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Assessment of Household Electricity Consumption and Appliance Energy Demand in Maiduguri, Nigeria

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ABSTRACT

Rapid urbanization, population growth, and increased ownership of electrical appliances have contributed to rising residential electricity demand in many developing countries, including Nigeria. This study assessed household electricity consumption patterns and appliance-specific energy demand in Maiduguri, Borno State, Nigeria, with the aim of identifying the major drivers of residential electricity use. Data were collected from fifty (50) households in the 202 Housing Estate through household surveys and direct observation of electrical appliances. A total of 2,876 electrical appliances with a combined connected load of 479,535 W were recorded across the surveyed households. The estimated total household electricity demand was 1,750.92 kWh/day, corresponding to 52,527.60 kWh/month, while the average household electricity demand was 35.02 kWh/day or 1,050.55 kWh/month. Refrigerators constituted the largest share of electricity demand, consuming 258.00 kWh/day (14.74%), followed by air conditioners with 160.00 kWh/day (9.14%) and ceiling fans with 144.00 kWh/day (8.22%). Cooking-related appliances, including electric cookers, stoves, and toasters, also accounted for a substantial proportion of total electricity consumption. The results indicate that refrigeration, cooling, and cooking appliances are the major drivers of residential electricity demand in the study area. The study provides valuable insights into household electricity consumption patterns and highlights the need for the adoption of energy-efficient appliances, consumer awareness programmes, and demand-side management strategies to promote sustainable energy utilization. The findings will assist policymakers, electricity distribution companies, and energy planners in developing effective residential energy management and conservation policies.

INTRODUCTION

Electricity is one of the most important forms of energy in modern society and plays a vital role in economic growth, industrial development, education, healthcare, and the overall improvement of living standards (Dogaru, 2020; Xu *et al.,* 2024). In residential settings, electricity is used to power a wide range of household appliances, including lighting systems, cooling devices, entertainment equipment, cooking appliances, and communication technologies (Strielkowski *et al.,* 2022). As urban populations continue to grow and living standards improve, the demand for residential electricity has increased significantly across many developing countries.

The residential sector constitutes a major component of total electricity demand worldwide. Several factors, including population growth, household size, income level, climatic conditions, lifestyle, and appliance ownership influence household electricity demand. Among these factors, the type, quantity, and duration of use of electrical appliances are recognized as the primary determinants of residential electricity demand. Consequently, understanding appliance ownership patterns and their associated energy requirements is essential for effective energy planning, load forecasting, and demand-side management (Ofetotse *et al.,* 2021; Proedrou, 2021).

In many developing nations, rapid urbanization has resulted in increased ownership of electrical appliances and a corresponding rise in residential electricity demand. This trend has created additional pressure on existing electricity infrastructure, particularly in countries where electricity generation and distribution systems are already inadequate. As household access to electrical devices continues to expand, there is a growing need to assess the contribution of individual appliances to overall residential energy demand in order to identify opportunities for energy conservation and efficiency improvement (Poblete-Cazenave & Pachauri, 2021; Usman *et al.,* 2022).

Nigeria possesses abundant energy resources; however, the electricity supply remains insufficient to meet the growing demand of its population (Oyedepo *et al.,* 2018). The country continues to experience challenges associated with inadequate generation capacity, transmission losses, aging infrastructure, and frequent power outages. These challenges have significant implications for residential consumers, who often face unreliable electricity supply and increasing energy costs. Understanding the electricity demand characteristics of households is therefore important for developing effective energy management strategies and improving the efficiency of electricity utilization (Chanchangi *et al.,* 2022).

Previous studies have shown that household electricity demand is strongly influenced by appliance ownership and usage characteristics (Lee and Song, 2022; Olaniyan *et al.,* 2018; X. Xu *et al.,* 2020). Research conducted in various countries has demonstrated that appliances such as air conditioners, refrigerators, lighting systems, televisions, electric cookers, and water heating devices account for a substantial proportion of residential electricity demand (Liaqat *et al.,* 2021; Mathias *et al.,* 2023). Studies have further indicated that cooling appliances often represent the largest share of household energy demand in regions characterized by high ambient temperatures, while lighting systems remain significant contributors in areas where energy-efficient technologies have not been widely adopted (Colelli *et al.,* 2023; Gorgulu and Kocabey, 2020).

