Journal of Infrastructure, Policy and Development 2024, 8(3), 2895.
https://doi.org/10.24294/jipd.v8i3.2895

Article

Household electricity consumption determinants in major Nigeria cities

Obinna Ubani[1], Chinwe Sam-Amobi[2,*], Emeka Mba[2,*], Egbenta Idu[3], Emmanuel Ezeama[2], Peter I. Oforji[2]

[1] Department of Urban & Regional Planning, University of Nigeria, Enugu campus, Enugu 4031, Nigeria
[2] Department of Architecture, University of Nigeria, Enugu campus, Enugu 4031, Nigeria
[3] Department of Estate Management, University of Nigeria, Enugu campus, Enugu 4031, Nigeria
*** Corresponding authors:** Chinwe Sam-Amobi, chinwe.sam-amobi@unn.edu.ng; Emeka Mba, emeka.mba@unn.edu.ng

CITATION

Ubani O, Sam-Amobi C, Mba E, et al. (2024). Household electricity consumption determinants in major Nigeria cities. Journal of Infrastructure, Policy and Development. 8(3): 2895. https://doi.org/10.24294/jipd.v8i3.2895

ARTICLE INFO

Received: 19 September 2023
Accepted: 16 November 2023
Available online: 16 January 2024

Abstract: The increasing epileptic electricity supply, mainly in the residential areas of Nigerian cities, has been linked to the incorrect knowledge of the numerous socio-economic and physical indices that influence household electricity usage. Most of the seemingly identified explanatory factors were done at macro level which does not give a clear estimate of this electricity demand. The thrust of the study is to analyse empirically the household electricity determinants in Nigerian cities with a view to evolving a more informed and sustainable energy policy decision. Multistage area cluster sampling method was adopted in the study where 769 copies of structured questionnaire were distributed to electricity users of prepaid meters in five major Nigerian cities. The research hypothesis was tested using the multiple linear regression statistical tool. The result revealed that nine variables which include age (r = 0.05, p-value: 0.05), household income (r = 0.00, p-value: 0.05), number of hours that people stay outside the house (r = 0.043, p-value: 0.05), number of teenagers at home, (r = 0.006, p-value: 0.01) number of electrical appliances (r = 0.016, p-value: 0.01), type of house (r = 0.012, p-value: 0.01), hours that the electrical appliances are used (r = 0.043, p-value: 0.05), weather condition, (r = 0.011, p-value: 0.05) and the location of the building (r = 0.045, p-value: 0.05) were significant in determining the household electricity consumption. Policies based on the findings will give energy and urban planners an empirical basis for accurate and robust forecasting of the determinants that influence household electricity consumption in Nigeria that is devoid of any speculation or unfounded predictions.

Keywords: consumption; electricity; residential; sustainable; city; socio-economic

1. Introduction

The growth and development of most national economy is strategically tied to her energy since this is linked to the national industrial, agricultural and commercial activities. Countries that have forged ahead in recent times, in the path of development have been linked to have had well co-ordinated energy. Electricity has remained one of the very core determinants of country's economic development. (Zaman et al., 2012). Different field of study across the world have had attraction in matters of energy use efficiency. The United Nations has been at the forefront through its sustainable development goals (SDG). This body has pushed for improved global rate of energy use efficiency by the year, 2030. (United Nations, 2015). This veritable policy agenda for energy planners was targeted for conservation, reduction, and saving of energy resources which was due to global climate change. It is now an issue associated with industrial and commercial competitiveness as well as energy security. Recent studies have presented that at the household level, the primary source of energy for entertainment, heating, lighting and other energy related services in urban, semi-urban and rural areas has become

electricity (Islam and Hasanuzzaman, 2020; Azhgaliyeva et al., 2020). It has become obvious that even though electricity consumption have been noticed to have great impact on economic development of countries, it is of particular importance for households and residential areas. There is indeed a global trend of rise in electricity consumption all over the world. Proper understanding and accurate prediction of this electricity consumption and the knowledge of the variables that have a significant impact on electricity consumption is of great necessity for policy makers and energy planners in order to develop a robust energy strategies. Various studies done in different Asian and western countries have addressed this problem in order to ascertain the factors that influence electricity consumption and create an adequate and appropriate strategy to handle the increasing household electricity demand. (Kim, 2018; Bedir et al., 2013; Kavousian et al., 2013; etc.). In the African context, access to electricity is the nexus between the global economy grid and Africa (Latham and Watkins Practice, 2016). It is clear that access to electricity is indeed a catalyst that drives the development and growth of an economy. Despite the knowledge of this fact, most countries of the world that have been blessed with abundance of gas, oil, coal and other renewable energy sources are still been confronted with serious and unimaginable energy problems and crisis (Onisanwa and Adaji, 2020).

In Nigeria and in other developing countries of the world, for there to be an appropriate energy policy formulated, there is the dire need to have clear knowledge of the drivers and predictors of energy consumption. Among the essential energy spectrum in Nigeria is electricity and the proper understanding of the variables that determine its consumption is essential towards formulating an energy policy for the country. Tewathia (2014) posited that electricity is a key contributor towards the improvement of households and individuals' standard of living. Tully (2006) asserted that with the aid of electricity, basic household functions are carried out and that man's development will be quite difficult without access to electricity. It is obvious that electricity has remained an indispensable resource for technological advancement and growth. Also, for there to be any educational advancement, electricity support is needed in other to facilitate researches and studies. In other words, electricity serves as means by which ideas and thoughts are transformed into practical and profitable realities (Kwakwa, 2018).

Over the years, it has been noted that there has been continuous rise in electricity consumption in Nigeria without a corresponding increase in supply (Kostakis, 2020). The increase in the need for electricity is based on population growth and the expanding economic activities in the country, with household electricity consumption accounting for a large proportion of the energy consumption (Onisanwa and Adaji, 2020). As at 2017, available figures revealed that in Nigeria, the commercial, industrial electricity and residential consumption accounted for 51.3%, 26.7% and 22.0% of the total electricity consumption respectively (CBN, 2017). However, in 2021, the residential, commercial and industrial sectors have consumed 58.3%, 21.2% and 20.5% of the total electricity consumption respectively (CBN, 2022). This was attributed to increased urban areas in the country at large. Electricity in the households provides power for various electrical equipment that may be used for relaxation, preparation and preservation of food stuff, etc.

Certain household activities which have remained indispensable cannot be

replaced by any other form of energy except electricity. According to International Energy Agency (2020), such activities include refrigeration, running of household appliances and lightening, hence this explains the crucial nature of electricity to human and national development. Little wonder why Babatunde and Shuaibu (2009) remarked that electricity is used for various reasons which include commercial, household and industrial purposes.

