Current Research Journal of Social Science 4(2): 121-127, 2012
ISSN: 2041-3246

Submitted: November 28, 2011 Accepted: December 23, 2011 Published: March 20, 2012

Analysis of Households' Demand for Alternative Power Supply in Lagos State, Nigeria

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Abstract: Epileptic public power supply and household quest to obtain power from alternative sources has become a daily occurrence in Nigeria. Meanwhile, little is known about household expenditure and demand pattern for these alternative sources. This study therefore assessed the demand for various sources of alternative power supply to households in Lagos state, Nigeria. Data were collected from a total of five hundred and ninety-one households who were selected using a multi-stage sampling technique. Data were analyzed using descriptive statistics, Ordinary Least Square (OLS) regression analysis and the Tobit regression model. The results showed that average household consisted of four people and realized a total monthly income of ₦153,122.78. They mostly rely on generators for power supply and spent about ₦6,854.43 on generator fuelling, maintenance and depreciation monthly. Expenditure on generator power supply increased with household income and the age of household head. Households living in duplex, mansions and flats also spent more on generators than others. The study suggests among others that government policy aimed at privatizing the Power holding Company of Nigeria (PHCN) should be encouraged in order to ensure that the people have assess to uninterrupted public power supply in the country.

Key words: Electricity, energy sources, expenditure, generators, income, regression

INTRODUCTION

Power supply is one of the most important needs of man. Scientifically, power is the rate of dissipation of energy. Hence, the two terms are mostly used interchangeably. Energy is required at individual, household, industrial and business levels. Energy availability has remained a major precursor for national development in every country around the world and no country in the world has achieved national growth and sustainable development without stable and adequate energy.

According to Dzioubinski and Chipman (1999), the household sector is responsible for about 15 to 25% of primary energy use in developed countries and for a higher share in many developing countries. UN (1997) stated that average per capita household energy use in developed countries is about nine times higher than in developing countries, even though, in developing countries a large share of household energy is provided by non-commercial fuels that are often not reflected in official statistics.

According to Wolde-Rufael (2006), while the availability of electricity by itself is not a panacea for the economic and social problems facing Africa, the supply of electricity is nevertheless believed to be a necessary requirement for Africa's economic and social development. Nigeria is the most populous country in Africa and belongs to the group of countries with the lowest electricity consumption per capita in the continent (Ibitoye and Adenikinju, 2007). According to Albrecht and Orlamünder (2008) the most valuable kind of energy used in economic systems of industrialized countries is electricity.

Different energy sources abounds which are available to households in Nigeria. These include firewood, charcoal, petrol, diesel, kerosene, gas and electricity. Among these sources, electrical energy source appears to be the cheapest and the cleanest. However, Nigeria has been suffering from acute shortage of electricity supply. According to Sambo (2008), the electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature. The country is faced with acute electricity problems, which is hindering its development notwithstanding the availability of vast natural resources in the country.

Nigeria suffers from a serious crisis in electricity supply due to decades of poor management, planning, monopolistic inefficiency, and a lack of capital funding. Several hydro and thermal stations have been constructed

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in Nigeria in the last 50 years with the view to meeting the energy demand of Nigerians. However, none of these power generating stations have been able to operate near the installed capacity, with obsolete equipment while others need upgrading. Hence, output has been very low with Nigerians relying heavily on alternative energy sources for both industrial and domestic needs. For instance, in 2010, Nigeria has less than 5000 MW actual power generation capacity to serve a population of 150 million resulting in a per capital consumption of 137 kWh per person which is 4 times less than the African average and 19 times less than the world average.

The demand for energy can be divided into three main categories i.e Industrial, commercial and domestic levels. The over-reliance on alternative energy sources is believed to be raising cost of production in the industries thereby causing cost-push inflation; increasing the cost of trade and commerce thereby increasing prices of goods and services; and finally increasing the cost of living among households in Nigeria. The purchase and use of generators and other alternative sources of power supply mechanisms is a common scene among households in Nigeria. However, there is little if any empirical research findings on the household expenditure on these alternative energy sources especially generators that is commonly used by households for alternative source of electricity. In an attempt to fill this knowledge gap therefore, this study assessed the demand for the various sources of energy, amount of households' disposable income consumed by these alternative sources and household socioeconomic characteristics affecting them in Lagos State Nigeria.

