



Determinants of Solar Energy Demand among Households in Maiduguri, Borno State Nigeria

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ABSTRACT

The study assessed the prospect of solar energy demand in Maiduguri, Borno State Nigeria, using primary data obtained through snowball sampling method collected between June and July 2022. The study employed descriptive statistics, Ordinary Least Square, and logistic regressions to achieve its objectives. The result showed that 73% of the household heads are male, with 30% of them as businessmen. In addition, 80% are married; while 47% have a first degree. Most have income between ₦50, 000 and above. Most of them installed solar of ₦5, 00 000 to ₦ 1, 000 000. The reasons for solar demand include poor electricity supply (32%), convenience (32%), comfortability (29%) and affordability (7%). About 70% of the respondents have been using solar for 2 to 4 years. Similarly, 75% and 80% reported that their electricity bills and generator maintenance cost have declined from ₦10, 000 and above to ₦5, 000 or less monthly after solar installation. The 95% of the respondents are satisfied with solar energy with the level of their Income, convenience and education on solar energy positively influencing their solar energy demand at 5%, 5%, and 10% respectively. In addition, the duration of solar power supply by the appliances, affordability of solar energy equipment as well as the comfort its provides coupled with the poor electricity supply in the study area positively and significantly influence solar energy demand at 5%, 5%, 10% and 5% respectively while reliability of the solar equipment negatively influences solar energy demand. Moreover, income is the most important determinant of solar energy demand with households that spent more on solar energy installation are more satisfied. Therefore, the study recommends policies that improve income, reduce the cost of solar installation and create more awareness of the advantages of solar power.

Keywords: Determinants, Solar, Energy, Households, Demand.

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INTRODUCTION

Renewable energy development is a key to infrastructural development. Thus, exploiting it in less developed economies such as Nigeria will contribute greatly to a sustainable environment. Several studies have shown that exploiting it is the best way of achieving a less carbon environment. Moreover, due to unsustainable energy exploitation and its speedy depilation, the

concept of renewable energy development has become the order of the day (Mohammed, Mustafa & Mokhtar, 2013).

Nigeria is well endowed with abundant natural resources. However, various pieces of literature have reported heavy reliance on inefficient energy sources, which is mainly attributed to very poor access to electricity. Hence, millions of households are facing severe energy crises and the most affected groups are low and middle-income. Similarly, due to poor electricity supply, a greater share of household income is spent on expensive, alternative energy sources on a daily or monthly basis, which results in a rise in the level of poverty (Maina, Kyari & Dori, 2020).

Similarly, Maiduguri is well endowed with abundant solar radiation but the households are heavily dependent on inefficient energy sources (FAO, 2019). Therefore, examining the prospects of solar energy demand among households could improve the existing energy situation by proffering ways to reduce the level of dependence on inefficient fuels. Maina, Yakubu & Kyari (2019), conducted the study on energy demand in the study. However, the study did not look at solar energy, therefore the key objectives of the study is to examine the socio-economic characteristics of the households and the nature of solar energy demand, assesses the determinants of demand for solar energy, and their satisfaction with solar energy.

MATERIALS AND METHOD

Study Area

The study area is Maiduguri, Borno state, Nigeria. It lies between latitudes $11^{\circ}.83^1$ - $13^{\circ}.15^1$ north of the equator and longitudes $11^{\circ}50^1$ - $13^{\circ}09^1$ east of the Greenwich meridian. The population of the area was 521,492 (NPC, 2006) and was projected to increase to 890382 at 3.4% growth rate at the end of 2022. In Maiduguri, the wet season is hot, oppressive and mostly cloudy and the dry season is sweltering and partly cloudy. The temperature of the area varies between 58°F to 106°F (Weather Spark, n.d). Thus, considered to have abundant solar radiation suitable to utilise solar energy source of energy, however, most households in Maiduguri rely on multiple fuels for cooking and lighting their homes with over-dependence on biomass use. Other fuel sources available include, Charcoal and LPG for cooking and Petrol used in power generating plants for lighting (Maina, Yakubu & Kyari, 2019).