According to Aydinalp et al. (2015), of the sectors that use electricity in Nigeria, the household sector consumes one third of it, this implies that this sector should be given due attention. Hence, there is therefore the need that energy policy makers and the government address the dynamic and pattern of household electricity consumption in various cities so as to achieve sustainable development. Given that several efforts aimed at raising the supply of electricity by the government are not yielding the desire result, calls for policy makers to be abreast with the factors that determine electricity demand become imperative (Ubi et al., 2012).

In addition, the few studies done to investigate the variables that drive household electricity consumption in Nigeria have not been investigated at the micro level, most studies focused mainly on the relationship between electricity and determinants of residential electricity consumption on a macro level with aggregated data elicited at the national level and this gap is what this study intend to fill. More so, the few studies (Adam, 2013; Onisanwa and Adaji, 2020; Ubi et al., 2012) that attempted to find this association at the micro level used very few household electricity explanatory variables which made their results skeletal and non-robust. Onisanwa and Adaji (2020) acknowledged the deficiency of their study by recognizing that these studies did not capture many different factors that influenced demand for household electricity in Nigeria. Hence, micro level analysis will definitely help give more robust calculation of demand for residential electricity in Nigeria. The outcome of this study will aid energy planners to evolve workable electricity reform through the availability of data on the drivers of household electricity consumption in Nigerian cities. This is because households with different socio-economic status make different choices regarding their energy use (Sarkodie and Adom, 2018). Household heterogeneity should be taken into account when analyzing household energy demand. The aim of this study is to empirically x-ray household electricity determinants in Nigerian cities using household data. This understanding of reliable household level data will aid for a more informed and successful energy policy for Nigeria residential urban areas. A micro- level analysis will help in obtaining a clearer estimates of household electricity demand dynamics in a typical sub-Sahara African country. It was hypothesized in this study that household per capita electricity usage is not significantly related to households' socio-economic variables.

The paper is organized into five sections. Section one introduced the study, section two captured the empirical underpinnings and reviews. Section three specified the methodology adopted for the study while section four showed the result output, interpretations and discussions. Finally, section five contained the research implications and conclusion.

2. Case study

Nigeria is located on the West coast of Africa. It is bounded on the north by Niger and Chad Republics, on the east by Cameroon, on the west by Benin Republic and on the south by the Gulf of Guinea and Equatorial Guinea. It has a total area of 923,766 square kilometers of which the land area consists of 910,768 square kilometers, while the balance of 13,000 square kilometers is water with a total coastline of 853 km (Iloeje et al., 2002). This is shown in **Figure 1** indicating the position of Nigeria in the map of Africa. Nigeria lies between latitudes 4° and 14°N and longitudes 2°2′ and 14°30′E.

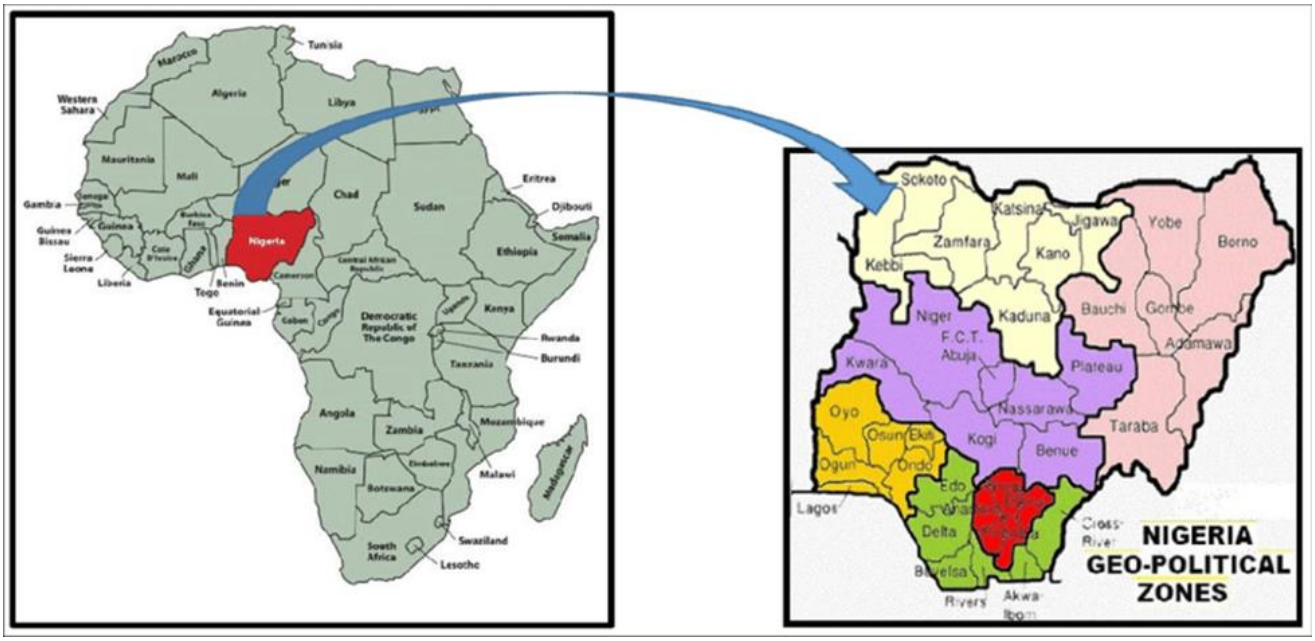

Figure 1. Map of Africa showing Nigeria.
Source: MoN, 2022.

Temperature and humidity remain relatively constant throughout the year in the southern part of Nigeria, while the seasons vary considerably in the north; during the northern dry season, the daily temperature range 36–40 °C. On the coast, the mean monthly maximum temperatures are steady throughout the year, remaining about 90 °F (32 °C) at Lagos and about 91 °F (33 °C) at the eastern part of the country; the mean monthly minimum temperatures are approximately 72 °F (22 °C) for Lagos and 68 °F (20 °C) for the east. In general, mean maximum temperatures are higher in the north, while mean minimum temperatures are lower. In the north region, for example, the mean monthly maximum temperature may exceed 100 °F (38 °C) during the hot months of April and May, while in the same season frosts may occur at night. The humidity generally is high in the North, but it falls during the harmattan (the hot, dry northeast wind), which blows across the desert region for more than three months in the North but rarely for more than two weeks in the South and along the coast (Iloeje et al., 2002).