Several studies conducted in Nigeria have investigated residential energy consumption patterns and appliance ownership characteristics. These studies generally report that household electricity demand is largely driven by lighting systems, refrigeration equipment, cooling devices, cooking appliances, and entertainment electronics (Abubakar *et al.,* 2024; Hassan *et al.,* 2020; Jesuleye *et al.,* 2023). Researchers have emphasized the importance of identifying high-energy-consuming appliances as a prerequisite for designing effective energy-efficiency policies and consumer awareness programs. The adoption of energy-efficient appliances and improved electricity management practices has been widely recommended to reduce residential electricity demand and minimize pressure on the national electricity grid (Lawal *et al.,* 2024).

Maiduguri, the capital city of Borno State in northeastern Nigeria, has experienced substantial population growth and urban expansion in recent decades. The city has a hot semi-arid climate with prolonged periods of high temperatures, leading to increased reliance on cooling appliances such as ceiling fans and air conditioners (Nasara *et al.,* 2025). In addition, improvements in socioeconomic conditions and increased access to electrical appliances have contributed to steady growth in residential electricity demand. Despite this rising demand, limited information exists on appliance ownership patterns and the relative contribution of household appliances to residential electricity demand within the city (Akeh & Babayo Mohammed Adamu, 2023).

Most previous studies in Nigeria have focused on general electricity consumption, energy expenditure, or electricity access, with limited attention given to appliance-level electricity demand estimation (Athanasiadis *et al.,* 2021; Dioha, 2018; Ezeamama & Sciences, 2020; Isihak *et al.,* 2020; Ojo *et al.,* 2025). Consequently, there remains a need for detailed assessments of the electrical appliances commonly used in households and their respective contributions to total residential electricity demand. Such information is essential for identifying major energy-consuming appliances, promoting efficient electricity utilization, and supporting future energy planning initiatives.

This study therefore assesses household electrical appliance energy demand in selected households within the 202 Housing Estate, Maiduguri, Nigeria. The study estimates the electricity demand associated with various household appliances based on their power ratings, quantity, and operating duration. The findings are expected to provide useful information on appliance ownership characteristics, identify major contributors to residential electricity demand, and provide recommendations for improving household energy efficiency and sustainable electricity utilization. This study aims to assess the energy demand of household electrical appliances in selected households in Maiduguri, Nigeria. The specific objectives are to: Determine the ownership characteristics of electrical appliances in selected households, estimate the daily electricity demand for household electrical appliances, identify the major household appliances that contribute to residential electricity demand, evaluate the percentage contribution of individual appliances to total household electricity demand, and estimate the total monthly electricity demand for the surveyed households.

MATERIALS AND METHODS

Study Area

The study was conducted in Maiduguri, the capital city of Borno State, northeastern Nigeria. Maiduguri is located between latitude 11°50′N and 11°55′N and longitude 13°05′E and 13°15′E. The city serves as the administrative, commercial, and educational hub of Borno State and has experienced rapid population growth and urban expansion over the past few decades.

A hot semi-arid climate with distinct dry and wet seasons characterizes Maiduguri. The dry season typically extends from October to May, while the rainy season occurs between June and September. Temperatures in the area frequently exceed 35°C during the hot season, resulting in increased demand for cooling appliances such as air conditioners and ceiling fans. These climatic conditions make residential electricity demand an important aspect of household energy management within the city.

The study focused on Complete Line A of the 202 Housing Estate, Maiduguri, which consists predominantly of residential buildings occupied by households with varying socioeconomic characteristics and electricity consumption patterns.

Data Collection

Data for this study were collected from fifty (50) households located along Complete Line A of the 202 Housing Estate, Maiduguri, Borno State, Nigeria. Primary data were obtained using structured questionnaires, follow-up interviews, and direct field observations.

The structured questionnaire was administered to the household head or an adult occupant in each household. The questionnaire collected quantitative information on the types of electrical appliances owned, the number of each appliance in the household, the rated power of each appliance (where available from the appliance nameplate), and the respondents' estimates of the average daily operating hours for each appliance under normal household conditions.

Following the questionnaire survey, follow-up interviews were conducted with respondents to clarify and validate the reported appliance usage patterns. During these interviews, respondents described the typical periods of the day during which each appliance was used (e.g., morning, afternoon, evening, or overnight), the frequency of use (daily, occasionally, or seasonally), and any variations in usage due to weather conditions, occupancy, or electricity supply. These interviews were particularly useful for resolving inconsistencies in questionnaire responses and confirming the reported operating hours.