Sampling Technique

The Snowball sampling method was used because solar energy usage is not common among the households in the study area. Hence, few solar installers were identified and they made referrals to their customer. A total of 110 households were selected between June-July 2022 in the state capital. However, only 109 gave detailed responses to all the questions. Thus, the sample size considered.

Sources of Data

The source of data employed was primary data which was collected through the use of structured questionnaire designed on a kobo collect form and was administered to the respondents. The questionnaire was divided into three sections, which included information on the socio-economic characteristics of the households, the nature of solar energy demand, and their satisfaction with solar energy.

Analytical Technique

Descriptive Statistics

Frequencies, percentages, and bar charts were used to describe the socioeconomic factors of the household heads and the nature of solar energy demand in the study area.

Multiple Regression Analysis

To assess the prospects of solar energy demand in the study area in relation to the respondents the some socio-economics characteristics were considered, the Ordinary Least Square Regression (OLS) model was utilised. To achieve this objective, four independent variables were considered for the study. The choice of the variables was informed by available literatures, solar energy is a luxury good hence different variables determine its demand (Maina, et .al 2020).The model is specified as:

$$Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + U_i \dots\dots\dots (i)$$

Where: Y_i	=	Household expenditure on solar installation measured in (N)
X_i	=	Household income measured in (N)
X_2	=	Poor electricity supply dummy (Yes 1, No 0)
X_3	=	Comfortability dummy (Yes 1, No 0)

X_4 = Level of Education, measured by years spent in school

U = Error term

A priori expectation

Income, awareness, and comfortability would be positive while poor electricity supply would be negatively

Logistic Model

To assess the level of satisfaction of solar energy demand by the respondents, logistic regression model was used. It is the appropriate technique here because the dependent variable is dichotomous. The model is given as $\ln[p/(1-p)] = \alpha + \sum (\beta_k)(X_k)$, where p is the probability that a household is satisfied with the services of solar energy, $p/(1-p)$ is the odds that a household is dissatisfied, α is a constant term, β_k represents the effects parameters of the explanatory variables, and X_k represents the explanatory variables in the model. Coefficients in a logit model give the change in the log-odds of being dissatisfied for a unit change in the explanatory variables.

Variables	Measurement
Consumer Satisfaction	Is the dependent variable, measured as dummy 1 for households who are satisfied with their installed solar energy and 0 if otherwise.
Duration	Is measured by the number of hours of light a household gets in a day.
Reliability	The reliability indicator variable is measured in terms of regret 0 or not 1 for installing solar
Comfortability	Is determined by the households who found solar energy efficiency is measured in dummy 1 for yes and 0 otherwise.
Affordability	Is measured in Naira as the cost of solar energy installation.

Independent Variables Coined and Adopted by the author (2022).

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Household Heads

Table 1 and figure 1 present the socioeconomic factors of the households and the nature of solar demand.

Table 1: Socioeconomic Characteristics of the Household Heads

Variable	Frequency	Percentage
Gender		
Male	80	73
Female	29	27
Occupation		
Civil Servant	22	20
Politician	24	22
Businessman	33	30
Private Sector Employee	27	25
Others	3	3
Marital Status		
Married	87	80
Single	6	6
Widow/Widower	9	8
Divorced	7	6
Educational Qualification		
Islamic/Christian Theology	5	5
Primary	13	12
Secondary	11	10
First Degree	51	47
Second Degree	23	21
P.H.D.	6	6
Income		
<=N30, 000 Or Less	1	1
N 30, 001 to N 50, 000	7	6
>= N 50, 001	101	93

Source: Field survey, 2022.

The result in Table 1 shows a dominance of the male gender as the household head (73%). The occupation with the highest frequency was businessmen (30%), followed by private-sector employees (25%), politicians (22%) while civil servants and others are the least with 20% and 3% respectively. Thus, the nature of Job one does translates to the source of income and consequently the likelihood for solar demand. Also, 80% of the households are married with 47% having a first degree. It could mean the more the household head is educated, the more he/she is aware of the advantages of demanding solar energy. Similarly, the level of income with the highest frequency is ₦50, 000 and above. This is not surprising because solar energy installation is costly as also affirmed by the Office of the Energy Efficiency and Renewable Energy (2022).