3. Literature review

Vast volumes of researches have been done on the determinants of residential

electricity consumption and these studies have focused mainly on developed countries using macro-economic variables (price of oil, urbanization, real income and weather) as the main explanatory variables (Narayan et al., 2007; World Energy Council, 2016). Studies on household electricity consumption in developing countries have received less attention. Some of the few studies were those of De Vita et al. (2016)—Kenya; Babatunde and Shuaibu (2009) as well as Babatunde and Enehe (2011)—Nigeria. A sizable number of the electricity studies have focused more on the aggregate demand of the economy without giving much consideration to the factors or determinants that are behind the decision of households to demand for electricity. This is still lacking in the body of literature.

It is obviously clear that household electricity consumption provides energy for different and diverse electrical appliance in homes that are used for food preservation and that could be used for recreation and relaxation. Shibalal (2019) posited that the frequency in the use of household electrical appliance was a function of the price and the expected cost of these appliances while the intensity of its use depends on the energy price and other non-economic factors. Again, some studies that have reviewed household electricity consumption and socio-economic variables that were both individual and household-specific, have shown that real income, weather, and electricity price influence household electricity consumption (Huang, 2015; Ngutsav and Aor, 2014; Ubani, 2013). However, most of these studies have actually been done on State-by-State aggregated basis. These studies were actually faulted by Pachauri and Jiang (2008) when they stated that households with different socio-economic profile are more likely to make different choice regarding their energy use. He argued that family differences must be considered in any household energy consumption analysis in order to engender more informed and robust energy policy decision.

Sakah et al. (2019) on their study, investigated the effect of time of the day, electricity pricing, electrical appliance stocks and demographic factors on household electricity consumption. They concluded that number of households' electrical appliances has statistically significant relationship with electricity demand function and their study equally found a negative relationship between electricity consumption and time of electricity usage. In contrary, Adam et al. (2013) posited that there was a clear negative relationship and association between home appliances and the selection of electricity as a household energy source. However, previous study by De Vita et al. (2006) submitted that homes that have room heaters and wood burners have more tendency to use electricity. Their study posited that number of electrical appliances in homes is a strong driver of household electricity consumption. Al-Majali (2004) estimated the electricity demand function for electricity and found a non-significant relationship between electricity per capita consumption and electricity price for the household sector. This finding was in consonance with the studies of De Vita et al. (2006) and Ziramba (2008). However, this finding disagreed with the study done by Adegoriola and Agbanuji (2020) where they noted in their study that variations in electricity prices do not affect electricity demand. They however, findings from their study posited that household income has a strong relationship with household electricity demand.

Similar studies that linked household disposable income to electricity

consumption were that of Athukorala and Wilson (2009) and Ngutsav and Aor (2014). Rajagopal and Fischer (2013) who in their studies on the determinants that drive residential electricity consumption in China revealed that household monthly income was among the major determinants of residential electricity consumption. They posited that this variable have direct and significant relationship with residential electricity consumption. Ingelesi-Lotz and Pouriz (2016) observed that income and household economic input were significant factors that are associated with household electricity demand in South Africa. Adam et al. (2013) had similar findings in their study in Ghana.

Similarly, Gram-Hanssen (2011) in his study on the explanatory variables that influence household energy consumption in Denmark revealed that households income, the presence of teenagers (12–25 years) in a house and size of the building all have positive effect on electricity consumption. This was corroborated by the study of Wiesmann et al. (2011) where they investigated the link between household electricity consumption and the dwelling characteristics in Portuguese electricity consumers. They found out that, aside electrical appliance ownership, house area has positive influence on per capita electricity consumption. This was similar to the findings of Dimitra and Polychrondou (2021). Other studies that had similar results were that of Tewathia (2014) where they found out that weather and physical characteristics of residential area have positive relationship with household electricity demand.

Esmaeilimoakher et al. (2016) and Aqilah et al. (2021) revealed also that the number of users of electrical appliances, size of houses and educational level were major drivers in influencing the monthly electricity consumption in his study. Aqilah et al. (2021) in their study done in Delhi, India observed that highly educated families consume more electricity than the less educated ones. This finding corroborates with the findings by Mensah and Adu (2013); Laureti and Secondi (2012); and Jones et al. (2015). On the contrary, Sanquist et al. (2012) in their study found out that variables like marital status, the dwellings size, educational level, sex, and number of rooms were not found to have significant impact in energy consumption. However, they noted that the usage of electricity energy was less intense among the younger people than the older ones. Furthermore, previous studies such as ones done by Jumbe and Angelsem (2010) and Nlom and Karimov (2014) proved there was no relationship between electricity consumption behaviour and sex of the household head. Further findings by a logit analysis done by Danlami et al. (2016) show that there was actually a negative relationship between household electricity consumption pattern and a households' head's gender.

However, these studies reviewed above focused mainly on the interaction between some household physio-economic exploratory variables and household electricity consumption on macro level with aggregated data elicited either at the national or State level. More so, very few number of exploratory variables were considered in these studies. The study of this relationship at the micro level has been lacking in the body of literature. To the best of the authors' knowledge, these factors have not been investigated at micro level in the emerging cities of Nigeria. This is an aspect of the existing research gap the present study attempted to fill.

4. Methodology

The study adopted the multistage cluster area sampling method in selecting the electricity household consumers who made use of installed prepaid metering within the five major cities in Nigeria including the national capital, Abuja. The cities were Abuja, Lagos, Enugu, Kano and Ibadan. These cities spread across five geographical region of the country. The choice of these cities was apt because they are ancient and densely populated towns, and according to the National Population Commission (NPC, 2007), these cities have the highest percentage of households in their regions and had high rate of electricity consumers that are connected to the national grid. The use of cluster sampling techniques in the study was because there were no available sample frame containing the list of households that use the prepaid meters in the study areas. As argued by some scholars (Rao, 2009; Sekaran, 2003; OECD, 2007), this sampling techniques is apt where there are absence of accurate and complete list of the universal elements under study. Aside the clustering of the country into geopolitical regions, the selected five cities were then clustered into residential densities—high, medium and low. High density residential areas are always characterized with relatively smaller plot sizes of between 450 to 500 square meters per plots. Most buildings in this area are mainly tenements house type and few block of flats. Most times, this residential area is mostly resided by the low-income earners. The Low-density residential areas, on the other hand, have bigger plots of between 650 to 700 square meters per plot and are mainly occupied by the high-income earners with bungalows characterizing the area. It's mostly one building per compound unlike the high-density residential plots that mostly house more than a building per plot. The medium density residential areas are mainly occupied by middle income-earners with block of flats pronounced in this area. In the third stage of clustering, five neighborhoods were randomly selected from each of the residential density in each city. 15 neighborhoods were chosen from each of the cities, thus a total of 75 neighborhoods were used for the study. According to Kothari (2004) and Saunders et al. (2009), researchers can randomly select clusters to represent entire area. Purposive sampling technique was then used to select households that used prepaid-metering in the study areas. The choice of households with prepaid metering was to avoid electricity consumers that are billed by estimation which was characterized with the non-prepaid meter users. It is normal in Nigeria cities for buildings especially newly built ones not to have electricity meters and they are billed by estimation by the electricity distribution companies. This is common for many buildings in Nigeria city (Ngutsav and Aor, 2014). Simple random sampling techniques was finally used to select the respondents.

