PATTERNS AND DETERMINANTS OF DEMAND FOR ALTERNATIVE ELECTRICITY IN NIGERIA

Maina, Yakaka Bukar[1]
Department of Economics,
Faculty of Social Sciences,
University of Maiduguri, P.M.B 1069
Borno, Nigeria;

Kyari, Baba Gana[2]
Department of Agricultural Economics,
Faculty of Agriculture, P.M.B 1069
University of Maiduguri, Borno, Nigeria.

Tahir, Abdulmajid Dori[3]
Department of Agricultural Economics,
Faculty of Agriculture, P.M.B 1069
University of Maiduguri, Borno, Nigeria.
*Corresponding E-mail:**yakakabkm@unimaid.edu.ng***
Corresponding Tel: +2348031197055;

ABSTRACT
Due to epileptic electricity supply in Nigeria, the household sector spends a more significant share of its income on alternative sources which could have been used to improve their welfare. Despite this effect, not much has been exploited. This study, therefore, analyzed the pattern and determinants of alternative electricity sources based on secondary data from NBS on General Household Survey 2018-19. The statistical methods used were descriptive and OLS. The results revealed that 79% of the household heads were male, with an average age of 52 years and a household size of 6, most have secondary education earning a low income of ₦35,192. The most used alternative energy is generator 85.4%, rechargeable lantern 8%, candles 6% and solar energy 0.4%. Also, 50.5% of the generators and the solar panels were bought between 2015-2019. The commonly used generator was tiger generator whose purchase price starts from ₦15,000 with an average capacity 950watt. The demand for generator was affected positivity by income, family size, age and educational level at 1% levels respectively. For the rechargeable lantern, income was significant at 1% but negative while positive and significant for family size (1%), age (1%) and educational level (10%). Demand for candle on the other hand, was negatively related to income (10%), educational level (5%), family size (5%) while age was insignificant likewise sex for all the three sources. The conclusions were; the use of generator has been increasing over the years while few households have started titling towards solar energy. The study recommends that government should improve electricity supply.

KEYWORDS: Patterns, Determinants, Demand, Alternative Electricity

1. INTRODUCTION

The key to a country's economic development and social prosperity depend on the level of its electricity supply. The world is advancing in every aspect of development, such as in science and technology. Thus, the more it improves, the more energy demand increases and that makes energy utilization to be of paramount importance. However, as energy demand increases, the resources become strained from the burden (Alter & Syed, 2011). Nigeria is well endowed with abundant renewable natural resources enough to boost its electricity supply. Each zone has one source of energy or the other, which includes solar power from abundant solar radiation, wind, hydro and geothermal (Maina, Kyari & Maina, 2019). Moreover, the country has constructed several hydro and gas stations in the last 50 years to catch up with the growing demand for electricity. However, despite all these efforts it is still grasping with inadequate electricity supply due to obsolete equipment, poor planning and management inefficiency which led to these power stations to be operating below the capacity installed (Omolade, Nwosa, & Amassoma, 2019).

As of Dec 2019, the electricity production in Nigeria has reached 7,842 GWH, compared to the 8,952 GWh in the previous quarter. Thus, the average electricity production from March 2005 to Dec 2019 stood at 6,890 GWh. (Census & Economic Information Centre [CEIC], 2020). In an effort, to improve the supply, the Nigerian government established a plan on electricity generation, including renewable energy which links them directly to a transmitting network. This allows both public and private investors to partake on power generation without going through the main distribution network. Thus, by implementing these reforms, the country intends to generate the capacity of about 40,000MW in the year 2020 (Nigerian Electricity Regulatory Commission [NERC], 2020).

However, due to shortage of electricity supply, the country faces now and the household sector in it, pursuits for improving access to electricity, has resorted to the use of various sources of energy for cooking and lighting homes (NBS, 2011). The over-dependence on alternative electricity has serious cost implications. Already, the populace is faced with a high unemployment rate of 23.1%, underemployment rate of 20.1% and an abject poverty rate of 46.5%, indicating that almost half of Nigerians live on less than a dollar per day (NBS, 2019). Thus, spending more money on anything other than the necessities of life has serious implication on their welfare. Given this, there is the need to understand this extra financial burden incur monthly by the households as a result of alternative electricity demand, for an effective policy to be formulated and implemented.