METHODOLOGY

Study area: Lagos state is located in the south-west corner of Nigeria. It was created on May 27, 1967. The state has a land size of about 3,577 Km^2 which represents about 0.4 percent of the entire land of the country but has a population of about 9,685,781 (about 6.4% of the country's population). Lagos State lies between Latitudes 6º22′ North and 6º42′ North and Longitudes 2º42′ East to 4º20′ East. It is bounded in the North by Ogun State and in the east by Ondo State. It shares an international boundary of about 45 km with the Republic of Benin, while the vast, deep blue Atlantic Ocean constitutes the approximately 180 km long southern boundary. It roughly resembles an inverted anvil. The presence of two sea ports, an international airport, large number of people, large number of manufacturing companies, head offices of corporate organizations among others make the state the commercial capital of the country (with the highest population density) despite the movement of the federal capital from the state to Abuja since 1991.

Sampling technique and sample size: A multi-stage sampling technique was adopted in this study. The first stage involved the delineation of the state into high, medium and low income areas. The next stage was the random selection of one Local Government Area each from each of the group. To this extent, Lagos Island, Surulere and Alimosho Local Government Areas were selected to represent the high, middle and low income areas of the state. Households were subsequently selected randomly using the street number by adopting the systematic random sampling procedure. Two hundred households were selected from each of the Local Government areas. This gave a total of six hundred households. Meanwhile, nine questionnaires were discarded and five hundred and ninety-one (591) were actually used for the study. Data were collected on basic household socioeconomic characteristics (such as household size, age, income, educational levels of household members e.t.c), alternative sources of energy demanded and expenditure on various sources of energy among others.

Analytical techniques:

- Descriptive statistics involving the use of means and frequency tables were used to describe socioeconomic characteristics of sampled households
- Multiple Regression Analysis
- Tobit Regression Model

According to Akinbode *et al.* (2011), the Ordinary Least Squares (OLS) regression is a quantitative response model widely used because of its relative ease of handling and its capacity to solve a wide range of problems. Least squares regression analysis may be used in estimating marginal effects of explanatory variables on the dependent variables and to estimate elasticities. According to Gujarati and Porter (2009), regression analysis is concerned with the study of the dependence of one variable, the dependent variable, on one or more other variables, the explanatory variables, with a view to estimating and/ or predicting the (population) mean or average value of the former in terms of the known values of the latter. In this study, OLS was used to determine the socioeconomic variables affecting demand for generator as a source of alternative power source in Lagos state Nigeria.
This is implicitly stated as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, U)$$

where,
Y = Amount spent by household on particular power source
X_1 = Age of the household head in years
X_2 = Gender of the household head (dummy variable: 1 = if male, 0 if otherwise)

X_3 = Educational level of the household head in years spent in school
X_4 = Household Income in Naira
X_5 = Household Size
X_6 = Type of building occupied by the household (dummy variable: 1 = mansions, flats or duplex, 0 if otherwise)
X_7 = Area of residence (dummy variable: 1 if high or middle income area, 0 if otherwise)

Tobit model: The Tobit model was used instead of the Ordinary Least Square (OLS) method to determine factors affecting demand for other sources energy source apart from generator as a number of responding households recorded zero values for expenditure on them. It has been established in literatures that for data sets with a substantial number of zero values, OLS estimates will be biased downwards. Tobit regression analysis was carried out using the maximum likelihood estimation technique. For this study, the Tobit model is implicitly stated thus:

$$Yi = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$$

Generally the Tobit model (which is a censored regression) is defined as:

$$yi = b_1x_i + u_i \text{ if RHS} > 0$$
$$yi = 0 \text{ if otherwise (i.e., if RHS} < 0)$$

If y* is assumed to have a normal distribution, with mean m and variance s^2. Consider a sample size of n (y_1*, y_2*.....y_n*) and record only those values of y* greater than a constant C and for values of y* £ C, record C. The observations are:

$$yi = y_i^* \text{ if } y_i^* > C$$
$$yi = C \text{ otherwise (for this study, C is equal to zero)}$$

The resulting sample y_1, y_2,.....y_n is said to be a censored sample

RESULTS AND DISCUSSION

Socioeconomic characteristics of households:

House type: More than half (52.7%) of the sampled households lived in flats. This is a reflection of the extreme urban lifestyle of typical resident of Lagos state. Lagos state is the commercial capital of Nigeria and remained the most industrialized. About 32% of the sampled households live in "face-to-face" buildings. Face-to-face is commonly used to describe houses which have rooms on both sides with a common rectangular space at the centre (usually called a "passage". The upper breadth leads to common kitchen, toilet, bathroom and possibly the store. Eleven percent lived in boys-quarters and less than 5% lived in mansions.