The study employed Cochran sample size determination formula as seen in Equation (1) since it has infinite population. Mathematically, the formula is expressed as

$$n = \frac{Z^2 p(100 - p)}{X^2} \tag{1}$$

where

Z = Confidence level,

X = precision (percent),

p = Estimated proportion population
n = Sample size

The estimated sample size for the survey was 726. This was based on 1.64 confidence level (on critical value at 90%), 5 percent precision and 50 percent estimated proportion population. Although the minimum calculated sample size for the study was 726, in order to accommodate incomplete and invalid questionnaires, 797 copies of the questionnaire were administered in the study. A total of 71, representing 10% of the calculated sample size was added to accommodate for non-responses, invalid or lost questionnaires. This was similar to the works of Cooper and Schindler (2006) and Dipeolu et al. (2021) where they added an extra 11% and 10% of the calculated sample size, respectively, to the already determined sample size in their studies. This translated to a minimum sample size of 797 respondents in this study. Out of the 797 copies of questionnaire administered to household head, 778 copies, representing 97.6% response rate were retrieved and used in the analysis (see **Table 1**).

Table 1. Distribution of questionnaires in the various cities.

S/N	Cities	*Population	Questionnaire distributed	Distribution retrieved
1	Abuja	590,400	80	80
2	Lagos	9,000,000	272	262
3	Enugu	688,862	90	89
4	Kano	3,626,068	188	184
5	Ibadan	3,565,108	167	163
Total		17,470,438	797	778

Source: WPP, 2023. /Authors' fieldwork, 2023.

Data were primarily collected with copies of questionnaires structured mainly at interval measurement scale for robustness and better statistical interpretation. Some of the variables used are dummy variables. The questions in the questionnaire were framed in simple English Language to ensure that they were easily understood by the respondents. Before the survey, the questionnaire was pre-tested among a few respondents during a pilot survey. The pilot survey helped the researchers ensure that the users of the electricity have comparable standards of assessment. The questionnaire survey was conducted between September 2022 and August 2023. This period covers all the weather season in the country. The survey was conducted by the researchers and employed research assistants. The research assistants were engaged in the counting and administration of the questionnaires in each of the sample area and helped to interpret the content of the questionnaire to respondents that were not able to read and write. They also helped in measuring the area of any building that was sampled in other to get data on the size of the building. The administration and retrieval of copies of the questionnaire were done on weekdays between 10 a.m. and 1 p.m. and between 8 a.m. and 1 p.m. on weekends. This is in line with the methods adopted by Idiowu and Adaji (2020). The questionnaire was administered face-to-face to ensure that sampling across the respondents represented different education, professional backgrounds and gender.

Multiple linear regression was used to test whether there was a significant relationship between Household Electricity Consumption [HHEC] and household Socio-economic characteristics in the study area. The choice of the independent variables in this study was done based on the specific uniqueness of the study areas.

The implicit form of model that was used was given as seen in Equation (2).

$$HHEC = a + b_1AG + b_2S + b_3ED + b_4IN + b_5AUT + b_6MS + b_7NH + b_8PE + b_9HHS + b_{10}NT + b_{11}HT + b_{12}FEA + b_{13}W + b_{14}SB + b_{15}HL + e \quad (2)$$

where HHEC = Household electricity consumption,
a = constant,
b = co-efficient,
e = Error,
AG = Age [years],
S = Sex,
ED = Education qualification,
IN = Income [naria],
AUT = Appliance Usage Time,
MS = Marital status [1 single.2 married],
NH = Number of hours spent outside your house,
PE = price of electricity,
HHS = household size,
NT = number of teenagers in the house,
HT = House type,
FEA = number of functional electrical appliance used,
W = weather,
SB = Size of building,
HL = House Location.

For the purpose of this analysis, the variable with more than two categories were recoded into two categories and this made them dummy variables. For instance, respondents who had educational qualification lower than primary school education were grouped as illiterates while those that attended primary school and above were regarded as literates coded '0' and '1' respectively. All other exploratory variables were also coded as binary variable, either 0 or 1. For instance, sex has either male or female; house type is either permanent or temporary; weather is either dry or wet season; marital status is either single or married. House location is either planned coded as 0 or unplanned area coded as 1. Instances of respondents who were either widows or divorcee, were graded under married for the purpose of this study. Variables like age, household size, price of electricity and appliances usage time are collected as continuous variable. Data on size of building were derived through measurement. Data processing and analysis for this study were performed using the Statistical Products and Services Solutions (SPSS) 22 for windows for statistical analysis of the quantitative data.

The internal consistency of the variables was tested with Cronbach Alpha. A score of 0.82 was made and this is accepted since the common threshold of 0.7 is acceptable. However, only 769 copies of questionnaires which were corrected filled were used in the study.

5. Results

5.1. Socio-economic and demographic of the respondents

The study revealed the respondents' age, educational status, and occupation, marital status, household size (family members), sex, monthly income and other demographical characteristics of the respondents as presented in **Table 2**.

Table 2. Some demographic data of the respondents, *N* = 778.

S/N	Characteristics	Percentages
1.	Gender	Male (63.4%), Female (35.6%)
2.	Age	<20 (1.0%), 20–29 (22.0%), 30–39 (18.0%), 40–49 (14.0%), 50 + (45.0%)
3.	House type	Temporary (31.7%), Permanent (67.3%)
4.	Education status	No formal education (1.1%), primary school (9.3%), Secondary school (59.9%), Above Secondary school (29.7%)
5.	Occupation of Respondents	Unemployed (13.7%), Employed (65.3%), Retired (21%)
6.	Average Annual Income	<50,000 (9.8%), 50,000–100,000 (36.1%), 135,000–200,000 (42.1%), Above 200,000 (12%)
7.	Average hours spent outside	<5 (31.7%), 5–8 (35.6%), 9–15 (22.8%), 16+ (9.9%)
8.	Marital status	Married (81.7%), single (8.3%), widows (6.0%), divorcees (4.0%)
9.	No of teenagers at home	<2 (36.1%), 2–4 (27.8%), Above 4 (36.1%)
10.	Average daily appliance usage time (hours)	<3 (12.2%), 3–5 (34.4%), 5–8 (20.7%), Above 8 (32.7%)

Source: authors' fieldwork, 2023.