Despite the implication of shortage of electricity to the welfare of the household in Nigeria, not much has been exploited on the demand for alternative sources of electricity for lighting homes. Most studies dwelt on energy for cooking, although, Omolade *et al*. (2019) have analyzed the pattern and structure of alternative electricity sources. However, they didn't look at the determinants of demand. While, the study by Olaleye and Akinbode (2012) analyzed the households' demand for alternative power supply, but the study was limited to only Lagos state. Hence, to bridge a gap, there is the need to understand the major sources of alternative electricity

used by the household sector of Nigeria and their determinants. This study, therefore, assesses the demand for the various alternative sources of electricity, the expenditure of these energy sources and the households' socio-economic factors determining their demand in Nigeria.

2 LITERATURE REVIEW

2.1 Theoretical Literature

2.1.1 Theory of Demand

Demand is the quantity of a commodity that a consumer is willing and able to purchase at a particular price and time. Demand for a commodity depends upon several factors called determinants. The demand function can be symbolically expressed as: Q_{dN}=f(P_{N},P_{R},I,T,E,O)} .Where, QdN = Quantity demanded for the commodity, PN = Price of the commodity, PR = Price of related commodity, I = Income of consumers, T = Taste & preferences of the consumers, E = Expectations about the future prices, O = Other factors. Demand for a commodity is generally negatively affected by its own-price. It is expressed by price elasticity which describes the degree of responsiveness of the demand for a good due to the various factors that affect demand (Adegeye & Dittol, 1985). Another factor that determines demand is the income of consumers. An increase in income of a consumer increases his purchasing power; consequently, it increases his demand for goods. Moreover, the change in demand due to change in income is explained through the income elasticity of demand for the good (Jhingan, 1999). The elasticity of a normal good is positive, implying that its demand increases as income increases. For an inferior good, demand decreases with a decrease in Income (Ayanwuocho 2001). More so, the price of related commodities can affect the demand for a good. Two types of relationships exist among commodities; there are complimentary and substitutability. A complementary relationship exists. If two goods are used together to satisfy a want. An inverse relationship exists such that when there is a fall in price of a commodity, it raises the demand for its complementary goods. While for substitute commodities where one can replace the other, the demand for one negatively affects the demand for the other. So the larger the number of substitutes, the smaller the demand for anyone of them. (Lipsey, 1995). Other, factors such as taste and preferences of a consumer and level of employment also affect demand. A change in taste and preferences affect the level of demand for various goods. (Jhingan, 1999). Similarly, the level of employment also affects the demand for a particular good. The more people are receiving a steady income and expecting to continue receiving one, the more there are in a position to make discretionary spending purchases. Therefore, the monthly unemployment rate report is one leading economic indicator that gives clues to demand consumer goods (Maverick, 2015).

2.2 Empirical Review

Olaleye and Akinbode (2012) studied the demand for alternative energy in Lagos, based on a cross-sectional data using descriptive and OLS. The result revealed that, although the majority of the households in Lagos state are connected to the National Electricity Grid. Still, due to the epileptic supply, most of them use power generating plants in their homes with an average monthly expenditure of ₦6,854.43 which includes generator maintenance, depreciation and fuel cost, i.e.

(diesel and petrol). They further added that the factors that determine power generating plant are gender (male), households' incomes and type of building. Similarly, Maina *et al.* (2017) showed in their study of household energy demand in the northeast region of Nigeria that, households use both diesel and petrol generators as alternative electricity sources. Petrol's use in generator has the highest expenditure more than all the other energy sources studied. More so, monthly income, household size and age were found to be positively related to petrol use in generators. However, it is price elastic, but a complementary relationship exists between petrol/diesel used in generators and electricity. Furthermore, Omolade *et al*. (2019) revealed four alternative energy sources in their research on the structure and nature of alternative sources of electricity supply to households in Nigeria. These include rechargeable appliances, electricity generating set, inverter and solar/inverter.

The major literature gab is that all the studies conducted were on micro-level also none considered the determinants of other energy sources such as rechargeable lantern and candle other than a generator. Hence, the need for this study.

