

Electricity Consumption Profile of Urban Households in Nsukka, Enugu State: Implications on Energy Expenditures and Savings

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Abstract

In recent times, the uncontrollably rising global energy consumption has become a global problem with its attendant socio-economic and environmental consequences. Hence, this study utilized linear regression model to examine how households' socio-economic attributes and use of appliances together determine electricity consumption and savings in Nsukka metropolis, Enugu state, Nigeria. Socio-economic variables found to have positive and significant effect on electricity consumption were age of working-class respondents, being married, household size, household active members, unemployed household members, prepaid and estimated electricity billing system, monthly income and high electricity supply hours. In terms of electrical appliances, high hours of electronics' use per week, incandescent and LED bulbs usage, high number of bulbs, cooling hours of 9 and above per week, lighting hours of 16 and above and weekly heating hours were positively related to electricity consumption and statistically significant. We suggest that the creation of energy efficiency awareness at the household and educational institution levels should be vigorously pursued. Government should subsidize the prices of energy efficient appliances to encourage purchases by low-income earners. Constant overbilling of estimated and postpaid electricity users, as lamented by respondents in the survey, should be discouraged by electricity providers. This will enable users to conserve energy and not waste energy as revenge tactics for overbilling. The promotion and full deployment of prepaid meters in the study area by electricity providers would go a long way in complementing the efforts for clean development mechanism in Nigeria.

Keywords: Electricity, Nsukka, Energy Expenditures, Clean Energy, Nigeria.

Introduction

Electricity is arguably the most convenient form of energy usage in modern time and a key driver of socio-economic activities in households and other sectors of society. Growth in things that probably results in development depends significantly on adequate and regular access to electricity (Uzoma and Amadi, 2019). Generally, the household consumes the highest amount of total energy generated; this is because of the numerous activities that take place within it and the fact that individuals spend more time at home than in other

sectors. This argument is supported by Electricity Demand Projection by Price Water Coopers in which household electricity consumption was 64% of total electricity generation (PwC 2020). According to The World Bank (2022), Nigeria has population of nearly 214 million people. Thus, electricity generation of meagrely 3,500 megawatts is grossly insufficient (This Day, 2023)

These scenarios suggest that while attempts to improve electric power generation begin to provide the anticipated advantages, effective use of the electric energy that is currently available is still necessary. According to some Nigerian authors, the few Nigerians who have access to electricity utilise it inefficiently (Nnaji et al 2023, Uzoma and Amadi, 2019; Oseni 2015). They went on to say that the government had paid little attention to how energy is used, instead concentrating nearly solely on the production of power. Based on the fact that accessible energy resources are finite, energy-saving has become crucial in all sectors, for most countries to achieve sustainable and steady socio-economic growth (Kotsila and Polychronidou, 2021; Laicane et al 2015). Energy-saving means utilising less energy when it is not required therefore maximizing available energy and minimizing energy depletion. Energy conservation can help to lessen environmental challenges and mitigate the effects of energy shortages.

Nsukka Town in Enugu State is an emerging urban centre coming into the limelight in the last few decades. It has seen continuous influx of people from its hinterlands and beyond and consistent increased socio-economic activities, as well as structural expansions. There are fundamental needs for regular electricity access in households whether in urban or rural settings, ranging from lighting, heating, communication, education, cooking, water-pumping, security, recreation, storage, domestic production etc. According to Enugu Electricity Distribution Company (EEDC) Service Centres Report 2021, about 70% of rural areas of Nsukka are placed on estimated billing methods, while 60 percent, 17% and 13% of the semi-urban and urban areas are placed on prepaid, estimated and postpaid billing systems respectively. These modes of billing systems and other socio-economic variables will definitely impact on the energy consumption and energy- saving capacities of household since the expenditure pattern has been found to be a key variable in energy utilisation. It is imperative to have a thorough understanding of the factors that influence and forecast energy consumption in Nigeria and other emerging nations in order to design suitable energy policies.

Given these scenarios, developing effective energy efficiency policies is critical for Nsukka metropolis and electricity providers. Thus, it is important to look at how urban inhabitants in Nsukka save energy, as encouraging personal energy-saving measures can lower urban residents' needless energy use and improve energy efficiency

It is therefore important to conduct this critical assessment of the electricity demand profile of Nsukka urban households in order to ascertain areas of energy wastages and efficiency improvements. This will also help for necessary projection and planning.

Objectives of the Study

1. To determine socio-economic factors affecting electricity consumption of urban residential consumers in Nsukka area.
2. To examine how electricity consumption expenditure is affected by the use of electrical appliances.
3. To determine electricity billing method necessary for efficient energy use and high energy savings.
4. To contribute to the body of knowledge that would guide effective policy making in the energy sector.

Electricity Consumption Profile in Nigeria

Current electricity generation in Nigeria is inadequate to meet the demand needs of households and businesses; as a result, Nigeria has a low per capita consumption of electricity, 144 kWh in 2019 (World Bank 2021). Nigerian electricity production falls far short of demand with just 12 GW installed and often only one-third of that delivered, which is a major barrier to economic growth. According to United Nations Tracking SDG 7's Energy Progress Report 2022, out of Nigeria's 200 million people, 92 million do not have access to electricity, making it the country with the lowest level of electricity access globally.

