"Structure and nature of alternative sources of electricity supply to households in Nigeria"

| AUTHORS | Adeleke Omolade (iD) https://orcid.org/0000-0003-3306-3879
Philip Nwosa
Ditimi Amassoma |

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
15	6	19

Adeleke Omolade, Ph.D., School of
Accounting, Economics and Finance,
University of KwaZulu-Natal, South
Africa.

Philip Nwosa, Ph.D., Lecturer,
Department of Economics, Faculty of
Social Sciences, Federal University of
Oye-Ekiti, Ekiti State, Nigeria.

Ditimi Amassoma, Ph.D., Senior
Lecturer, Department of Economics,
Faculty of Social Sciences, Federal
University of Oye-Ekiti, Ekiti State,
Nigeria.

Adeleke Omolade (South Africa), Philip Nwosa (Nigeria),
Ditimi Amassoma (Nigeria)

STRUCTURE AND NATURE OF ALTERNATIVE SOURCES OF ELECTRICITY SUPPLY TO HOUSEHOLDS IN NIGERIA

Abstract

The study examined the nature and structure of alternative supply of electricity in Nigeria. It has been observed that all the efforts of the Nigerian government to improve electricity supply and promote access to electricity have been proving abortive and households at various levels are confronted with the challenge of searching for alternative supply of electricity. Also, state government and some private organizations are interested in solving this challenge, but they lack appropriate empirically grounded information on the choice of alternative source of electricity. The study, which is a pure exploratory one, used primary data through well-structured questionnaire from a sample of 4,758 households across 16 local governments in Ekiti State of Nigeria. Applying descriptive statistics, the strengths and weaknesses of various alternative sources of electricity supply among households were analyzed. The results indicate that rechargeable appliances, electricity generating set, inverter and solar/inverter are the four major types of alternative sources of electricity supply common among the households. It was also revealed that out of all the positive ratings such as regularity in supply, ease of maintenance and capacity, solar powered source of alternative electricity supply appears to be the best. The only rating that is unfavorable to the solar type of alternative sources of electricity supply is in the area of affordability. Government and interested private organizations should embark on establishment of solar powered stations for some communities or distribution of solar panels and inverters at subsidized rate to households to improve their socio-economic well-being.

INTRODUCTION

Over the years, the contributions of households to nation building cannot be overemphasized, hence, the need to take the issue of their well-being seriously. Apart from the fact that Nigeria ranked 152nd out of 157 countries on Human Development Index (HDI) ranking, the households have been faced with different socio-economic challenges, which have limited their contributions to the overall Nigerian economic performance. These challenges are compounded by the inadequate power supply and poor access to electricity (Efurumibe, Asiegbu, & Onuu, 2014).

Nigeria is one of the developing countries battling with the perennial problem of electricity supply. Percentage of the population having access to electricity dropped by more than 10.6% during the last one decade, making the country one of the most backward countries in terms of electricity consumption per capita and access to electricity (UNDP, 2017).

The irony of this scenario is that smaller countries in terms of national income across the Sub-Saharan Africa (SSA) have regular supply of electricity and improved access to electricity supply. For instance, Benin Republic with the GDP of less than 40 billion USD has about 78% access to electricity in 2013, this figure has risen to about 80% in 2017. Ghana with a GDP of about 100 billion USD in 2015 celebrated un-interrupted supply of electricity for a whole calendar year with an improved access to electricity of about 6.5% between 2014 and 2016 (UNCSD, 2016). These situations are in sharp contrast to what is obtainable in Nigeria, the largest economy in Africa with the GDP of more than 400 billion USD. Nigeria is among the countries in the SSA with the worst percentage of access to electricity supply.

Various administration in the past have embarked on different program to ensure that there is improvement in the electricity power generation to the national grid in order to boost supply, but it appears that this perennial problem has remained unchanged. In recent times, the total electricity generation in Nigeria has dropped drastically, precisely from about 5,000 MW in June 2015 to less than 3,000 MW in November 2017. Evidently, the problem of electricity generation in Nigeria can be described as multifaceted with the advent of gas-based electric power plant. For instance, in the 70s and 80s, most of the power plants in Nigeria were hydro-based, but the upsurge in electricity consumption has led to the construction of alternative gas-based plants, since Nigeria has a comparative advantage in gas production. However, despite this initiative, the incessant gas pipeline destruction has made most of the plants to be operating far below installed capacity (NERC, 2014; Oladeji, 2014).

Furthermore, NERC (2016) pointed out that the current total installed capacity of all the power plants in Nigeria handled by the power generating companies GENCOS[1] is around 10,000 MW with Egbin power plant contributing the highest of about 1,300 MW, whereas GENCOS is only contributing about 30% of installed capacity. In addition to the problem posed by the transmission companies, ironically, the government still owns 100% of the TCN[2], but the total capacity of power that can be transmitted to the national grid is just 5,000 MW. The implication of this is that, even if the GENCOs operate at full capacity, the TCN do not have enough facility to transmit all the power generated for distribution by the distribution companies (this includes 60% DISCOs that are owned by private sector and 40% owned by government). Surprisingly, the DISCOs on their part are still battling with the inherited dilapidated and moribund structures ranging from outdated wires and cables, obsolete transformers, among others, which largely have inhibited the capacity of the DISCOs to distribute electric power effectively.