3. MATERIALS AND METHOD

3.1. Study Area

The study area is Nigeria which lies between latitudes 4º 12′ 40.37″ N to 13º51′ 36.50 ″ N of the equator and longitudes 2º 45′ 47.735″ E to 14º42′ 55.123″ E of the Greenwich meridian. The country is located at the extreme inner corner of the Gulf of Guinea on the west coast of Africa, and it occupies an area of 923,768 sq. km (356,669 sq mi), extending 1,127 km (700 mi) East to West and 1,046 km (650 mi) North to South. The country has 36 states and a projected population of 214, 312, 387at the end of 2019 (National Population Commission [NPC], 2006). Many sources of electricity characterize the household sector. The most commonly used ones include electricity, generator, rechargeable lanterns and touch lights/ batteries (NBS, 2019).

3.2. Sources of Data

A Secondary data set was used for the study, obtained from the database of the National Bureau of Statistics (NBS) on General Household Survey Panel wave 4 2018-2019. The data set interviewed 4611 households across the country. However, only 2257 reported the use of one alternative energy source or the other. Thus the sample size considered.

3.3. Analytical Technique

3.3.1. Descriptive Statistics

Descriptive statistics were used to describe the characteristics of the data set. These include frequencies, mean, standard deviation and bar chat to present the socio-economic characteristics of the household heads in Nigeria and their expenditure on the various alternative energy sources and the nature of these alternative sources.

3.3.2. Multiple Regression Analysis

Ordinary Least Square Regression (OLS) analysis deals with the study of a dependent variable and one or more independent variables, to predict the value of the population's mean (Gujarati & Porter, 2009). OLS regression model estimates the marginal effects of the independent variables on the dependent variables in quantitative terms and their elasticities. This study utilizes this model to determine the socio-economic variables affecting demand for alternative energy sources in Nigeria. Five independent variables were considered. The choice of the independent variables was informed by their theoretical and empirical relevance judging from previous literature works as important determinants of demand. Also, they are important in household energy transition because the choices of energy types depend on what a household believes technology is worth rather than what it's worth. Therefore, for this study, the three alternative energy sources used by households, i.e. generator (both diesel and petrol), rechargeable lantern /battery dry cell and candles were considered. In contrast, solar energy was dropped due to inadequate data. The model is specified as:

$$Y = \beta o + \beta 1X1i + \beta 2X2i + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Y = $Household\ monthly\ expenditure\ on\ any\ of\ the\ alternative\ energy\ sources\ in$ (

Xi = $Household\ income(₦)$

$X2$ = $Age\ of\ household\ head\ (years)$

$X3$ = $Sex\ of\ respondent\ (Male\ (1), Female\ (0)$

$X4$ = $Educational\ level\ (years)$

$X5$ = $Household\ size\ (Numbers)$

U = $Error\ term$

A priori expectation

The coefficients of household income and educational level would be positively related to generator use while negatively related to family size. With regards to rechargeable lantern, income would be negative, while education and family size would be positive. Candle, on the other hand, would be negatively related to income and family size while positively related to education. The coefficients of age and sex could be positive or negative for all three sources.

4.1 Results and Discussion

4.1.1: Socio-economic Characteristics of the Household Heads in Nigeria

In this study, the socio-economic factors of the households that demand alternative electricity are considered. Hence, the result is presented in table 1 and figure 1.

From table 1, it can be observed that the sex of household head with the highest frequency of 79% was male. This implies that there is a dominance of male gender as the household head in Nigeria. This coincides with the finding of Maina, Kyari and Maina, (2019). The high percentage of male respondents relates to the consistent norm, tradition and culture of Nigeria. The man as the head has the role of taking every decision about the household due to his economic importance (Food and Agricultural Organization [FAO], 2010). With regards to the age of household head, the result revealed that the mean age of the respondents was 51 years and a low standard deviation of 15,

indicating a little variability in the data set. This falls within the active period identified by FAO (1992). Thus he can support the financial decision of his household, including the demand for alternative energy sources.