The study shows that 53.4% of the respondents are male, while 45.6% are female. This shows a gender-balanced representation in the study areas. The influence of men in the family may also be the reason for larger number of men in the study area. Shafiu et al. (2021) remarked that it is the culture of Nigerian women to always keep questionnaires till their husbands return in order to get consent to answer the questions in the questionnaire.

The study revealed that about 88% of the respondents in the survey were low-income earners. This distribution accentuates the dominance of the 135,000–200,000naira income brackets, indicating a diverse range of income levels among the surveyed population. The study shows that the largest portion, constituting 45.0% of the participants, fall within the 50+ age category, highlighting the presence of older individuals. Following this, 22.0% are in the 20–29 age range, indicating a substantial representation of young adults. Moreover, 18.0% belong to the 30–39 age group, while 14.0% are situated within the 40–49 range. Notably, 1.0% of respondents are under 20 years old. This distribution sheds light on the prominence of respondents in their fifties and twenties, it could then be presumed that the respondents have the tendency and capacity to understand the contents of the questionnaires. The study further revealed the educational attainment of the respondents. **Table 2** notably revealed that majority of the respondents are literates as more than 89.6% had secondary school education and above, only about 11.4% possess lower than secondary school educational qualification. This distribution reinforces the internal validity of the study.

The study, surprisingly, revealed that 36.1% of the respondents use electrical appliances in their home less than 3 h daily. Those that use theirs above 8 h daily were 32.78% of respondents. The study additionally revealed the number of hours respondents stay outside their homes daily. This data were presented in **Table 2**.

5.2. Household electricity consumption determinants

Generally, it was revealed from this research that household electricity consumption in Nigerian cities was significantly linked to the observed socio-economic and physical determinants at 0.01 significant level. This was shown in **Table 3** where the R^2 was 0.824. This implies that the aggregate of the 15 predictor variables (socio-economic and physical variables) influenced household electricity consumption in Nigeria. However, out of the 15 identified socio-economic and physical variables that were used in the study, the parameters that were quite significant were household monthly income, type of house, number of hours that people stay outside the house, number of teenagers at home, hours that electrical appliances are used, weather condition, number of household electrical appliances, age, and the building location as shown in **Table 4**. The results shows that six other exploratory variables, namely: sex, educational attainment, size of the building, marital status, households size, and electricity price were not significant at 0.05 significant level as shown in **Table 4**. Further analysis was carried out where these 6 non-significant determinants were excluded from the analysis, and the result was as shown in **Table 5**. The results show a more robust and reliable model. R^2 was 0.909 as against 0.824 when all the 15 variables were used. Hence, these nine socio-economic determinants were significantly related to household electricity consumption at 0.01 significance level. The result showed a more robust model representation which is actually a contribution to the body of research since no study has been able to give this revealing model, with such number of variables aggregated together.

Table 3. The regression result showing all the predictor variables in the model.

Parameters	**values**
R^2	0.824
Adjusted R^2	0.787
F value	375.67
Error	10.12
P sign	0.000
Significant level	0.01

Source: SPSS regression.

Table 4. Household electricity consumption and socio economic factors.

Variable	***P***	**α-Sign**	**Remarks**
Sex	0.673	>0.01	Not Significant
Education	0.435	>0.05	Not Significant
Age	0.050	<0.05	Significant
Marital status	0.179	>0.05	Not Significant

Table 4. (*Continued*).

Variable	*P*	α-Sign	Remarks
Income	0.000	<0.05	Significant
Appliance usage time	0.043	<0.05	Significant
Households size	0.181	>0.01	Not Significant
No of Teenagers	0.006	<0.01	Significant
House Type	0.012	<0.05	Significant
Number of Appliances	0.016	<0.05	Significant
Weather Effect	0.011	<0.05	Significant
Hour outside Home	0.043	<0.05	Significant
house location	0.045	<0.05	Significant
Size of building	0.879	>0.05	Not Significant
Price of Electricity	0.211	>0.01	Not Significant

Source: SPSS regression.

Table 5. Regression result shown when the six non-significant predictor variables were excluded from the model.

Parameters	values
R^2	0.909
Adjusted R^2	0.862
F value	217.6
Error	3.4426
P sign	0.000
Significant level	0.05

Source: SPSS regression.

6. Discussion

Firstly, it became clear from the analysis that very significant and strong association existed between household electricity consumption and nine out of the fifteen socio-economic and physical determinants used in this study in Nigeria. These nine determinants are namely: age of residents, household monthly income, type of house, number of hours that people stay outside the house, number of appliances, number of teenagers at home, hours that electrical appliances are used, weather, and the location of the building (R^2 = 0.909 significant at 0.05 significant level). This regression result suggests that these determinants accounted for 90.9 percent of the household electricity consumed in Nigeria cities. However, 9.1% of the unexplained variables were not discussed in this study.

The significance influence of marital status on the household electricity consumption rate was not noticed in the study. This shows that the singleness or otherwise of household member does not have effect on the rate of electricity that households demand. This however, disagrees with the finding of Oteh et al. (2017) in this study.

On the other hand, age significantly influenced household electricity consumption in Nigeria cities at 5%. This explains the role of age in determining the

electricity consumption pattern in homes. This finding was in line with the studies of Jones et al. (2015), Esmaeilimoakher et al. (2016) and Filippini and Pachauri (2004) where they found that buildings that have more residents and younger households head had the tendency to consume less electricity from those that had less elder people. Further assertion that agreed with this findings was made by Ndiaye and Gabriel (2011), Bartusch et al. (2012) and Brounen et al. (2012) where they posited that households with youths and children especially those that are of younger ages are found to have a positive effect on per capita electricity consumption.