Table 1: Distribution of households by building type and educational level of the head

Variable	Frequency	Percentage
Type of house		
Flat	246	41.6
Mansion	55	9.3
Duplex	49	8.3
Boys-quarter	64	10.8
Face-to-face	166	20.1
Others	11	1.9
Total	**591**	**100**
Educational level of head		
Primary school	70	11.8
Junior school completed	102	17.3
Senior school certificate	132	22.3
Ordinary national diploma	78	13.2
National certificate of education	51	8.6
HND/BSc	106	13.9
Masters degree	49	8.3
PhD	3	0.5
Total	**591**	**100.0**
Occupation of household head		
Artisan	96	16.2
Private sector worker	137	23.2
Self-employed	112	19.0
Civil servants	177	29.9
Trading	539.0	
Retiree	11	1.9
Others	5	0.8
Total	**591**	**100.0**
Alternative fuel source		
Kerosine	436	39.9
Firewood	24	4.1
Charcoal	27	4.6
Gas	67	9.6
Others	5	0.8

Table 2: Summary statistics of households' socioeconomic characteristics

Variable	Mean	SD
Household size	4	1.4
Age of household head	45	11.3
Income of household head in naira	78253	31,345.2
Pooled household income in naira	153,122.5	101,234.45

$1: ₦150 as at the time data collection for this study; Computed from field survey data

Household size: Household as used in this context consists of family or relatives living together and feeding from the same pot under a single head and possibly pulling resources together to achieve common goals. Forty-four percent (44%) of the sampled household had between 3 to 4 people in their household with mean household size of 4. The few number of people in the household is also a reflection of modern urban lifestyle in

Nigerian cities. Household size is expected to impact positively on energy demand i.e larger households are expected to spend more on both conventional and alternative power sources.

Age of household head: The results revealed that the average age of household heads in the sample was 45 years which means that most of the household heads were still in the economically active age group. This is expected to have positive influence on the living standard of the household members. The standard deviation value of 11 means that there is a moderate dispersion around the average age reported by this study.

Educational level of household heads: More than half of the sampled household heads (50.7%) were not educated beyond high school (secondary school) level. Furthermore, about 10 percent were educated beyond university first degree (Table 1)

Occupation of household head: About 30% of the sampled household heads were civil/public servants while 23.2 and 16.2% were private sector workers and artisans respectively. Others got involved in trading, while some were self-employed among others (Table 1).

Household income: The results in Table 2 shows that average household earn ₦153,122.50 (153 thousand 122 naira 50 kobo only). This amounts to about $1,020 (1020 Dollars) per month. The household head contributed an average of ₦98,253.30 which represented about 64 percent of the total household income. This may partially explain the age-long overbearing influence of the household heads (who are mostly male) on the household's decision and behavioral pattern.

Energy sources utilized among households: All the sample households subscribed to the public power supply by the Power Holding Company of Nigeria (PHCN). About 99% of the sampled households uses generating plant in their household in order ensure supply of electricity when the public supply is not available. About 74% of the sampled households used kerosene as a fuel source while 4.6 and 4.1% used charcoal and firewood respectively. Others use gas and sawdust (Table 1).

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Expenditure pattern on different energy and fuel sources: Table 3 revealed that households spend an average of ₦1,809.95 on the payment of PHCN monthly electricity bill. Despite this high bill, households spend an average of ₦6,854.43 on generating set (generator maintenance, depreciation and fuel cost i.e diesel and petrol). This amount which is about 4.48% of the total household in come represents a major leakage in the households' disposable income and would certainly impact negatively on household welfare because this could have well being used in purchasing more of basic household needs. Furthermore, households spend average of ₦465.93 and ₦147.25 on cooking gas and firewood per month respectively. The demand for firewood potent a great danger for sustainable environmental management because harvesting of firewood from the wild usually results in deforestation which causes erosion, flooding, land degradation and desert encroachment among other adverse effects.

Table 3: Summary statistics of the expenditure pattern on alternative power and energy sources

Source	Mean monthly expenditure (in naira)	SD
Generator (fuelling, depreciation and maintenance)	6,854.43	3,098.34
Kerosine	2110.78	1145.24
Diesel	372.52	235.45
Petrol	5,145.05	4,765.87
Charcoal	147.25	105.45
Firewood	55.34	40.05
Cooking gas	1421.93	1050.23
PHCN bill	1,809.95	1,578.89
Depreciation cost of generator/month	567.42	345.34
Fuel cost	5,684.10	4,139.44
Maintenance of generator	665.87	342.12

$1: ₦150 as at the time data collection for this study; Computed from field survey data

The analyses further revealed that households still expend substantially on other fuel sources for their daily energy needs. These are kerosene (₦2,110.78) and battery (₦200.00). Batteries are mostly used to power transistor radio and other radio receivers in order to listen to news and entertainments on radio. This energy source always become the next available means of getting in touch with current happenings when there is public power failure and when putting on the generator is considered uneconomical to the household.