Furthermore, the result revealed that the mean household size was 6; a similar range was reported by Maina, Kaura & Kyari, (2017). Family size has an implication, especially on the financial strength of the household. The more the size, the higher the dependency ration and the more the burden on the household income. Also, the mean household income was found to be ₦35,192. A similar rage was reported by Maina *et al.* (2019). Thus, implying that most households are low-income earners. This could mean that the demand for cheap alternative energy sources would be high. The low-income result could also be justified by the effect on the educational level of the household head, where the mean shows ten years of formal schooling, which tallies with secondary education. This means that the majority of the household heads had only secondary school. Thus, if the majority were to be government workers with such qualification, it would only translate to junior rank and low income. Hence, the justification for the weak mean for the income level.

With regards to the types and expenditure on alternative energy sources, the result shows that most households used petrol generators. On average they spent ₦3, 942 in a month on petrol. At the same time, those that used diesel generator and rechargeable lantern and touch batteries accounting for 8% and 9% respectively had the same mean of ₦360 monthly. A candle, on the other hand, accounted for the mean value of ₦260. However, solar energy is found to be the least used alternative energy but had the highest mean value of ₦108714 and a standard deviation of ₦110852 which gives a higher variability, indicating that the value is dispersed. This could be due to high installation cost and the variation in the types. The average expenditure for generator reported here is lower than what was presented by Olaleye and Akinbode (2012), this could be because their study was Lagos which represents different income status compared to the most studies areas in Nigeria.

The implication of this result is, due to the lack of constant electricity supply the household sector is spending on average ₦4, 926 from one form of alternative fuel or another per month. This amount reduces the households' disposable income. It would undoubtedly have a negative impact on households' welfare because the amount spent could have been channeled towards the purchase of other basic household needs.

To understand the nature of some of the alternative energy sources, figure 1 is presented.

It can be observed from figure 1 that the demand for generator has been increasing over the years with a total of over 50% of them being bought between 2015-2019. This could be attributed to the epileptic power supply in Nigeria. It implies that most households have resorted to using it as alternative electricity in their homes. Also, most of the houses purchased generators of ₦15,000 and above. There highest capacity, including solar power lie between less than or equals to 950watt. With regards to solar panels, all the households interviewed reported that they purchased them between year 2015-2019. This implies that few households have gradually started tilting towards renewable energy sources; this is in line with the findings of Omolade *et al*. (2019). More

so, the majority of the solar users purchased the types that ranged between less than or equal ₦75,000.

4.2. Socio-Economic Factors Affecting the Demand for Alternative Energy Sources

OLS regression analysis was employed to determine the socio-economic factors affecting the demand for alternative energy sources in Nigeria. The coefficients and significant levels are presented in Table 2.

I**ncome:** Analyses of the results show that the level of monthly household income was a significant determinant at (1%) for the three alternative energy sources. However, it was positively related to generator use but negatively related to both candle and rechargeable lantern and touch batteries use. These agree with the *a priori* expectation which assumed that the coefficient of income wouldbe positive for generator and negative for the remaining two sources. *Ceteris paribus*, income is one of the significant determinants of budget share allocation among households. The coefficient of income for the generator was positive, implying the higher the income, the more households in Nigeria would demand generator. This is justified by the findings presented in figure 1. The pattern of demand for the generator is observed to be increasing over the years. This result agrees with the results of Olaleye and Akinbode (2012) for the determinant of alternative energy demand in Lagos However, the negativity of the coefficients for candle and lantern and touch imply that the more income increases the lesser the budget share allocation for these energy sources. This means that households would switch to the use of a generator, which is more convenient in terms of efficient electricity supply. This in line with the findings of Davis (1998), where he showed poor households use candles and lantern more as alternative electricity.

Family Size: The coefficients of household size were significant at 1% for generator and lantern and 5% for candle. The positivity of the generator agrees with the findings of Maina *et.al.*(2019) while that of candle is in line with the result of Heltberg (2005). Also, the positivity of the result for generator is contrary to the *a priori* expectation but in line with the assumptions for lantern and candle. The coefficients were positive for generator and lantern indicating that the more the family size increases the more the use of these two alternative energy sources. Although they both have positive coefficients, however, there is a difference in terms of the magnitude of their t-values. As can be seen from table 2, a 1% increase in family size would increase the need to demand generator by 5% while that of the lantern by 2%. This could still be attributed to the fact that the more the household size increases the more the need to get an efficient source of lighting in the home. More kids mean an increase in school attendance, the need to do homework at night, watch television, charge phones etc. All these advantages would be gotten more via the use of generator than lantern and touch. With regards to the candle, an increase in family size could pose more risk to the family members, because it is risky and therefore requires more caution while using, hence, the diminishing effect.