In Nigeria, self-generation using filthy diesel generators is quite common; small-scale diesel and petrol generators have a combined capacity of around 14 GW, and approximately half of all energy used is self-generated. This implies a big unmet demand with high economic and environmental costs.

In 2021, the Nigerian government announced that they disbursed over 3.2 billion US dollars to support power supply to Nigerians in the last five years. According to the government, the monies were disbursed to electricity Generating and Distribution companies to acquire equipment, buy meters and improve electricity supply in the country. Yet Nigerians have continued to battle poor power supply (africanews 2022)

Nigeria's ongoing power crisis has impeded industrial progress, limited the expansion and profitability of corporate operations, and had a detrimental effect on the welfare of the country's population. According to the International Monetary Fund 2019 country report on Nigeria, electricity problem causes the Nigerian economy to lose an estimated \$29-billion annually. With respect to electricity consumption, the residential sector has been the major consumer of electricity in Nigeria. Reports have shown steady increase, on the average, in residential energy consumption in Nigeria over the years (figure 1). Figure 2 depicts electricity consumption in Nigeria by sectors in the year 2020. According to the figure, over 58,900 terajoules of electricity representing 59 % of the total consumption were consumed in residences, while other sectors like commercial and public services, and industry are 27 % and 14 % respectively (statistica.com). On the other hand, electrical energy used in commercial and public services reached around 27,300 terajoules, while industrial

consumption stood at approximately 13,700 terajoules. The World Bank predicts that by 2035, the demand for electricity would have increased by a factor of 16.8 as a result of a population expansion and a significant electrification gap (World Bank, 2021).

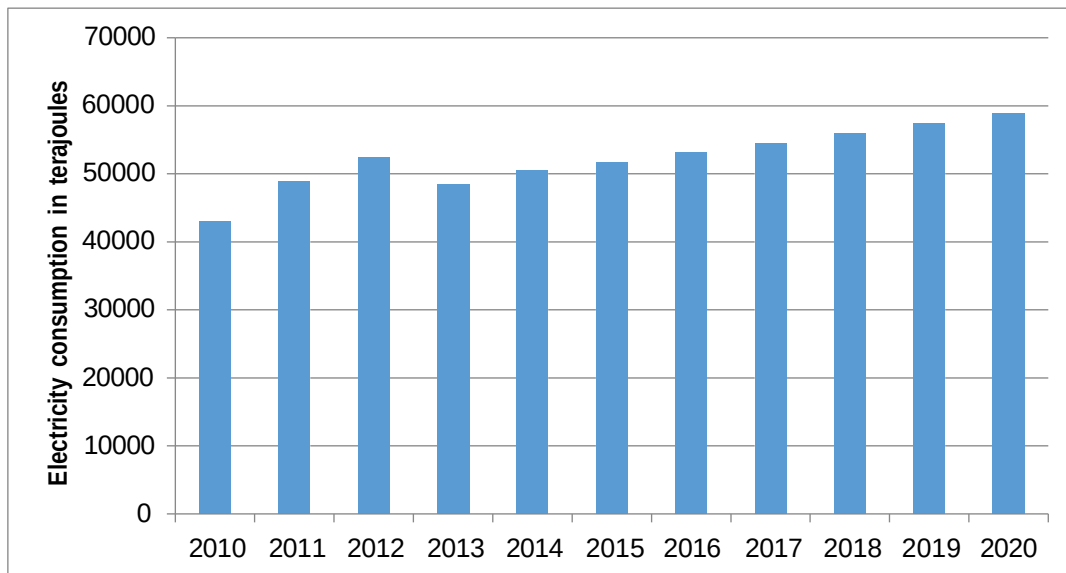


Figure 1: Residential Electricity Consumption in Nigeria (2010-2020)