Direct field observations were carried out in each household to verify the presence and quantity of the reported electrical appliances and to record the rated power from the appliance nameplates wherever accessible. Where the nameplate information was unavailable or unreadable, the rated power was obtained from the manufacturer's specifications or standard appliance power-rating references.

The electrical appliances considered in the study included air conditioners, lighting systems, ceiling fans, refrigerators, freezers, televisions, decoders, electric cookers, electric kettles, water dispensers, computers, washing machines, and other domestic electrical appliances commonly found in residential buildings.

The average daily operating hours used in the analysis were obtained directly from respondents through the structured questionnaire and subsequently verified during the follow-up interviews. Respondents were asked to estimate the number of hours each appliance was typically used during a normal day based on their regular household routine. For appliances with variable usage, respondents were encouraged to describe their typical daily usage pattern, and a representative average daily operating time was determined from their responses. The reported operating hours were then cross-checked with field observations of appliance availability and household usage patterns before being used in the estimation of daily electricity consumption.

Estimation of Household Electricity Demand

The electricity demand associated with each appliance was estimated using its rated power, quantity, and average daily operating duration. The daily energy demand was calculated using (Rodrigues *et al.,* 2014):

$$E_i = P_i \times N_i \times t_i \quad (1)$$

Where, E_i is the daily energy demand of the appliance (Wh/day), P_i is the rated power of the appliance (W), N_i is the number of appliances, and t_i is the average operating duration of the appliance (hours/day).

The total daily electricity demand for all appliances was obtained by summing the individual appliance demands:

$$E_T = \sum_{i=1}^{n} E_i \quad (2)$$

Where, E_T is the total daily electricity demand (Wh/day), and n is the total number of appliance categories considered.

The calculated energy values were converted from watt-hours (Wh) to kilowatt-hours (kWh) using:

$$Energy\ (KWh) = \frac{Energy\ (Wh)}{1000} \quad (3)$$

The estimated monthly electricity demand was determined by multiplying the daily electricity demand by 30 days:

$$E_m = 30E_T \quad (4)$$

Where, E_m is the estimated monthly electricity demand (kWh/month).

2.4 Percentage Contribution of Appliances

The contribution of each appliance to the total household electricity demand was determined using:

$$C_i = \frac{E_i}{E_T} \times 100 \quad (5)$$

Where, C_i is the percentage contribution of appliance (i), E_i is the electricity demand of appliance (i), and E_T is the total electricity demand of all appliances.
This analysis enabled the identification of major electricity-consuming appliances within the surveyed households.

Data Analysis
The collected data were analyzed using descriptive statistical techniques. Frequencies, percentages, totals, and averages were used to summarize appliance ownership characteristics and electricity demand patterns.
Tables and charts were used to present the distribution of appliance ownership, estimated electricity demand, and the percentage contribution of individual appliances to total household electricity demand. The results were interpreted to identify major electricity-consuming appliances and to assess the overall residential electricity demand characteristics of the study area.

Limitations of the Study
The electricity demand estimates presented in this study were derived from appliance rated power, quantity, and reported operating durations rather than direct electricity meter readings. Consequently, the results represent estimated appliance-based electricity demand and may differ from actual household electricity consumption due to variations in appliance efficiency, user behaviour, intermittent operation, and fluctuations in electricity supply.

RESULTS AND DISCUSSION
Results
This section presents the findings of the assessment of household electrical appliance energy demand in the surveyed households within the 202 Housing Estate, Maiduguri. The analysis focuses on appliance ownership characteristics, estimated electricity demand, and the contribution of individual appliances to total household energy consumption.

Table 1: Household Appliance Inventory, Connected Load, and Estimated Daily Electricity Consumption in Selected Households in Maiduguri, Nigeria