Educational Level of Household Head: The coefficients for generator and lantern were positive and significant at 1% and 10% respectively. While the candle was negative but significant at 5%, these coefficients agree with the a priori expectations. *Ceteris parabus* an educated household head would prefer to use a generator or lantern as his alternative energy source. Moreover, the magnitude of the t values for the generator is higher than that of the lantern. Indicating that with all things being equal an educated household head would prefer to use generator than a rechargeable lantern or touch battery to efficiently utilize it through watching of television, charging off his laptop or telephones etc. Also, the educational level could be related to employment opportunity. A household head with a high level of education is likely to be an employee who could bring his office work home, and such can only be achieved efficiently with the electricity from a generator. More so, a high educational level could be related to having a higher income than with low or no education. Thus, he has the opportunity to support the demand for petrol or diesel to fuel his generator. This is in line with the findings of Olaleye and Akinbode (2019). With regards to candle, the negativity of the t value implies that the more educated a household head is, the more he is aware of the risk associated with candle usage at home. Also, if he is employed and well paid, he would prefer to use a generator or rechargeable lantern than candle.

Age: The coefficients of the age of household head was significant for generator and rechargeable lantern at 1%. With regards to the signs of the coefficient, the variable was positive for generator and lantern but negative for candle. These indicate that the older the household head becomes, the more the use of generator and lantern or touch batteries but less for candle. These could be justified by the fact that most households are comfortable using the two alternative sources as they grow older and the insignificance and the negativity for candle could mean as age increases there is a likelihood of an increase in household size. Thus, more conscious of the household members. The positivity of the variable agrees with the finding of Olaleye and Akinbode (2012).

Sex: The coefficient of the **s**ex of household head was found to be insignificant for all the three energy sources but positive for all the alternative energy sources. In the analysis, a dummy was used given one (1) for male and zero (0) for female; thus, positivity relates to the male gender. This corresponds with the findings of Omolade, *et al*. (2019). Therefore, *ceteris paribus* an average male-headed household would want to spend his money on generator or lantern than an average female-headed household would do per month. This could be due to the reasons that most men like watching live football matches, news etc. even when there is power outage by PHCN. Also, whenever there is an issue relating to a faulty generator the men of the house step in to fix it. While the female considers it is too tasking because most of the types used are manually started. Moreover, the coefficient is positive for the two other sources too because from table 1 we have observed the dominance of male gender and been his role as expected by the culture of the study area to take financial decisions this is the reason for the positivity.

5. Conclusions

Male gender dominates the household sector in Nigeria as household heads who are in their active age with moderate household size. Most of them have secondary education with a low income. The most used alternative energy source is petrol based generator than diesel, followed by rechargeable lantern and torch batteries, candles and then solar panels. The use of a generator has shown sign of an increase over the years. The most increase was during the period of the survey. Also, most of the households use the tiger generator of moderate power capacity. The purchased time for solar panel suggests that few houses have gradually started titling towards solar energy sources, although the installation cost is very high. The demand for the generator was positivity related to income, family size, age and educational level. Rechargeable lantern/torch batteries were negatively associated with income but positively related to family size age and educational level. The demand for candle, on the other hand, was negatively related to income, educational level, family size. In contrast, the age for candle and sex for all the three sources were insignificant. The conclusions were; the use of a generator has been increasing over the years.

6. Recommendation

The policy implications and recommendations of these findings include

1. Due to the lack of constant electricity supply, the household sector is spending a more significant part of its disposal income on alternative energy sources which they could have used to improve their welfare. Hence, the Nigerian government should try and actualize the construction of the Mambila hydro dam which would generate about (3000 MW) and other energy sources to improve electricity supply.