Source: statistica.com 2023

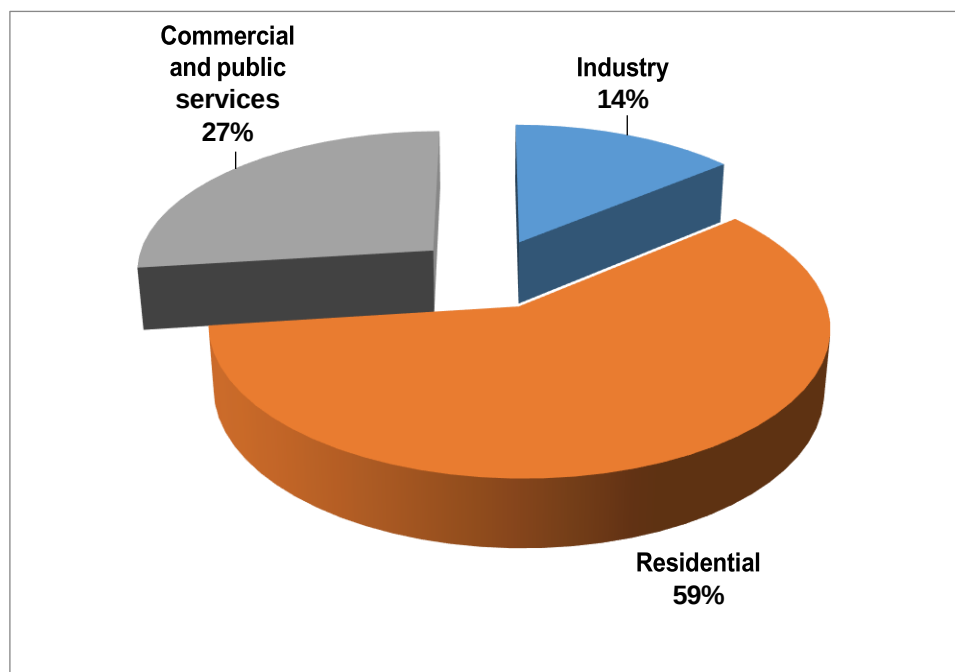


Figure 2: Electricity Consumption in Nigeria by Sectors in 2020

Source: statistica.com 2023

Review of Related Literature

Studies have been carried out on the electricity consumption profile of residential dwellers around the globe. By observing from two perspectives—socioeconomic and direct usage, Noeurn (2021) used an end use model and step-wise linear regression analysis to evaluate the key variables that influence the energy consumption of the residential customer type in Cambodia. The results of the survey's real data showed that the level of income had an impact on the elements that determined how much energy was used. The total monthly income, degree of education, and number of persons per family all strongly influenced how much electricity inhabitants used, according to the regression analysis of socioeconomic characteristics. Comfort appliances used the most energy, accounting for 40.53% of all monthly usage, from a direct-use perspective.

Ordinary least squares (OLS) regression was used by Kotsila and Polychronidou (2021) to estimate the variables influencing household electricity usage in Greece. Two statistical models were created using the data gathered from 1801 homes across all of Greece for this study. Both of them come to the conclusion that the number of residents, the size of the residence, the kind of heating, the hours of heating and cooling, and the weather conditions are the most important factors determining the amount of electricity consumed.

A thorough review of the literature was conducted by Jones et al. (2015) to determine the factors that affect or do not affect home power consumption. They investigate 62 variables as potential influences on how much electricity is used. Higher family income, more inhabitants, and the presence of teenagers all have a positive impact on energy usage in relation to socioeconomic characteristics. The dwelling age, the number of rooms, the number of bedrooms, and the floor space all have an impact on the amount of electricity used. The presence of a desktop computer, television, electric oven, refrigerator, dishwasher, and tumble dryer, as well as the increased use of washing machines and tumble dryers positively impacted on electricity usage.

Esmaeilimoakher et al. (2016) successfully provide an overview of the variables affecting electricity consumption. Their findings are supported by a survey that was carried out in nine Perth, Western Australia, houses. The primary findings are that there is a negative link between the average annual electricity consumption per person per m² floor area (AAEC/P m²) and the number of occupants and the size of the house.

Tewathia (2014) surveyed Delhi residents to examine what factors influence their use of power. The household income, the number and usage of electrical appliances, the size of the home, the number of family members, the amount of time spent away from the home, and the higher educational level affect the monthly electricity consumption in the entire seasons. Higher educated families often use less electricity, hence there is an inverse relationship between education level and electricity consumption.

According to Bedir et al. (2013), the Netherlands' household size, type of housing, and amount of time spent using electrical appliances (such dryers and washing machines) all

significantly affect how much electricity is consumed. Additionally, Brounen et al. (2012) examined data from 300,000 homes in the Netherlands. Electricity usage is influenced by the kind of housing, with detached and semi-detached homes consuming more per person than row homes or apartments. It is discovered that homes with kids, and particularly those with teenagers, have a favorable impact on per capita power use. The number of people living in a household has a negative impact on per capita energy consumption, but income has a favorable impact.

Sanquist et al.'s (2012) study is based on information from the Residential Energy Consumption Survey (RECS), which was carried out in the USA in 2005. The electricity consumption is greatly influenced by the use of the air conditioner, laundry, computers, climate zone of dwelling, and TVs.

Empirical evidence from Nigeria centered mainly on the determinants of electricity consumption at the national or aggregate level with scanty investigation at the micro household-level, while some studies that investigated at the micro level were done years ago at different geo-political zones with limited determining factors and without inclusion for prepaid meters effects on electricity savings (Babatunde and Shuaibu 2008; Ubani 2013; Ebere et al 2018; Babatunde and Enehe, 2011; Ugwoke, et al 2016; Kayode, et al 2013).

This study tries to fill the research gap by providing evidence from a micro-level study of Nsukka urban households with several determining factors at a time of massive deployment of prepaid meters.

Materials and Methods

Data sources

The project data set was based on a survey conducted by the staff of Energy and Environment Unit (EME) of the National Centre for Energy Research and Development, University of Nigeria, Nsukka between late April and mid-May 2023 in which structured questionnaires and oral interviews covering the following items: socio-economic profile, building information, monthly energy bills, number and usage time of household appliances and other pertinent variables were administered to 400 urban households in Nsukka zone of Enugu State. Relevant data were collected using both structured and semi-structured data collection tools. A log-linear regression model as well as descriptive statistics were utilised to analyse the data obtained from the survey.