S/N	Appliance	Power Rating (W)	Quantity	Connected Load (W)	Operating Hours (h/day)	Energy Consumption (Wh/day)	Energy Consumption (kWh/day)	Contribution (%)
1	Air Conditioner	1000	40	40000	4	160000	160	9.138053
2	Blender	50	33	1650	1	1650	1.65	0.094236
3	Borehole	1100	14	15400	3	46200	46.2	2.638613
4	Bulb	15	453	6795	12	81540	81.54	4.65698
5	Ceiling fan	60	200	12000	12	144000	144	8.224248
6	Cloth dryer	100	9	900	2	1800	1.8	0.102803
7	Coffee maker	800	3	2400	2	4800	4.8	0.274142
8	Decoder	10	40	400	10	4000	4	0.228451
9	Desktop	100	4	400	4	1600	1.6	0.091381
10	Dishwasher	1300	5	6500	1	6500	6.5	0.371233
11	Electric cooker	1200	26	31200	4	124800	124.8	7.127681
12	Electric kettle	1200	22	26400	2	52800	52.8	3.015558
13	Freezer	300	10	3000	10	30000	30	1.713385
14	Fryer	1000	12	12000	1	12000	12	0.685354
15	Game console	60	5	300	4	1200	1.2	0.068535
16	Hair dryer	70	13	910	1	910	0.91	0.051973
17	Hair stretcher	60	7	420	1	420	0.42	0.023987
18	Heater	1000	9	9000	2	18000	18	1.028031
19	Hot plate	1500	14	21000	3	63000	63	3.598108
20	Hot water dispenser	1000	6	6000	2	12000	12	0.685354
21	Humidifier	35	30	1050	4	4200	4.2	0.239874
22	Iron	1000	28	28000	3	84000	84	4.797478
23	Lamp	150	90	13500	3	40500	40.5	2.31307
24	Lantern	60	150	9000	1	9000	9	0.514015
25	Laptop	150	51	7650	3	22950	22.95	1.310739
26	Microwave	600	17	10200	1	10200	10.2	0.582551
27	Mixer	100	60	6000	1	6000	6	0.342677
28	Oven	150	40	6000	1	6000	6	0.342677
29	Phone charger	25	350	8750	5	43750	43.75	2.498686
30	Pressure cooker	1000	27	27000	2	54000	54	3.084093

31	Printer	300	8	2400	2	4800	4.8	0.274142
32	Projector	250	4	1000	1	1000	1	0.057113
33	Refrigerator	500	43	21500	12	258000	258	14.73511
34	Rice cooker	500	7	3500	3	10500	10.5	0.599685
35	Socket	3	500	1500	12	18000	18	1.028031
36	Speaker	60	24	1440	5	7200	7.2	0.411212
37	Steamer	500	20	10000	2	20000	20	1.142257
38	Stove	1000	40	40000	3	120000	120	6.85354
39	Television	70	81	5670	10	56700	56.7	3.238298
40	Toaster	800	67	53600	2	107200	107.2	6.122496
41	Torch	10	250	2500	1	2500	2.5	0.142782
42	Vacuum cleaner	450	12	5400	2	10800	10.8	0.616819
43	Washing machine	500	30	15000	4	60000	60	3.42677
44	Water dispenser	100	7	700	12	8400	8.4	0.479748
45	Water purifier	100	15	1500	12	18000	18	1.028031
	TOTAL	20338	2876	479535	188	1750920	1750.92	100

Table 1 presents the distribution of electrical appliances identified in the surveyed households. A total of 2,876 appliances were recorded across the fifty households. The most frequently owned appliances were sockets (500), bulbs (453), phone chargers (350), torches (250), and ceiling fans (200), and also shows the estimated daily electricity demand of household appliances based on their rated power, quantity, and average operating duration. The total connected load of all appliances was 479,535 W, while the estimated total daily electricity demand was 1,750.92 kWh/day.

Table 2: Top Energy-Consuming Appliances

Rank	Appliance	kWh/day	Contribution (%)
1	Refrigerator	258	14.74
2	Air Conditioner	160	9.14
3	Ceiling Fan	144	8.22
4	Electric Cooker	124.8	7.13
5	Stove	120	6.85
6	Toaster	107.2	6.12
7	Iron	84	4.8
8	Bulb	81.54	4.66
9	Hot Plate	63	3.6
10	Washing Machine	60	3.43
11	Other	548.38	31.50

Table 2 presents the ranking of the ten highest electricity-demand appliances in the surveyed households. Refrigerators emerged as the largest contributors to household electricity demand, accounting for 14.74% of total electricity demand.