Furthermore, a rise in income per capita raises the household electricity consumption as found in the study. It was revealed that income was a major propeller for electricity consumption in the cities of Nigeria. This finding provides support to previous studies of Ekpo et al. (2011), Khattak et al. (2010), Adam et al. (2013), Idiowu and Adaji (2020) where they all found out that the rising income level has a direct and significant link with increased usage of household electrical appliances. However, Ubani (2013) has a contrary outcome where he found out that income has a positive, yet insignificant relationship with electricity consumption. Ngutsav and Aor (2014) also contradicted the outcome of this study where their study revealed that household income has negative effect on electricity consumption in their study area. Generally, these contradicting results from these studies may be due to the few number of explanatory variables that were used at the macro level in those studies.

Again, according to this study, the average number of electrical appliances and the hours they are used were found to positively impact the household electricity consumption in Nigeria. This implies that electricity consumption rate will increase as there is corresponding increase in the number of hours that electrical appliances are used at homes. This is expected and normal. This outcome is sync with the studies of Tewathia (2014), Danlami (2017), Wiesmann et al. (2011) who recorded significant and positive relationship among electrical appliances, frequency of its usage and electricity consumption.

The study equally shows that weather positively and significantly affect household electricity consumption rate. This is expected because it is always natural that cold weather result in households using heater and other heating appliances to warm the environment. Study done by Jovanovi et al. (2015) and Blázquez et al. (2013), corroborate this result where the findings of their studies showed a significant relationship between weather and household electricity usage. Other factors that indicated significant and positive relationship with household electricity demand found in the study were the number of hours people stay outside their homes as well as the location of houses (either in an unplanned—slum, or planned areas). Expectedly, it was revealed that as people stay outside the houses more often, it decreases the consumption of electricity at home. As par the influence of the location of building on electricity consumption, studies of Sena et al (2021), Abbasi et al. (2020) and Zhuang et al. (2022) posited that planned urban areas, due to the economic vitality, increases energy consumption than in slummy areas. This assertion which agrees with the findings of this study contradicts the findings of Qiao and Liu (2020) and Soydan (2020) where they submitted that electricity consumption is reduced in planned built environment due to the presence of energy-

saving home electrical appliances common in this areas. However, in the study area, mainly in the high density areas, most compounds which are characterized with tenements house types have many houses in them, this invariably attracts more electricity consumption. Again, contrary to the finding of this study that shows a non-significant relationship between size of building and electricity consumption, the study done by Gram-Hanssen (2011) and Laureti and Secondi (2012) concluded that there was a positive relationship between the size of homes and the adoption of electricity as their source of energy. They concluded that this relationship did exist due to many number of possible electrical appliances that are present in most of the rooms in the building. This is not true in most Nigeria cities where residents are known to have big houses but would prefer to have a central television in the living room especially during the recent period of the prepayment electricity metering system (Onisanwa and Adaji, 2020).

The core limitation of this study is the insufficiency of the explanatory variables that could influence household electricity consumption in Nigeria. Further research should increase more variables to get more robust results. This will give an answer to the unexplained variables in the model. Again, the respondents were only households that used the digitalized pre-payment metering system. The need to elicit information from household electricity consumers that use both the digital and analogue metering will improve the quality of the research as well as provide better information on the structure of household electricity in Nigeria.

7. Research implication/conclusion

The present research investigated the determinants of household electricity consumption in Nigeria. Based on the findings, it can be concluded that age, household monthly income, weather, number of hours that people stay outside the house, number of teenagers at home, number of appliances, type of house, hours that electrical appliances are used, and the location of the building influenced significantly household electricity consumption in Nigeria. Secondly, sex, price of electricity, size of the building, marital status, number of households per capita, and educational attainment, exerted insignificant influence on demand for electricity in homes in Nigeria. The findings of the study hold the potential for guiding electricity energy designers and managers of electricity energy towards emphasizing key factors in their distribution and planning.

These findings have some noteworthy implications. Firstly, the robust identification and analysis of these significant variables revealed in the study will aid energy policy makers in the country to evolve more reliable policies on household electricity consumption since these determinants identified in this study were elicited at the household levels. This will help in the making of an empirically based Nigeria electricity reform. There have been few analysis of study done in this subject in Nigeria, but none has been able to aggregate and combine all these variables that were used in this research. This aggregate combination of these variables gave rise to the robust statistical result that was generated in the study.

The study, therefore, recommends polices aimed at providing reliable and steady electricity supply mainly at residential areas by encouraging the government

to factor in those significant variables that were identified in the study during her residential electricity power reform. Furthermore, government should encourage the citizens to regularly renovate their houses so as to reduce the house temperature, thereby reducing the use of appliances like heater. The use of new technology energy appliance that consumes less current should also be encouraged.

Next, policies that will empower the citizens economically should be aggressively pursued, this will help place the households in the position to afford less energy consuming electrical appliances. There is the need also for the government to further pursue policies that will increase employment. The current integration of the informal home-based activities into the formal urban planning policies and practices by the government and economic stakeholders in the country's economic sphere should be sustained. This is to stabilize the economic base of most households especially that of the urban poor.

The result of this study has the capacity to solve the continuous electricity supply challenges noticed in most Nigeria residential cities since it has given energy and urban planners an empirical basis for accurate and robust forecasting of the determinants that influence household electricity consumption in Nigeria that is devoid of any speculation or unfounded predictions.

Author contributions: Conceptualization, OU; methodology, OU, CSA, EI and EM; software, OU; validation, OU, CSA, EI and EM; formal analysis, OU; investigation, OU, CSA; resources, OU, CSA, EI, PIO and EM; data curation, EI; writing—original draft preparation, OU, EI; writing—review and editing, OU, CSA, EI, PIO and EM; visualization, OU; supervision, EE, OU, CSA; project administration, CSA; funding acquisition, OU, CSA, EI, PIO, EE and EM. All authors have read and agreed to the published version of the manuscript.

Data availability statement: On behalf of all the authors, the corresponding authors state that our data are available upon reasonable request.

Conflict of interest: The authors declare no conflict of interest.

References

Abbasi K, Hussain K, Abbas J, Adedoyin N (2020). Analysing the role of industrial sectors' electricity consumption, prices and GDP. A modified empirical evidence from Pakistian. AIMS Energy 9(1): 29-49.

Adam FW, Brew-Hammond A, Essandoh EO (2013). Relationships between energy use and income levels, for households in Ghana. European Scientific Journal 9(16): 233-245.

Adegoriola AE, Agbanuji DA (2020). Impact of Electricity Consumption on Economic Growth in Nigeria. Theijhss 8(5). doi: 10.24940/theijhss/2020/v8/i5/hs2005-034

Al-Majali K (2004). The Demand for Electrical Energy in Jordan During the Period (1975-2002). Department of Economics, Mu'tah University.