Model Specification

A log-linear regression model is used to estimate the determinants that affects electricity consumption of urban households in Nsukka, Enugu state. Log-linear regression models are preferred over ordinary least squares (OLS) in situations where the explanatory variables are large in order to handle arbitrary, overlapping features and minimize cases of collinearity in regressions (Rudas 2015, Fienberg 2005). When comparing trends across

groups where the rates are very different, the advantage of a log-linear model is that it makes more sense to compare across widely different scales (Dranove 2012). Another two great advantages of log-linear models are that they are flexible and they are interpretable. In other words, they have natural interpretations in terms of odds and in terms of independence (Rudas 2015)

Model Estimation

The study utilized two models to estimate the socio-economic determinants of electricity consumption as well as the effects of use of electrical appliances on electricity consumption in the study area. Two models were utilized in order to reduce the effects of multicollinearity that may arise from adoption of numerous explanatory variables which may undermine our regression output and make the regression results spurious.

Model 1

We regress all the socio-economic determinants on the log of dependent variable, Electricity Consumption (lnEC), obtaining the following result:

$$EC = \alpha_0 + \alpha_1 A + \alpha_2 MAR + \alpha_3 HS + \alpha_4 AM + \alpha_5 NR + \alpha_6 UM + \alpha_7 MEP + \alpha_8 Y + \alpha_9 SPD + \mu$$

Where A=age of respondent; MAR=marital status; HS=size of household; AM= active members in household; NR=number of rooms; UM=unemployed members; MEP=mode of electricity payment; Y=income of household; SPD=hours of electricity supply per day; α 's are the coefficient of the parameters and μ represents the error term.

Model 2

The use of electrical appliances are regressed on the log of dependent variable, Electricity Consumption (lnEC) obtaining the following result:

$$EC = \beta_0 + \beta_1 EUW + \beta_2 TBU + \beta_3 NB + \beta_4 CHW + \beta_5 LHW + \beta_6 HHW + \epsilon$$

Where EUW= hours of electronics use per week; TBU= types of bulbs; NB=number of bulbs; CHW=cooling hours per week; LHW= lighting hours per week; HHW= heating hours per week; β 's are the coefficient of the parameters and ϵ represents the error term

Table 1: Definition of the explanatory variables for model 1

Explanatory Variables (x_i)	Definition
Age of respondent (dummy)	1=(18-27);2=(28-37); 3=(38-47); 4=(48-57); 5=(58-67) 6=(Above 67)
Marital status of respondent (dummy)	0-Others; 1-Married (dummy)
Size of household (continuous variable)	Number of household members
Number of active members in the household	Continuous variable
Number of rooms in the household	Continuous variable
Number of unemployed adult members	Continuous variable
Mode of payment for electricity consumption	Dummy; 1-prepaid;2-post paid;3-estimation billing
Income of household (dummy)	1=(N10000-N30000);2(N31000-60000);3=(N61000-N90000);4=(N91000-N120000); 5=(Above N120000)
Hours of electricity supply per day(dummy)	1=(0-2);2=(3-5);3=(6-8);4=(above 8 hours)

Table 2: Definition of the explanatory variables for model 2

ExplanatoryVariables (x_i)	Definition
Hours of use of electronics per week (dummy)	1=(0-8);2=(9-15);3=(16-20);4=(above 20)
Types of bulb (dummy)	1= Incandescent;2=CFL; 3=LED
Number of bulbs (dummy)	1=(2-4);2=(5-7);3=(8-10);4=(above 10)
Cooling hours per week (dummy)	1=(0-8);2=(9-15);3=(16-20);4=(above 20)
Lighting hours per week (dummy)	1=(0-8);2=(9-15);3=(16-20);4=(above 20)
Heating hours per week(dummy)	1=(0-8);2=(9-15);3=(16-20);4=(above 20)

Table 3: Summary statistics of some variables in the survey

VARIABLE NAME	N	DISTRIBUTION		%	MEAN
Age of respondents	400	18-27	32	8	
		28-37	68	17	
		38-47	100	25	
		48-57	140	35	
		58-67	52	13	
		Above 67	8	2	
Marital Status	400	Married	302	76	
		Others	98	24	
Size of household	400	Maximum	10		5.1
		Minimum	3		
GENDER	400	Male	306	77	
		Female	94	23	
Number of HH active members	400	Maximum	2		2.3
		Minimum	5		
Unemployed Adults in household	400	Maximum	5		2.6
		Minimum	1		
Number of rooms	400	Maximum			
		Minimum			
Highest level of formal education	400	None	4	1	
		Primary	22	6	
		Secondary	185	46	
		Tertiary	213	48	
Occupation of respondents	400	farming	27	7	
		trading	182	46	
		Civil/pub. servant	169	42	
		others	22	5	
Mode of electricity payment	400	Prepaid	213	53	
		Postpaid	86	22	
		Estimation	101	25	
Monthly electricity expenditure	400	Maximum	12000		4200
		Minimum	2000		