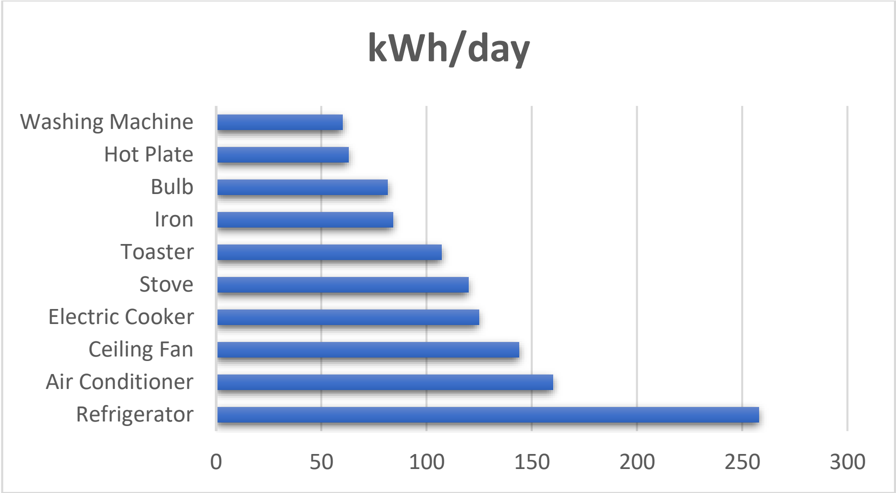

Figure 1: Daily electricity demand of the ten highest electricity-consuming household appliances

Figure 1 presents the ten highest electricity-demand appliances in the surveyed households. Refrigerators recorded the highest daily electricity demand (258 kWh/day), followed by air conditioners (160 kWh/day) and ceiling fans (144 kWh/day).

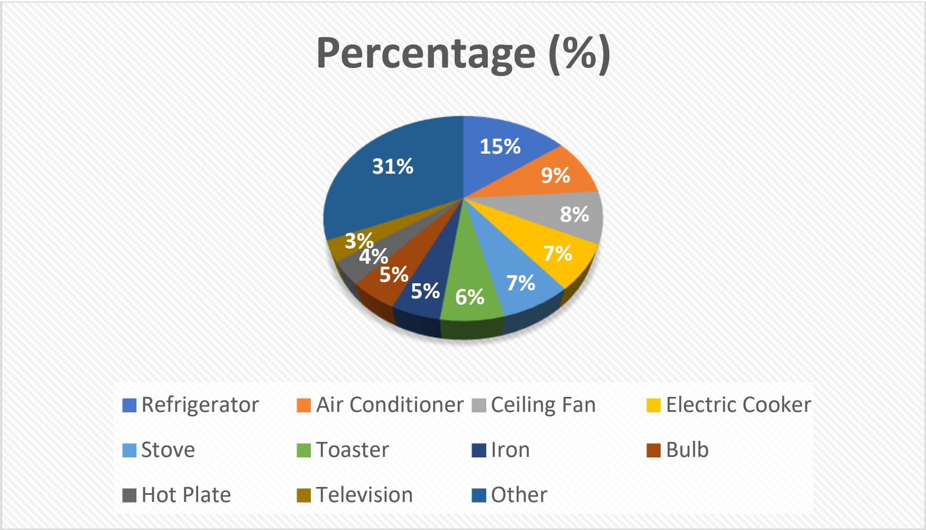

Figure 2: Percentage contribution of major household appliances to total household electricity demand (percentages rounded to the nearest whole number)

Figure 2 illustrates the percentage contribution of major appliances to total household electricity demand. Refrigerators accounted for the largest share (14.74%), followed by air conditioners (9.14%), ceiling fans (8.22%), and others (31.50%)

Table 3: Summary Statistics of Household Electricity Demand

Parameter	Value
Number of households surveyed	50
Total appliances recorded	2,876
Total connected load	479,535 W
Total daily electricity demand	1,750.92 kWh/day
Total monthly electricity demand	52,527.60 kWh/month
Average daily electricity demand per household	35.02 kWh/day
Average monthly electricity demand per household	1,050.55 kWh/month

Table 3 presents the summary statistics of household electricity demand in the study area. A total of 2,876 electrical appliances were recorded across the 50 surveyed households, with a combined connected load of 479,535 W. The estimated total daily electricity demand was 1,750.92 kWh/day, corresponding to a monthly demand of 52,527.60 kWh/month. The average electricity demand per household was estimated at 35.02 kWh/day and 1,050.55 kWh/month.