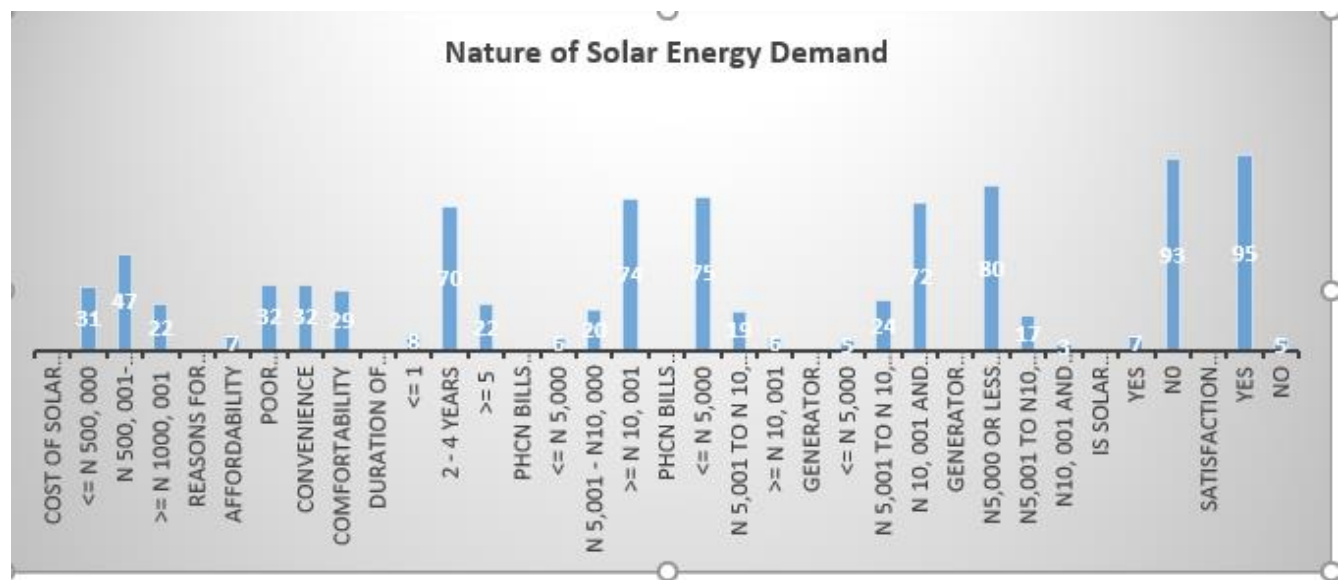


Figure 1: Nature of Solar Energy Demand in the Maiduguri. Source: Field Survey 2022.

Figure 1 shows the nature of solar energy demand in the study area. The cost of solar energy with the highest frequency is within the range of ₦5, 00 000 to ₦ 1, 000 000. The cost of solar installation depends on the power load demanded by a household, as well as the duration of the power to be supplied. Thus, the more the number of solar panels, the capacity of the inverter and battery voltage, the higher the cost of installation. In addition, the brands of the products in the market determine the cost of a solar installation; some products are more efficient than the others hence more costs variations.

Furthermore, some of the reasons given for installing solar energy in the study area include poor electricity supply as well as convenience, which have the highest frequencies of 32% respectively. Comfortability accounted for 29% while affordability 7%. The justification for the

low affordability percentage lies in the fact most of these households had to save for months before they could afford it. It was not something they bought immediately they wanted it. Thus, according to the respondents, it was not easily affordable; that was the reason for the low response. Also, about 70% of the respondents have been using solar energy for between two to four years. It justifies the fact that most households installed solar power because, for many years now, the electricity supply in Nigeria has been epileptic (Omolade, Nwosa & Amassom, 2019). With regards to electricity bills and generator maintenance cost, the results showed that before the installation of solar energy about 74% and 72% of the households spent ₦10, 000 and above respectively but after solar installation, 75% and 80% of the respondents spend only ₦5, 000 or less on the two energy sources respectively. These show that both electricity bills and the cost of fueling and maintaining generator plants have decreased after solar power installation. It means that installation of solar power is cost-effective in the long run unlike the use of a generator or other alternative energy sources that attract the allocation of monthly expenditure (Maina, Kyari & Dori, 2020). The reason for the decrease in electricity bill could be attributed to the fact that most households choose to load-shed between solar energy and PHCN electricity, especially those households who use prepaid meters, hence the reduced bills. The cost of maintaining a generator, on the other hand, also shows a decline. It is because its usage decreases to only appliances such as water pump and fridges, which could not be supported by solar energy without easily draining the batteries or reducing its life span. With regards to the reliability of solar energy and satisfaction derived from using it, the majority 95% and 93% gave their responses in affirmation. In contrast, the few that opposed it complained about the inefficiency of the brands of the solar equipment they bought. This affirms the report by the Office of the Energy Efficiency and Renewable Energy (2022) that some solar appliances are not efficient.