Major needs for electricity (multiple choice)	400	lighting Cooking/heating Cooling Storage Phone-charging Entertainment Education News Food processing Business Others	400 264 363 31 400 400 367 400 24 196 27	100 66 91 31 100 100 92 100 6 49 7	
Average monthly income	400	N10000-30000 N31000-60000 N61000-90000 N91000-120000 Above N120000	32 76 88 92 112	8 19 22 23 28	
Hours of electricity supply per day	400	0-2 3-5 6-8 Above 8 hours	94 184 108 14	23.5 46 27 3.5	
Hours of use of electronics per week	400	0-8 9-15 16-20 Above 20	42 93 186 79	10.5 23.25 46.5 19.75	
Types of bulb	400	Incandescent CFL LED	23 27 350	5.75 6.75 87.5	
Number of bulbs	400	2-4 5-7 8-10 Above 10	56 105 132 107	14 26.25 33 26.75	
Cooling hours per week	400	0-8 9-15 16-20 Above 20	96 101 87 116	24 25.25 21.75 29	
Lighting hours per week	400	0-8 9-15 16-20 Above 20	64 109 68 159	16 27.25 17 39.75	

Heating hours per week	0-8	173	43.25	
	9-15	61	15.25	
	16-20	97	24.25	
	Above 20	69	17.25	

Source: Field survey 2023

Results and Discussions

Results of Model One

The results of model one regression are presented in Table 4. The results from the model are in line with the components of the extant literature. The model explains approximately 58% of the variations in electricity consumption. Even though this model explains more than 50% of the changes in electricity consumption, it still shows that more parameters need to be studied to explore up to 40% of other explanatory variables. However, the estimated R^2 is an acceptable goodness of fit.

The model shows that the age of respondents positively influences the electricity consumption, precisely, the working age group (28-67). It implies that as long as occupants who are in the working class group can foot electricity bill, the more electricity is consumed. To be more specific, if the age group (48-57) increases by 1 unit then an increase of 3.5% is expected in monthly electricity expenditure. This revelation is in agreement with some studies that found the positive effect of age of head of household and working class group on the electricity consumption (Kotsila and Polychronidou, 2021; Bedir et al., 2013; Esmaeilimoakher et al., 2016)

Table 4: Estimation results for model 1

Variable	Definition	Coefficient	Prob
Age(A)	18-27	-0.015	0.203
	28-37	0.062	0.071*
	38-47	0.041	0.040**
	48-57	0.035	0.043**
	58-67	0.018	0.082*
	Above 67	0.009	0.715
Marital status (MAR)	Married	0.011	0.036**
	Others	0.002	0.879
HS	Size of household	0.027	0.068*
AM	Number of HH active members	0.014	0.048**
UM	Unemployed Adults in household	0.022	0.081*
NR	Number of rooms	0.003	0.764
Mode of electricity payment	Prepaid	0.006	0.001***

(MEP)	Postpaid	0.011	0.913
	Estimation	0.032	0.029**
Average monthly income	N10000-30000	-0.004	0.027**
	N31000-60000	0.007	0.638
	N61000-90000	0.021	0.810
	N91000-120000	0.013	0.000***
	Above N120000	0.018	0.025**
Hours of electricity supply per day (SPD)	0-2	0.002	0.098
	3-5	0.005	0.188
	6-8	0.011	0.039**
	Above 8 hours	0.019	0.000***
Constant		3.182	0.089*
R ²		0.589	
Adjusted R ²		0.584	

Note: *p<0.1; **p<0.05; ***p<0.01

Being married was found to be one of the social factors of demand for electricity. The estimated result indicates that being married was statistically significant ($P < 0.05$) and positively associated with expenditure on electricity consumption. This supports the work of Sardianou, 2007 who found that married households have higher responsibilities of increased electricity consumption which come with marriage. This is obvious given that a married respondent could require more energy to carry out daily tasks. The result indicates that if being married increases by 1 unit then an increase of 1.1% is expected in monthly electricity expenditure.

With respect to household size, results show that household size is positive and statistically significant ($p < 0.1$). This indicates that more electricity is consumed as the household size increases. Consequently, there is a positive effect of household size on electricity usage. (Kotsila and Polychronidou, 2021, Kostakis 2020, Bedir et al., 2013; Huang, 2015).

Number of household active members is strongly related with electricity consumption ($p < 0.05$). This implies that increased number of household active members consume more electricity. This is in line with the studies of Polemis & Dagoumas, 2013 and Ndiaye and Gabriel (2011).

Unemployed Adults in household is positive and statistically significant at the 90% level of significance ($p < 0.1$). This may imply that unemployed adults stay at home more often to utilise electrical appliances. This is in agreement with the studies of Kostakis and Carod, 2020, Bedir et al., 2013 and Kotsila and Polychronidou 2021.

Prepaid and estimation modes of electricity payments were found to be positive and statistically significant. However, estimation billing method has a higher level of energy consumption. Specifically, if estimation payment users increase by 1 unit, then an increase of 3.2% is expected in monthly electricity expenditure, while that of prepaid users increase

by only 0.6% if prepaid users increase by one unit. Yisa et al (2022) Ajenikoko and Adelusi (2015) and Malama et al (2014) also found similar evidence in their studies.

