) and kerosene (3.3%) amounting to (15,588 MJ), (204,187.5 MJ) and (39,285 MJ) of energy respectively implying the evidence of gradual transition to clean energy sources from hydrocarbon-based fuels. The present study is in agreement with that of Odesola, Awoyemi, Folorunso (2020) whose findings revealed that that various households consume energy at different quantities base on economic status of the households in Alagbaa community, Oyo State with Kerosene (1299.04 MJ) and firewood (1192.98 MJ) represented the largest energy source used for cooking followed by Charcoal (115.71 MJ) and LPG (540.10 MJ) daily by households.

Table 5: Estimated Quantity of Energy Consumed Daily for Cooking by the Respondent Per Month

Fuel Type	Quantity	Equivalent Energy	Frequency	Percent
Electricity	4,330 kWh	15,588 MJ	102	13.10
LPG	4,125 Kg	204,187.5 MJ	179	22.90
Kerosene	2,425 L	39,285 MJ	26	3.30
Charcoal	1,230.25 Kg	36,907.5 MJ	259	33.20
Fuelwood	2,521.95 Kg	40,855.59 MJ	215	27.50
Total			781	100.0

Source: Field Survey, 2021
Note: Multiple responses were allowed
Energy Conversion Method: See Table 4

Household Energy Mix for Cooking

Table 6 shows the respondents distribution of energy supply mix Fuelwood and charcoal mixed account for 33.7%. This indicated that the major source of energy mix use for domestic cooking by the respondents in the area is fuelwood and charcoal. Respondents utilizing LPG and charcoal as energy mixed constitutes 22.9%, electricity and LPG energy mixed account for 12.1%. Similarly, respondents utilizing LPG, fuelwood and charcoal mixed accounts for 7.4% while 6.5% of the respondents used electricity, LPG and charcoal as energy mixed and 5.6% used kerosene, fuelwood and charcoal. Furthermore, 4.6% of the respondents used electricity and charcoal for domestic cooking, 2.9% utilized LPG and fuelwood as energy mix, respondents utilizing kerosene, fuelwood for cooking account for 1.6%. In addition, 1.3% of the respondents used kerosene and charcoal as energy mixed for domestic cooking while 0.7% utilize LPG, kerosene and charcoal as energy mixed and those using electricity and fuelwood account for 0.7%.

This implies that energy transition is gradually taking place where some of the households in the area have started switching from completely using carbon related energy systems (fuelwood and charcoal) to the higher forms of energy (LPG and Electricity) for cooking however, some respondents obtained energy from different sources and use it concurrently which is an indication of energy transition. This findings is similar to that of Anugwom et al. (2020) who found that in southeastern Nigeria households used energy for cooking from the combination of traditional and modern energy sources which on one hand contribute to the energy

transition process and on the other hand consistent with assertion of the fuel stacking hypothesis which postulated that households utilized energy mix for cooking rather than single energy type as the major source of energy. This is also consistent with the findings of Alem, Beyene, Kohlin and Mekonnen (2013) who found that there is prevalence of multiple fuels used 'Fuel stacking behavior' in Ethiopia. On this note, it was found that in the study area households mostly used multiple fuels for cooking needs in line with the energy stacking theory. This findings is in line with that of Mukhadi et al. (2021) reveals that a significant number of the households practice energy-stacking hypothesis where majority of the households consume multiple fuels cooking and commercial needs.

Table 6: Energy Mix Used by Respondents

Energy Mix	Frequency	Percent
LPG and Fuelwood	9	2.9
Kerosene, Fuelwood and Charcoal	17	5.6
Kerosene, Fuelwood	5	1.6
LPG, Kerosene and Charcoal	2	0.7
Electricity, LPG and Charcoal	20	6.5
LPG and Charcoal	70	22.9
Electricity and Charcoal	14	4.6
Fuelwood and Charcoal	103	33.7
Electricity and LPG	37	12.1
Kerosene and Charcoal	4	1.3
Electricity and Fuelwood	2	0.7
LPG, Fuelwood and Charcoal	23	7.4
Total	306	100.0

Source: Field Survey, 2021

CONCLUSION

Household energy consumption is very crucial in energy studies across the globe for academic and scientific research. Household energy use accounts for one third of worldwide primary energy demand, having a considerable impact on the environment and human health. The majority of people in Nigeria has inadequate access to modern energy services, which has a variety of negative implications. As a result, shifting away from polluting sources of energy toward eco-friendly sources is a panacea to addressing the contending environmental issues that are currently threatening humanity. Hence, this study concluded that the higher proportion of households in Gombe metropolis obtained energy for cooking from hydrocarbon sources despite the environmental and health impacts emanating from its production and consumption.

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