Determinants of Solar Energy Demand among Households in Maiduguri

The study assesses the factors affecting expenditure on solar energy in the study area. Table 2 presents the results.

Table 2: Determinants of Solar Energy Demand Among Households in Maiduguri

Variable	Coefficient	Standard E.	T value	p>[t]	R ² (F value)
Constant	205102.2	29405.6	0.70	0.487 ^{NS}	0.59 (24)
Awareness	110076.2	65577.1	1.68	0.096*	
Income	0.210958	0.104775	2.01	0.047**	
Convenience	326713.7	171751.1	1.87	0.050**	
poor electricity supply	395837.2	211518.6	1.90	0.054**	

Source: Field Survey (2022) Note: Significant at 1% (*) 5% () 10 (***)**

The result from Table 2 revealed that the coefficient of the level of awareness is positively related to solar energy demand and significant at 10%. It is inconsonant with the *a priori* expectations. *Ceteris paribus*, the more the level of awareness, the more the demand for solar energy. It is in line with the findings of Maina, Kyari and Dori (2020) for the demand for alternative energy demand in Nigeria. Hence, the more the household head is aware of the efficiency of solar energy in terms of low cost of maintenance after the installation, its comfortability, and more duration of hours of light, the more he/she demands solar energy. Most high-income households can afford solar energy, but due to a lack of awareness of its advantages they end up buying other expensive alternative energy sources that attract reoccurring expenditures and are not even as convenient as solar.

Similarly, the result shows that level of income of the household head is positive and significantly related to solar energy expenditure at a 5% level. It is in line with the *a priori* expectation, which assumed that the coefficient of income would be positive. *Ceteris paribus*, income is an important determinant of budget share allocation among households. The positivity of the coefficient implies that the higher the income, the more households in the study area would demand solar energy. The result in Table 2 justifies that the majority of the solar energy consumers fell within the high-income group. This result is similar to the demand for power generating plants in Lagos as reported by Omolade, Nwosa and Amassom (2019). Solar energy involves huge installation cost. Therefore higher-income households are more likely to demand it than low-income households. Aside from income, one other factor determining solar energy demand in the study area is convenience. Its coefficient is also positive and significant at 5%. It shows that

households would prefer solar power over alternative sources, because of some factors such as being favorable to all seasons, cost-effective(non-reoccurring expenditure), comfortable to use with no loud noise and the automatic bypassing of power when PHCN restores light. Hence, the more the level of convenience gotten from such power, the more its demand.

Furthermore, the poor nature of electricity supply in the study area is another factor that determines solar energy demand. The result shows that poor electricity supply contributes positively and significantly at 5% for solar energy demand. It is cost-effective because once it is installed no monthly expenditure like in the case of other sources. It is also more convenient to use than generating plants that make loud noise and pollute the environment (Maina *et al.*2019). Moreover, the magnitude of the t values show that income is the most important determinant of solar energy demand with the value of 2.01, followed by poor nature of electricity supply with 1.90 then conveniences with 1.87 and lastly level of awareness with the least 1.68. It means that a 1% increase in income would increase demand for solar by 201% while Poor electricity, convenience and awareness would increase demand by 190%, 187% and 168% respectively.

Factors Affecting Household Satisfaction with Solar Energy Demand

Logistic regression shows the determining factors that affect household satisfaction with solar energy demand in the study area. Table 3 presents the results.