Average monthly incomes, from N91000.00 and above were positive and statistically significant. It indicates that high monthly incomes are associated with increase in electricity expenditure. This evidence is in line with the works of Kostakis and Carod (2020), Kotsila and Polychronidou (2021), Nnaji et al (2023) Wiesmann et al., (2011) and Bedir et al., (2013). With respect to hours of electricity supply per day, results show that it is positively related to electricity consumption. However, only supply hours of 6-8 hours and above 8 hours were statistically significant. It implies that higher hours of electricity supply impacts positively and significantly on electricity expenditure.

Results of model 2

Table 5: Estimation results for model 2

Variable	Definition	Coefficient	Prob
Hours of use of electronics per week (EUW)	0-8	0.004	0.742
	9-15	0.007	0.989
	16-20	0.012	0.041**
	Above 20	0.021	0.000***
Types of bulb (TB)	Incandescent	0.030	0.067*
	CFL	0.022	0.874
	LED	0.005	0.032**
Number of bulbs (NB)	2-4	0.004	0.577
	5-7	0.013	0.092*
	8-10	0.018	0.044**
	Above 10	0.022	0.000***
Cooling hours per week (CHW)	0-8	0.014	0.545
	9-15	0.017	0.038**
	16-20	0.023	0.040**
	Above 20	0.035	0.031**
Lighting hours per week (LHW)	0-8	0.006	0.799
	9-15	0.008	0.187
	16-20	0.011	0.003***
	Above 20	0.014	0.028**
Heating hours per week (HHW)	0-8	0.018	0.033**
	9-15	0.023	0.066*
	16-20	0.039	0.091*
	Above 20	0.046	0.037**
Constant		4.829	0.042**
R ²		0.511	
Adjusted R ²		0.499	

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5 lists the outcomes of model two regression. The model's output agrees with the elements of the body of existing literature. About 50% of the fluctuations in electricity consumption are explained by the model.

Hours of use of electronics per week (EUW) were found to be positively related to electricity consumption. Only consumption hours per week from 16 hours and longer, nevertheless, were statistically significant. These findings are in line with the work of Noeurn (2021) and Kotsila and Polychronidou (2021).

On the issue of types of bulbs, the use of incandescent bulbs and LED bulbs were found to be positively related and statically significant. If the use of incandescent bulbs increase by 1 unit, then electricity consumption is expected to increase by 3% while electricity consumption is expected to increase by 0.5% if the use of LED bulbs increase by 1 unit.

Cooling hours of 9 hours and above per week have a positive significant effect on electricity consumption expenditure. This is in agreement with the work of Kotsila and Polychronidou (2021).

The number of bulbs from 5 and above have a positive significant effect on electricity consumption implying that using high number of bulbs will lead to increase in electricity consumption expenditure. This finding is in line with the work of Laicane (2015).

Lighting hours per week (LHW) were found to be positively related to electricity consumption. However, only consumption hours from 16 and above were found to be statistically significant. This implies that only longer duration of lighting will have significant effect on electricity consumption expenditure. Sanquist et al. (2012); Ndiaye & Gabriel (2011) also found similar results in their findings.

With respect to heating hours per week, results show that they are positive and statistically significant. As the heating hours increases, the coefficients also increase indicating that more electricity is consumed as the heating hours increases. As a result, heating hours have a positive impact on electricity consumption (Kotsila and Polychronidou, 2021, Bedir et al., 2013; Brounen et al., 2012; Ndiaye & Gabriel, 2011).

Electricity Billing Systems and Energy Use

Table 6: Cross tabulation of mode of electricity payment and cooling hours per week

		MEP * CHW Crosstabulation				
		Count				
		CHW				Total
		0-8	9-15	16-20	Above 20	
MEP	prepaid	78	74	41	20	213
	postpaid	11	17	22	36	86
	estimation	7	10	24	60	101
Total		96	101	87	116	400

Table 7: Cross tabulation of mode of electricity payment and heating hours per week

Count		HHW				Total
		0-8	9-15	16-20	Above 20	
MEP	prepaid	159	26	19	9	213
	postpaid	5	15	38	28	86
	estimation	9	20	40	32	101
Total		173	61	97	69	400

Table 8. Cross tabulation of mode of electricity payment and types of bulb

Count		TB			Total
		INCAND	CFL	LED	
MEP	prepaid	0	0	213	213
	postpaid	8	10	68	86
	estimation	15	17	69	101
Total		23	27	350	400

Table 6 to table 8 explores the relationship between electricity billing systems and some electricity use parameters. Table 6 depicts cross tabulation of electricity billing systems and cooling hours per week. The table reveals that most prepaid meter users (71%) utilise from 0 to 15 hours as cooling hours per week while majority of other electricity billing systems (postpaid—67%) and estimation (83%) cooling hours per week is from 16 hours and above implying that other users apart from prepaid users are high energy consumers. Prepaid meters are in the form of pay-as-you use and thus, users would tend to minimise energy bill. Information from prepaid meter users in the course of the survey revealed that they are cautious of their electricity consumption and would use energy efficient appliances and reduce use of high wattage appliances to reduce energy bill.