In the total, average household spend a total of ₦9,778.39 which is about 6.4% of total household income (but 12.5% of the household head income) on alternative energy/power sources in the study area (Lagos state). These spending could have been avoided if the government has ensured regular power supply to the people.

On the other hand, the use of these various alternative means come with various side effects. For instance, air and noise pollution usually accompany the use of generators. The impact of this on people's health and environment appears difficult to quantify, at least, for now. In fact, there is little if any attempt has been made to evaluate these damages in Nigeria. There have been reported cases of entire household being killed as a result of suffocation by fumes from generators in Nigeria. All these call for urgent attention by both the federal and the various state governments in order to safeguard the lives and health of the citizenry.

Table 4: Results of regression analyzes

Variables	Generator power supply (OLS regression)	Kerosene (tobit regression)	Charcoal (tobit regression)	Firewood (tobit regression)	Cooking gas (tobit regression)
Constant	-2214.28(-0.34)	1.214(0.98)	-4.755(-0.0045)	-6.887(-0.082)	-8.600(-0.082)
Age of head	137.21*(2.04)	-0.091(-0.672)	0.0052(0.223)	0.081(1.343)	-0.011(-1.40)
Gender (male = 1)	2661.84*(2.34)	-0.073(-0.154)	6.681(0.0062)	6.815(0.081)	6.460(1.45)
Education of head	-165.42(1.05)	0.014(0.252)	-0.181*(-2.37)	-0.082(-0.384)	0.039(1.14)
Household income	0.041*(2.17)	-0.055*(-2.47)	-0.051*(-2.430)	-0.037**(-2.71)	0.045*(2.26)
Household size	-226.47(0.123)	0.109**(3.20)	0.032*(2.19)	-0.220(-0.568)	-0.053(1.03)
Type of building	1813.69**(4.22)	-0.241**(-4.34)	-0.0357(-0.084)	-0.594**(-3.92)	0.992*(2.16)
Area of residence	1332.46(1.06)	-0.345*(2.04)	-0.383(-1.07)	-0.723**(-2.95)	0.832*(2.23)
F-value	4.23 -	-	-	-	
Adjusted R^2	0.57 -	-	-	-	
LLR	-	-721.06	-115.92	-30.46	-136.74

**: Significant at 1%; *: Significant at 5%; Computed from field survey data

Factors affecting demand for alternative power sources: Table 4 shows the results of the Ordinary Least Square Regression analysis of determinants of demand for use of generators among households in Lagos state. The results revealed that age of household head, gender of the household head, household income and type of building were the significant factors affecting the amount of money spent on the use of generators (monthly depreciation cost+service maintenance+fuel cost) by households in the study area. All the significant variables came out with positive signs.

Age of household head (X_1) was significant at $\alpha = 0.05$ with a coefficient value of 137.22. Since the linear functional form was selected for the study, this value implies that an increase in the age of the household head by one year causes an increase in the expenditure on generator power supply by ₦137.22 i.e the older the household head the more the expenditure on generating set power supply to the household. Gender (X_2) was positive and also significant at 5% risk level. It should be recalled that "gender" was a dummy variable where male headed households were scored 1 while female headed households were scored zero in the quantification of the variable. Therefore, a positive value of 2661.83 means that if all other factors in the model were held constant, average male headed household spends ₦2,661.83 more on generator power supply than average female headed household per month in the study area. This may be due to the perceived general positive inclination of males to watching live football matches, news and other live events on the television even when there is public power failure. This always necessitate frequent and prolonged use of generators than female controlled households, hence, spending more on generator fuelling, maintenance and the inherent depreciation. Furthermore, females generally consider the task of putting on the generator as energy demanding especially the small type that is manually started.

Household income (X_4) was positive and significant at $\alpha = 0.05$. The positive sign shows that demand for generator power supply can be considered as a "normal good" in the study area. The coefficient of income represents the Marginal Propensity to Consume (MPC) of generator electric power. The value of 0.041 means that an increase in household income by one unit will cause a 0.041unit increase in expenditure on generator power supply by average household. For instance, a ₦100.00 (one hundred naira) increase in household income will cause a ₦4.10 increase in expenditure on generator power supply. This potential increase spending is likely to be expended on acquisition of bigger generators, increase in maintenance cost, increase expenditure on fuel due to increase in the frequency and length of use of generators.