Aqilah N, Zaki SA, Hagishima A, et al. (2021). Analysis on electricity use and indoor thermal environment for typical air-conditioning residential buildings in Malaysia. Urban Climate 37: 100830. doi: 10.1016/j.uclim.2021.100830

Athukorala PPAW, Wilson C (2010). Estimating short and long-term residential demand for electricity: New evidence from Sri Lanka. Energy Economics 32: S34-S40. doi: 10.1016/j.eneco.2009.08.005

Aydinalp Koksal M, Rowlands IH, Parker P (2015). Energy, cost, and emission end-use profiles of homes: An Ontario (Canada) case study. Applied Energy 142: 303-316. doi: 10.1016/j.apenergy.2014.12.077

Azhgaliyeva D, Liu Y, Liddle B (2020). An empirical analysis of energy intensity and the role of policy instruments. Energy Policy 145: 111773. doi: 10.1016/j.enpol.2020.111773

Babatunde I, Shuaibu S (2009). The demand for residential electricity in Nigeria: A bound testing approach. Energy Economics 21-27.

Babatunde M, Enehe J (2011). Determinants of household electricity demand in Nigeria. Econ Financial Review 49(2): 73-97.

Bartusch C, Odlare M, Wallin F, Wester L (2012). Exploring variance in residential electricity consumption: Household features and building properties. Applied Energy 92: 637-643. doi: 10.1016/j.apenergy.2011.04.034

Bedir M, Hasselaar E, Itard L (2013). Determinants of electricity consumption in Dutch dwellings. Energy and Buildings 58: 194-207. doi: 10.1016/j.enbuild.2012.10.016

Blázquez L, Boogen N, Filippini M (2013). Residential electricity demand in Spain: New empirical evidence using aggregate data. Energy Economics 36: 648-657. doi: 10.1016/j.eneco.2012.11.010

Brounen D, Kok N, Quigley JM (2012). Residential energy use and conservation: Economics and demographics. European Economic Review 56(5): 931-945. doi: 10.1016/j.euroecorev.2012.02.007

CBN (2017). Central Bank of Nigeria Statistical Bulletin.

CBN (2022). Central Bank of Nigeria Statistical Bulletin.

Coppel G, Wüstemann H (2017). The impact of urban green space on health in Berlin, Germany: Empirical findings and implications for urban planning. Landscape and Urban Planning 167: 410-418. doi: 10.1016/j.landurbplan.2017.06.015

Danlami A (2017). Determinants of Household electricity consumption in Bauchi, Nigeria. Hyperion Economics Journal 5(1): 16-28.

De Vita G, Endresen K, Hunt LC (2006). An empirical analysis of energy demand in Namibia. Energy Policy 34(18): 3447-3463. doi: 10.1016/j.enpol.2005.07.016

Dimitra K, Polychrondou P (2021). Determinants of household electricity consumption in Greece: A Statistical analysis. Journal of Innovation and Entrepreneurship 6(3): 56-64.

Dipeolu AA, Ibem EO, Fadamiro JA (2021). Determinants of residents' preferences for Urban Green infrastructure in Nigeria: Evidence from Lagos Metropolis. Urban Forestry & Urban Greening 57: 126931. doi: 10.1016/j.ufug.2020.126931

Ekpo UN, Chuku CA, Effiong EL (2011). The dynamics of electricity demand and consumption in Nigeria: Application of the bounds testing approach. Current Research Journal of Economic Theory 3(2): 43-52.

Esmaeilimoakher P, Urmee T, Pryor T, Baverstock G (2016). Identifying the determinants of residential electricity consumption for social housing in Perth, Western Australia. Energy and Buildings 133: 403-413. doi: 10.1016/j.enbuild.2016.09.063

Filippini M, Pachauri S (2004). Elasticities of electricity demand in urban Indian households. Energy Policy 32(3): 429-436. doi: 10.1016/S0301-4215(02)00314-2

Gram-Hanssen K (2011). Households' Energy Use—Which is the More Important: Efficient Technologies or User Practices? Linköping Electronic Conference Proceedings. doi: 10.3384/ecp11057992

Huang WH (2015). The determinants of household electricity consumption in Taiwan: Evidence from quantile regression. Energy 87: 120-133. doi: 10.1016/j.energy.2015.04.101

Iloeje NP, Onokala PC, Odemeho FO (2002). Basic Geography Course for Senior Secondary Schools 2. Longman Nigeria Plc 2002.

Inglesi-Lotz R, Pouris A (2016). On the causality and determinants of energy and electricity demand in South Africa: A review. Energy Sources, Part B: Economics, Planning, and Policy 11(7): 626-636. doi: 10.1080/15567249.2013.801536

International Energy Agency (2020). Electricity final consumption by sector, Greece 1990-2018. Available online: https://www.iea.org/data-and- statistics?country=GREECE&fuel=Electricity%20and%20heat&indicator=ElecConsBySector (accessed on 19 Octobert 2020).

Islam MM, Hasanuzzaman M (2020). Introduction to energy and sustainable development. Energy for Sustainable Development 1-18. doi: 10.1016/b978-0-12-814645-3.00001-8

Jones RV, Fuertes A, Lomas KJ (2015). The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings. Renewable and Sustainable Energy Reviews 43: 901-917. doi: 10.1016/j.rser.2014.11.084

Jovanović S, Savić S, Bojić M, et al. (2015). The impact of the mean daily air temperature change on electricity consumption. Energy 88: 604-609. doi: 10.1016/j.energy.2015.06.001

Jumbe CBL, Angelsen A (2011). Modeling choice of fuelwood source among rural households in Malawi: A multinomial probit analysis. Energy Economics 33(5): 732-738. doi: 10.1016/j.eneco.2010.12.011

Kavousian A, Rajagopal R, Fischer M (2013). Determinants of residential electricity consumption: Using smart meter data to examine the effect of climate, building characteristics, appliance stock, and occupants' behavior. Energy 55: 184-194. doi: 10.1016/j.energy.2013.03.086

Khattak NUR, Tariq M, Khan J (2010). Determinants of household's demand for electricity in district Peshawar. European Journal of Social Sciences 14(1): 7-16.

Kim MJ (2018). Characteristics and determinants by electricity consumption level of households in Korea. Energy Reports 4: 70-76. doi: 10.1016/j.egyr.2017.12.001

Kostakis I (2020). Socio-demographic determinants of household electricity consumption: Evidence from Greece using quantile regression analysis. Current Research in Environmental Sustainability 1: 23-30. doi: 10.1016/j.crsust.2020.04.001

Kothari C (2004). Research Methodology: Methods and Techniques, 2nd ed. New Age international (P) Limited Publishers.