2. There is a dominance of generator use as alternative energy and is positively related to Income. Thus, the policy implication is, the higher the income of the households, the more they would want to spend on electricity supply. Hence, the Nigerian government should encourage both public and private companies to invest in renewable energy from various sources. Because the households would be willing to pay more so long as there is improved electricity based on reliability and the duration of hours of light in a day.

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7. Appendices

Table 1: Socio-economic Characteristics of Household Heads in Nigeria

Sex	Frequency	Mean	Standard Dev
Female	21		
Male	79		
Age			
<=30	9	51	15
31-43	26		
44-56	30		
57-66	21		
>=70	13		
Household size			
1-4	40	6	3
5-8	43		
9-12	13		
13-16	4		
>17	1		
Primary school	1155	10	6
Secondary	580		

Diploma	421		
First degree	65		
Second and Third degrees	35		
Income			
<=10000	3	35192	23272
10001-30000	49		
30001-50000	25		
50001-70000	13		
>=70001	10		
Pattern and Expenditure on Alternative Energy Sources			
Petrol generator	76	3942	5680
Rechargeable Lantern/Battery/torch	9	360	338
Candle	6.6	264	344
Diesel generator	8	360	338
Cost of Purchase Solar	0.4	108714	110852

Sources (NBS,2019)

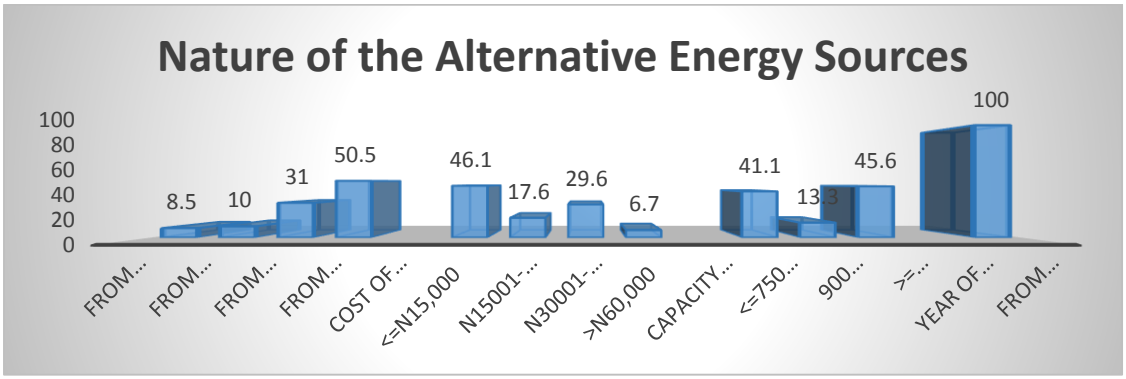

Figure 1: Nature of the Alternative Energy Sources (NBS,2019)

Table 2: Socio-economic Determinants of Alternative Energy Sources

Variable	Coefficient	Standard E.	T value	p>[t]	R^2 (*F* value)
Generator					**0.74** (24)
Constant	6.078	199.7	1.002	0.319^{NS}	
Education	0.158	0.0252	6.27	0.000***	
Income	0.492	0.133	3.69	0.000***	
Household size	0.252	0.049	5.14	0.000***	
Sex	0.191	0.235	0.81	0.152^{NS}	
Age	0.344	0.098	3.51	0.000***	
Candle					**0.43** (46)
Constant	2000.2	199.7	1.002	0.0319**	
Education	2.067	-0.348	-0.049	0.051**	
Income	0.002	-348	-4.82	0.091*	
Household size	12.059	-8.14	-0.675	0.051**	
Sex	108.7	88.34	1.231	0.222^{NS}	
Age	1.325	2..879	-0.482	0.631^{NS}	
Lantern					**0.47** (54)
Constant	-182.4	166.9	-1.092	0.277^{NS}	
Education	8.397	4.824	1.74	0.084*	
Income	0.343	-0.098	-3.51	0.000***	
Household size	19.14	8.356	2.525	0.013***	
Sex	71.44	84.22	0.848	0.398^{NS}	
Age	5.285	2.093	2.525	0.013***	

Sources (NBS, 2019)