In table 7, the result indicates that majority of the prepaid users (87%) have from 0 to 15 as heating hours per week. The majority of other users (postpaid—77%) and estimation (71%) have from 16 and above as their heating hours per week indicating a high energy consumption habit among them.

Table 8 displays the cross tabulation between mode of electricity payments and types of bulbs. Analysis from the table indicates that all the prepaid meter users utilise LED bulbs for lighting. While 68% of estimation billing users utilise LED bulbs, the bulb is used by 79% of postpaid meter users. The table also revealed that 15% of estimation users utilise incandescent bulbs while it is used by 9% of postpaid users.

Conclusion

The aim of this study was to understand how households' socio-economic attributes and use of appliances together determine electricity consumption and savings. It goes further to examine how electricity billing systems affect energy consumption. To actualize the said objectives, a survey was undertaken in 400 residential dwellings in Nsukka metropolis, Enugu state between late April and mid-May 2023. Socio-economic variables found to have positive and significant effect on electricity consumption were age of working-class respondents being married, household size, household active members, unemployed household members, prepaid and estimated electricity billing system, monthly income and high electricity supply hours.

In terms of electrical appliances, high hours of electronics' use per week, incandescent and LED bulbs usage, high number of bulbs, cooling hours of 9 and above per week, lighting hours of 16 and above and weekly heating hours were positively related to electricity consumption and statistically significant.

These empirical findings offer helpful guidance for developing and implementing policy, particularly at a time when the country strives for a significant increase in the share of renewable energy in her energy mix.

According to empirical findings, residential electricity is a necessity, and cutting back on its consumption could diminish society's level of welfare. It is crucial to put policies into place that will increase the effective use of electricity and safeguard the environment without endangering society's well-being.

Recommendations

Based on the findings of this study, the following recommendations are put forward:

- We suggest that the creation of energy efficiency awareness at the household and educational institution levels should be vigorously pursued. Government should subsidize the prices of energy efficient appliances to encourage purchases by low income earners.
- Constant overbilling of estimated and postpaid electricity users as lamented by respondents in the survey should be discouraged by electricity providers. This will enable users to conserve energy and not waste energy as revenge tactics for overbilling.
- Lastly, since the use of prepaid meters encouraged efficient energy use, the promotion and full deployment of prepaid meters in the study area by electricity providers would go a long way in complementing the efforts for clean development mechanism in Nigeria.

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References

- AfricaNews (2022) ["Oil rich, electricity poor. What will it take to solve Nigeria's energy crisis?"](#). *Africanews*. Retrieved 2023-05-02
- Ajenikoko G. A and Adelusi L. O. (2015) Impact of Prepaid Energy Metering System on the Electricity Consumption in Ogbomoso South Local Government Area of Oyo State. *International Institute for Science, Technology and Education (IISTE) Journal* [6\(5\): \(2015\)](#)
- Babatunde, A. M. & Enehe, J. E. (2011) "Determinants of household electricity demand in Nigeria." *Economic and Financial Review*, 49 (2)
- Babatunde, A. M and Shuaibu, M. I. (2008): "The demand for residential electricity in Nigeria: A bound testing approach".
- Brounen, D., Kok, N., & Quigley, J. M. (2012). Residential energy use and conservation: Economics and demographics. *Green Building, the Economy, and Public Policy*, 56(5); 931–945.
- Dranove, D (2012) "Practical Regression: Log. Versus Linear specification," Case #7-112-007 (Kellogg School of Management, 2012)
- Ebere, C., Rufai, A.A., Okedina, I.M. and Afodu, O.J. (2018) "Determinants of Electricity Demand in Nigeria from 1970-2016. Error Correction Mechanism Approach." *Journal of Economics and Finance (IOSR-JEF)*. e- ISSN: 2321-5933, p-ISSN: 2321-5925. 9 (4);
- Enugu Electricity Distribution Company (EEDC) Service Centres Report 2021. <https://www.enugudisco.com>
- Esmailimoakher, P., Urme, T., Pryor, T., and Baverstock, G. (2016). Identifying the determinants of residential electricity consumption for social housing in Perth, Western Australia. *Energy and Buildings*, 133, 403–413. <https://doi.org/10.1016/j.enbuild.2016.09.063>.
- Fienberg, S.E (2005) Contingency Tables and Log-Linear Models, [Encyclopedia of Social Measurement](#), 2005, Pages 499-506
- Jones, R. V., Fuertes, A., & Lomas, K. J. (2015). The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings. *Renewable and Sustainable Energy Reviews*, 43, 901–917. <https://doi.org/10.1016/j.rser.2014.11.084>.
- Kayode, R., Akhavan, F.M. and Ford, A. (2013) Analysis of Household Energy Consumption in Nigeria. Being a paper presented in the Department of Environment and Architecture, School of Built, London South Bank University.
- Kostakis I. and Carod J. A (2023) The key roles of renewable energy and economic growth in disaggregated environmental degradation: Evidence from highly developed, heterogeneous and cross-correlated countries. [Renewable Energy](#) **206**, April 2023, Pages 1315-1325
- Kotsila D and Polychronidou P (2021) Determinants of household electricity consumption in Greece: a statistical analysis *Journal of Innovation and Entrepreneurship* (2021) 10:19, <https://doi.org/10.1186/s13731-021-00161-9>
- Laicane I, Blumberga D, Blumberga A, Marika Rosa (2015) Evaluation of household electricity savings. Analysis of household electricity demand profile and user activities. *Energy Procedia* 72 (2015) 285 – 292