Table 3: Factors Affecting Household's Satisfaction with Solar Energy

Variable	Coefficient	Standard error	T value	p>[t]
.Constant	-1.682316	1.298915	-1.3	0.195 ^{NS}
Duration	1.223301	0.619058	1.98	0.048*
Reliability	-0.674121	0.924276	-0.73	0.054**
Comfortability	1.031568	0.569733	1.81	0.070***
Affordability	2.329651	1.132877	2.06	0.040*
Log-Likelihood	-41.28464			
Chi2 value	15.11			
Prob Chi2	0.0045			

Source: Field Survey (2022) Significant at 1% (*) 5% () 10% (***)**

Table 3 presents the major factors that affect household satisfaction with solar energy demand in Maiduguri. The log-likelihood value is greater than one and is significant at 1%, implying that the regression is fit for the model. The first factor considered in the study is the duration of solar energy usage. The result revealed that the coefficient is positive and significant at 5%. It implies that the more the number of hours the solar power is supplied to the household, the more their satisfaction. It agrees with the result of Aklin *et al.* (2014) which showed that the duration of electricity supply in a day has a strong relationship with household's satisfaction in rural India.

Moreover, the magnitude of the coefficient of t-value is the second highest (1.98), indicating that an hour increase in solar energy supply to the households the more their satisfaction increases by 198%. However, the coefficient of reliability is negative but significant, at 5%. It shows that any decrease in the number of hours of solar power supply due to either fewer hours of sunray, i.e. during the raining season or defect of any of the solar equipment, i.e. battery, panels etc, the more likely it would decrease the satisfaction by 73%. It coincides with the findings of Wakuru (2012) which revealed that the more reliable in terms of hours of electricity supply provided to customers in Kenya the more their satisfaction. The variable comfortability has a positive coefficient and significant at the 10% level. It shows that the more comfortable the solar energy is to use, the higher the level of satisfaction of the household.

Similarly, the affordability variable is positive and significant at 5%. It indicates that the more the cost of solar installation, the more the satisfaction a household derives. Households that spend more on solar energy get to have better brands of appliances that are more efficient and enjoy more power load supply due to the number of batteries and panels bought. Therefore, the more the hours of power supply and the number of appliances used, the more the cost of installation and the more the satisfaction and vice versa. It agrees with the findings of Ayomi (2014) which showed there was a direct relationship between less hours of electricity supply and the general dissatisfaction among consumers in Greater Accra region of Ghana. When the magnitude of the t values for all the variables were considered households get more satisfaction based on the cost they spent on solar installation than the disaffection they get when there is defect on the appliances that reduce the reliability of the products.

CONCLUSION

The male gender constitutes the majority of the household heads in Maiduguri that use solar energy, and most of them have a first degree and high income with about a quarter of them as businessmen and the majority of them are married. The nature of solar energy shows that most households spent between ₦5, 00 000 to ₦ 1, 000 000 as installation cost. The major reasons for solar installation are poor electricity supply and convenience. The majority of the households using solar have had it for two to four years. Also, electricity bills and generator maintenance costs declined after solar installation. The majority of respondents are satisfied with solar energy because it is reliable.

Moreover, income is the most important determinant of solar energy demand followed by poor nature of electricity supply then convenience, and lastly level of awareness. Finally, households that spent more on solar energy installation get more hours of power supply due to the comfortable nature of the equipment. Thus, given the households more satisfaction than the dissatisfaction they feel due to the unreliability of the solar power equipment.

RECOMMENDATION

Firstly, the income level of the consumer should be improved because it induces the demand for solar energy. It can be achieved through policies similar to the trader money and N-power packages but the ones that have long-term goals and by increasing the minimum wage of the populace.

Secondly, government should improve household satisfaction of solar energy demand through policies that reduce the cost of solar installation either by given some incentives such as a quota to households to make it affordable or by making the equipment that supplies high power load duty-free which in turn will make it affordable to the households.

Finally, there is a need to create more awareness of solar power as an alternative source of energy to households as the most cost-effective in the long run and environmentally friendly energy. It could be achieved through disseminating awareness via organizing workshops, focus groups discussion, and the use of mass media (television and radio) and also other social media platforms.

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