Discussion

The total connected load of all appliances (Table 1) was estimated at 479,535 W, while the total daily electricity demand was 1,750.92 kWh/day. Refrigerators, air conditioners, ceiling fans, electric cookers, and stoves accounted for a substantial proportion of total electricity demand due to their relatively high power ratings and longer operating durations. This observation is consistent with the findings of Ali et al. (2021), who reported that household electricity consumption in urban residential areas is strongly influenced by appliance ownership and usage duration. The dominance of cooling and food preservation appliances in electricity consumption is consistent with studies conducted in other Nigerian urban areas. Dong et al. (2021) found that refrigerators and air-conditioning systems constitute major contributors to residential electricity demand because of their continuous operation. Similarly, Oluwole et al. (2020) observed that climatic conditions significantly influence electricity consumption patterns in northern Nigerian households.

The high contribution of refrigerators can be attributed to their continuous operation throughout the day to maintain food preservation. Unlike many household appliances that are used intermittently, refrigerators operate for extended periods and therefore consume substantial amounts of electricity. A similar result was reported by Debnath et al. (2020), who identified refrigerators as one of the highest electricity-consuming appliances in residential buildings.

Similarly, the significant contribution of air conditioners and ceiling fans reflects the need for thermal comfort in Maiduguri's hot environment. According to Falchetta et al. (2024), cooling appliances account for a significant share of residential electricity demand in regions characterized by high ambient temperatures.

The substantial energy demand associated with electric cookers, stoves, and toasters indicates that food preparation activities contribute significantly to residential electricity consumption. This finding agrees with the work of Issi and Kaplan (2018), whose study showed that cooking appliances represent an important component of household electricity demand in developing countries.

Figures 1 and 2 collectively show that household electricity demand is dominated by a small number of high-energy-consuming appliances. Refrigerators accounted for the largest share of total electricity demand (14.74%), followed by air conditioners (9.14%) and ceiling fans (8.22%), indicating that cooling and food preservation appliances are the primary drivers of residential electricity consumption in the study area. Electric cookers and stoves also contributed substantially to the overall household load. This pattern is consistent with the findings of Dominguez et al. (2019), who reported that a limited number of high-power appliances account for most residential electricity consumption. Similarly, Satre-Meloy et al. (2019) observed that household electricity demand is largely driven by a relatively small number of energy-intensive appliances. Furthermore, Kwag et al. (2018) demonstrated that replacing inefficient refrigerators and air-conditioning systems with energy-efficient alternatives can significantly reduce household electricity demand. Therefore, improving the energy efficiency of these major appliances and promoting energy-conservation practices among consumers could substantially reduce residential electricity demand, as also recommended by Hafeez et al. (2020).

Table 3 summarizes that the relatively high average household electricity demand observed in this study may be attributed to the large number of electrical appliances owned by households and the extensive use of cooling and cooking appliances. A comparable observation was made by Yilmaz et al. (2019), who reported that appliance ownership is a significant determinant of household electricity demand. The findings suggest that residential consumers constitute a significant component of urban electricity demand and therefore play an important role in overall energy planning and demand management. According to Ali et al. (2024), accurate assessment of residential electricity demand is essential for sustainable energy planning and infrastructure development.

The estimated monthly electricity demand also highlights the potential economic implications of residential electricity consumption. Al-Marri et al. (2018) reported that increasing appliance ownership and prolonged appliance usage are associated with higher household energy expenditure.

CONCLUSION

This study assessed household electricity consumption patterns among selected households in the 202 Housing Estate, Maiduguri, Nigeria, using an inventory of household electrical appliances and estimated daily energy demand. A total of 2,876 electrical appliances with a combined connected load of 479,535 W were recorded across the fifty surveyed households, resulting in an estimated total electricity demand of 1,750.92 kWh/day (35.02 kWh/day per household) or approximately 52,527.6 kWh/month for all households. The findings revealed that residential electricity demand

is dominated by a relatively small number of high-energy-consuming appliances, particularly refrigerators, air conditioners, ceiling fans, electric cookers, and stoves, with refrigerators accounting for the largest share (14.74%) of total electricity consumption.
The study demonstrates that appliance ownership, power rating, and operating duration are the major factors influencing household electricity consumption in the study area. The dominance of cooling and refrigeration appliances further reflects the impact of Maiduguri's hot climatic conditions on residential energy demand. These findings provide useful baseline information for residential electricity demand assessment and energy planning in urban areas of Nigeria. Based on the findings of this study, it is recommended that households adopt energy-efficient appliances, particularly for cooling and cooking, while electricity distribution companies and policymakers strengthen consumer awareness and demand-side management programmes to improve residential energy efficiency and promote sustainable electricity utilization.

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