Type of building (X_6) was positive and significant at $\alpha = 0.01$. The implication of this is that people living in house types that were scored 1 in the quantification of the dummy variable spend more *ceteris paribus* than households living in the house types scored zero. It should be noted that mansions, duplex and flats were scored 1. Given the coefficient reported here, the implication is that households living in these types of houses spend about ₦1,813.65 more on generator power supply than others when other factors are held constant.

The R^2 value of 0.517 means that 57.1% of the total variations in expenditure on generator power supply among the sampled household were accounted for by the variables included in the model. The implication of this is that further researches should introduce more relevant variables capable of explaining more variations in the dependent variable.

RESULTS OF THE TOBIT REGRESSION

Demand for kerosene: The result of the Tobit regression model (Table 4) showed that households size (at $\alpha = 0.01$) had positive effect on kerosene demand while household income (at $\alpha = 0.05$), building type (at $\alpha = 0.01$) and area of residence ($\alpha = 0.05$) have significant negative effect on kerosene demand (i.e household monthly expenditure on kerosene). The implication of these is that larger households will tend to demand more kerosene (for cooking stove and to power local lamps) than households

with fewer people. Furthermore, the negative effect of income portrayed kerosene as an "inferior good" whose demand decreases with increase in income. In the same vein, households living in duplex, mansions and flats and households living in areas classified as high income areas demand less for kerosene compared to others. This may mean that these groups of households go for cleaner fuel sources.

Demand for charcoal: The Tobit regression result (Table 4) revealed that household size was positive and significant at $\alpha = 0.05$ while education and household income were negative and significant at $\alpha = 0.05$. These imply that larger households demand more charcoal than smaller households while households headed by less educated people demand for more charcoal than households headed by more educated people. The negative sign of income implied that as income increases households demand for less charcoal which may suggest that charcoal is an "inferior" energy source among the households.

Demand for firewood: Household income (at $\alpha = 0.01$), building type (at $\alpha = 0.01$) and area of residence (at $\alpha = 0.01$) exerted negatively on the demand for firewood in the study area. The results means that as household income increased, the demand for firewood decreased. The negative signs of building type and areas of residence imply that people living in face-to-face, self-contained and boys-quarters buildings demand for more firewood than others while households living in low income areas demand more firewood than others who live in middle and high income areas.

Demand for cooking gas: Household income ($\alpha = 0.05$), building type ($\alpha = 0.05$) and area of residence ($\alpha = 0.05$) impact positively on demand for cooking gas in the study area. This means that increase in these variables increase demand for cooking gas. Here, the positive sign of income as a variable in the model suggest that the commodity in question (cooking gas) could be classified as a "normal good". Households living in mansions, duplex and flats demand for more cooking gas than those living in boys-quarters, face-to-face buildings and other semi-permanent structures characteristics of shanties. This significant difference in demand pattern among these groups of households may indicate their standard of living and may be a reflection of poverty levels and a household welfare index.

SUMMARY AND CONCLUSION

The study showed that demand for alternative power supply is very high in Lagos state Nigeria. This was mainly attributed to the epileptic and insufficient nature of the public power supply system which is owned by the Federal government. Households spent an average of ₦6,854.43 on generator fuelling, maintenance and depreciation per month alongside about ₦1,809.95 incurred on the settlement of the inefficient public power supply bill by the PHCN. Other sources of energy utilized by the households included charcoal, firewood, kerosene, cooking gas and sawdust. Money spent on these sources would have been avoided if there was regular public power supply and the money might have been used to improve household welfare or invested in more meaningful ventures which may directly or indirectly contribute to economic growth. The OLS regression analysis revealed that income, age of household head, gender (in favor of male headed households) and type of building the household was living in (in favor of duplex, mansions and flats) had significant positive effect on demand for generator power demand. Expectedly, the Tobit regression results revealed that kerosene, firewood and charcoal were mostly demanded by low income households (suggesting that these commodities may be classified as "inferior goods") while cooking gas is mostly demanded by high income households. Kerosene, firewood and charcoal marketers should focus on low-income areas while marketers of cooking gas should focus more on high-income areas. It can be concluded that improvement in income would cause increase in demand for cleaner energy sources like cooking gas while worsening real income could result in greater demand on biomass fuel such as firewood, charcoal and sawdust.

Government policy aimed at privatizing the PHCN which is the government company supplying electricity may go a long way in improving efficiency and service delivery of the company. Furthermore, the sector should be opened up to private investors who are capable of managing businesses effectively, minimize corruption and ensure that enough and sustainable electricity is made available. Furthermore, the Nigerian Constitution's listing of power generation and supply under the "Concurrent Legislative List" should be a motivation. The clause implies that both the federal and the state government are empowered to legislate on the establishment of power generating station, transmission and distribution in the country.

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