Kwakwa P (2018). Analysis of the determinants of electricity consumption in Benin. Journal of Energy Management and Technology 2(3): 42-59.

Latham & Watkins Africa Practice (2016). Nigeria Power Sector: Opportunities and Challenges for Investment in 2016. Client Alert white paper.

Laureti T, Secondi L (2012). Determinants of households' space heating type and expenditure in Italy. International Journal of Environmental Research 6(4): 1025-1038.

McLoughlin F, Duffy A, Conlon M (2012). Characterising domestic electricity consumption patterns by dwelling and occupant socio-economic variables: An Irish case study. Energy and Buildings 48: 240-248. doi: 10.1016/j.enbuild.2012.01.037

Meher S (2019). Estimating and forecasting residential electricity demand in Odisha. Journal of Public Affairs 20(3). doi: 10.1002/pa.2065

Mensah T, Adu G (2013). An Empirical Analysis of Household Energy Choice in Ghana. Uppsala Working Paper series.

MoN (2022). Available online: https://maps-nigeria.com/ (accessed on 19 October 2022)

Narayan PK, Smyth R, Prasad A (2007). Electricity consumption in G7 countries: A panel cointegration analysis of residential demand elasticities. Energy Policy 35(9): 4485-4494. doi: 10.1016/j.enpol.2007.03.018

National Population Commission (2007). Nigeria Census Gazette, Abuja.

Ndiaye D, Gabriel K (2011). Principal component analysis of the electricity consumption in residential dwellings. Energy and Buildings 43(2-3): 446-453. doi: 10.1016/j.enbuild.2010.10.008

Ngutsav A, Aor R (2014). Analysis of determinants of electricity consumption in Nigeria. The Nigerian Journal for Energy and Environmental Economics 6(1).

Nlom JH, Karimov AA (2014). Modeling Fuel Choice among Households in Northern Cameroon. UNU-WIDER. doi: 10.35188/unu-wider/2014/759-2

OECD (2007). Glossary of Statistical Terms. OECD.

Onisanwa ID, Adaji MO (2020). Electricity consumption and its determinants in Nigeria. JEM 41: 87-104. doi: 10.22367/jem.2020.41.05

Oteh OU, Ibok IN, Nto CP (2017). Adoption and usage of ebanking channels in Nigeria: Implication for deepening financial inclusion. International Business and Management Journal 14(3): 1-8.

Pachauri S, Jiang L (2008). The household energy transition in India and China. Energy Policy 36(11): 4022-4035. doi: 10.1016/j.enpol.2008.06.016

Qiao R, Liu T (2020). Impact of building greening on building energy consumption: A quantitative computational approach. Journal of Cleaner Production 246: 119020. doi: 10.1016/j.jclepro.2019.119020

Rao R (2009). Area Sampling (Market Research). Available online: http//www.citeman.com/4713-area-sampling-market-research (accessed on 7 February 2017).

Sakah M, de la Rue du Can S, Diawuo FA, et al. (2019). A study of appliance ownership and electricity consumption determinants in urban Ghanaian households. Sustainable Cities and Society 44: 559-581. doi: 10.1016/j.scs.2018.10.019

Sanquist TF, Orr H, Shui B, Bittner AC (2012). Lifestyle factors in U.S. residential electricity consumption. Energy Policy 42: 354-364. doi: 10.1016/j.enpol.2011.11.092

Sarkodie SA, Adom PK (2018). Determinants of energy consumption in Kenya: A NIPALS approach. Energy 159: 696-705. doi: 10.1016/j.energy.2018.06.195

Saunders M, Lewis P, Thornhill A (2009). Research Methods for Business Students, 5th ed. Pearson Education.

Sekaran U (2003). Research methods for business: A skill building-approach, 4th ed. John Willy & Sons, Inc.

Sena B, Zaki SA, Rijal HB, et al. (2021). Determinant Factors of Electricity Consumption for a Malaysian Household Based on a Field Survey. Sustainability 13(2): 818. doi: 10.3390/su13020818

Shafiu A, Ashiru B, Sunday KH, Muhammad A (2021). Determinants and constraints to outdoor recreation participation in Nasarawa Local Government, Kano metropolis, Sokoto. Journal of the Social Sciences 11(2): 49-72.

Soydan O (2020). Effects of landscape composition and patterns on land surface temperature: Urban heat island case study for Nigde, Turkey. Urban Climate 34: 100688. doi: 10.1016/j.uclim.2020.100688

Tewathia N (2014). Determinants of the household electricity consumption: A case study of Delhi. International Journal of Energy Economics and Policy 4(3): 337-348.

Tully S (2006). The Human Right to Access Electricity. The Electricity Journal 19(3): 30-39. doi: 10.1016/j.tej.2006.02.003

Ubani O (2013). Determinants of the dynamics of electricity consumption in Nigeria. OPEC Energy Review 37(2): 149-161. doi: 10.1111/opec.12004

Ubi PS, Effiom L, O. Okon E, Oduneka AE (2012). An Econometric Analysis of the Determinants of Electricity Supply in Nigeria. IJBA 3(4). doi: 10.5430/ijba.v3n4p72

United Nations (2015). Department of Economic and Social Affairs. Available online: https://sdgs.un.org/goals/goal7 (accessed on 1 August 2016).

Wiesmann D, Lima Azevedo I, Ferrão P, Fernández JE (2011). Residential electricity consumption in Portugal: Findings from top-down and bottom-up models. Energy Policy 39(5): 2772-2779. doi: 10.1016/j.enpol.2011.02.047

World Energy Council (2016). Electricity use per household | Electricity Consumption Efficiency| WEC. Available online: https://wec-indicators.enerdata.net/xls/household-electricity-use.xls (accessed on 26 February 2018).

WPP (2023). Available online: https://population.un.org/wpp/ (accessed on 12 October 2023).

Zaman K, Khan MM, Ahmad M, Rustam R (2012). Determinants of electricity consumption function in Pakistan: Old wine in a new bottle. Energy Policy 50: 623-634. doi: 10.1016/j.enpol.2012.08.003

Zhuang D, Abbas J, Al-Sulaiti K, et al. (2022). Land-use and food security in energy transition: Role of food supply. Front Sustain Food Syst 6. doi: 10.3389/fsufs.2022.1053031

Ziramba E (2008). The demand for residential electricity in South Africa. Energy Policy 36(9): 3460-3466. doi: 10.1016/j.enpol.2008.05.026