- [Malama](#) A, [Mudenda](#) P, [Ng'ombe](#) A, [Makashini](#) L and [Abanda](#) , H (2014) The Effects of the Introduction of Prepayment Meters on the Energy Usage Behaviour of Different Housing Consumer Groups in Kitwe, Zambia, *AIMS Energy* 2(3) 237–259. doi: [10.3934/energy.2014.3.237](https://doi.org/10.3934/energy.2014.3.237)
- Ndiaye, D., & Gabriel, K. (2011). Principal component analysis of the electricity consumption in residential dwellings. *Energy and Buildings*, 43(2), 446–453. <https://doi.org/10.1016/j.enbuild.2010.10.008>.
- Nnaji, C.E., Okafor, I.F., Uzoma, C. C., Akubue, G. U., Adagba C. I and Onyekaozuru, E. F(2023) Determinants of Solar Energy Demand in Households in Nsukka Area, Enugu State. *International Journal Of Research And Innovation In Social Science (IJRISS)* 7 (4); 378-393 DOI: <https://doi.org/10.47772/IJRISS.2023.7429>
- Noeurn V (2021) Factors affecting electricity consumption of residential consumers in Cambodia. *IOP Conf. Ser.: Earth Environ. Sci.* 746 012034
- Oseni, O.M (2015) Assessing the Consumer's willingness to adopt a prepayment metering system in Nigeria. *Energy* 86, 154-165
- Polemis, M. L., & Dagoumas, A. S. (2013). The electricity consumption and economic growth nexus: Evidence from Greece. *Energy Policy*, 62, 798–808. <https://doi.org/10.1016/j.enpol.2013.06.086>.
- PwC (2020). COVID-19 and the Power Sector: Macro-economics, consumer purchasing power and cost reflective tariff. Retrieved from <https://www.pwc.com/ng/en/assets/pdf/covid-19-power-sector.pdf>
- Rudas, T (2015) Log-Linear and Marginal Models, [International Encyclopedia of the Social & Behavioral Sciences \(Second Edition\)](#) 2015, 322-327
- Sanquist, T. F., Orr, H., Shui, B., & Bittner, A. C. (2012). Lifestyle factors in U.S. residential electricity consumption. *Energy Policy*, 42, 354–364. <https://doi.org/10.1016/j.enpol.2011.11.092>.
- Statistica.com (2023) <https://www.statista.com/statistics/1307587/annual-residential-consumption-of-electricity-in-nigeria/>
- This Day (2023). DISCOS: Nigeria Yet to Generate Up to 6000MW of Electricity Since Independence. Retrieved from <https://www.thisdaylive.com/index.php/2022/08/12/discos-nigeria-yet-to-generate-up-to-6000mw-electricity-since-independence>
- Ubani, O. (2013) Determinants of the Dynamics of Electricity Consumption in Nigeria. *Organization of the Petroleum Exporting Countries, OPEC Energy Review*. John Wiley & Sons Ltd Publication, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA
- Ugwoke, T. I, Dike C. K. and Elekwa P. O. (2016) Electricity Consumption and Industrial Production in Nigeria. *Journal of Policy and Development Studies*. Vol. 10, No. 2, ISSN: 157-9385
- United Nations (2022), Tracking SDG7: The Energy Progress Report 2022. Retrieved from <https://sdgs.un.org/publications/tracking-sdg7-energy-progress-report-2022-47726>.
- Uzoma, C.C. and Amadi, K. (2019). Energy Access: A Key to Rural Development in Nigeria. *Research and Reviews: Journal of Social Science*, 5 (1) 452-456. Retrieved from <https://www.scholarscentral.com/pdfs/90958/energy-access-a-key-to-rural-development-in-nigeria.pdf>
- Wiesmann, D., Lima Azevedo, I., Ferrão, P., & Fernández, J. E. (2011). Residential electricity consumption in Portugal: findings from top-down and bottom-up models. *Energy Policy*, 39(5), 2772–2779. <https://doi.org/10.1016/j.enpol.2011.02.047>.
- World Bank (2021) Universal Access to Sustainable Energy Will Remain Elusive Without Addressing Inequalities. Press Release JUNE 7, 2021
- World Bank (2022). Population, total- Nigeria. Retrieved from <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NG>

Yisa, S. N., Saba, T. M., Usman, G. A., Kalat, I. K. (2022) Perception of Household Consumers on the use of Electrical Energy Prepaid Meter in Bwari Metropolis. Journal of Science Technology And Education 10(1), March,