All these problems highlighted above have continued to bedevil the power sector in Nigeria and they are taking their tolls on both the households' standard of living and industrial activities. This has made various end users to be looking for alternative sources of electricity supply, since the supply through the national grid is grossly inadequate and inefficient (Uzorh & Nnanna, 2014). Apart from the industrial sector, household units in Nigeria have continued to rely on different alternative sources of electricity power generation to improve their standard of living. It is obvious that leaving the electricity supply as an exclusive right of the government to provide is a complete misnomer in a developing country like Nigeria, where virtually every sector of the economy is experiencing upsurge in corruption every day, thereby crippling virtually all infrastructures, including electricity infrastructure (Popoola, Ponnle, & Ale, 2010).

In the quests of individual households in Nigeria to improve their access to electricity, some of them have been exploring some available sources of alternative supply of electricity. However, these efforts have been short-lived due to lack of available information on options opened to them in terms of alternative sources of electricity supply (ASES) available around their environments, the nature and the structure of such alternative sources of electricity supply. According to Omotayo, Olawuni, Oyajide,

---

1   GENCOS are generating companies in charge of power generation in Nigeria, they are privatized.
2   TCN are the transmission companies in charge of power transmission in Nigeria, owned by government.

and Babalola (2015), some private organizations and state government are trying to join the crusade of providing alternative source of electricity supply to households, since the Nigerian constitution made electricity generation a pure exclusive right of the federal government alone. These private entities and state government are also finding it difficult to assist the households in this drive to source for alternative supply of electricity due to lack of empirical information on the type, nature and the structure of available alternative sources of electricity supply around them (Oghogho, Sulaimon, Adedayo, Egbune, & Kenechi, 2014).

Having this information is necessary, because various sources of alternative supply of electricity exist with different implications in Nigeria, therefore, selecting the appropriate one for the right sets of households in a particular period is a major problem. For instance, the drive by various households to provide alternative source of electricity has led to quite a number of socio-economic implications on the households. These range from cost to convenience, noise pollution, among others. Despite various alternatives to electricity supply, a good number of the households are still uncertain about selecting the most appropriate choice of alternative electricity supply that will maximize their convenience at all times. Although there are few studies on alternative supply of electricity, the majority of them have focused more on impact analysis and concentrated more on solar energy leaving out other alternative sources of electricity supply that are opened to the households to make their choices (see Oghogho et al., 2014; Omotayo et al., 2015; Ismail, Ajide, & Akingbesote, 2012). All these studies were more concerned about the effects of ASES on socio-economic lives without exploring their nature and structure, which could have provided information and guide on appropriateness of a particular ASES that will maximize the satisfaction of the households.

Consequently, this study is an exploratory research effort with the major objective of analyzing the structure and the nature of alternative sources of electricity supply (ASES) available at the household level by providing answers to the following research questions.

Research questions

1. What are the various types of alternative sources of electricity supply available to the households?
2. What are the strengths and weaknesses of each of the alternative electricity source identified?
3. What is/are the best alternative source(s) of electricity supply for the households?

Research objectives

Apart from the major objective of analyzing the structure and the nature of alternative supply of electricity to the households, the following sub-objectives are also the focus of this study:

1) to identify various types of alternative sources of electricity supply available to the households;

2) to analyze the strengths and weaknesses of each of the alternative source electricity identified;

3) to guide the households, private organizations, state governments and other stakeholders on selection of the best alternative source(s) of electricity supply.

Hypotheses

H1:   *All the alternative sources of electricity supply do not have the same strengths and weaknesses.*

H2:   *Analysis of the structures and nature of alternative electricity supply does not have an effect on household choices.*

Scope

The study used Ekiti State of Nigeria as a case study. The selection of this state is premised on the fact that it is one of few homogenous states in the country in terms of culture and language. Again, it is the state with the highest percentage of literacy rate in Nigeria, therefore, a sizeable number of the households understand the research instrument with minimum assistance.

Definition of terms

Alternative sources of electricity supply (ASES): these are other sources of electricity generation available at the households' level apart from the national grid supplied electricity. From the literature, the most common alternative sources of electricity supply are generating set, solar powered inverter, inverter and rechargeable electrical appliances (Awosope, 2014).

Generating companies of Nigeria (GENCOs): these are electricity power generating companies in Nigeria.

National Electricity Regulatory Commission (NERC): this is the government agency that controls the supply of electricity in Nigeria.

Transmission company of Nigeria (TCN): it is the organization charged with the responsibility of transmitting the power generated to the national grid for distribution by the distribution companies.

Distribution companies (DISCOS): these are the organizations in charge of electricity power distribution in Nigeria.

Benin electricity distribution company (BEDC): this is the DISCO in charge of the electricity distribution in Ekiti State, which is the case study for this research.

1. LITERATURE REVIEW

Few literature exists on issues relating to alternative sources of electricity supply in Nigeria. Omotayo, Olawuni, Oyajide, and Babalola (2015) examined the economic effect of connecting solar power system to grid station, using the usual solar panels, but non-operational ones, and present a reliable and affordable autonomous energy system. According to them, performance of solar power plant was evaluated based on a developed model, which comprised photovoltaic array, battery storage, controller and converters. MATLAB/ SIMULINK software package was used to execute the model. Perturb and observe (P&O) algorithm was used for maximizing the generated power based on maximum power point tracker (MPPT) implementation. The outcomes of the developed model were validated and supported by a case study carried out using operational 28.8 kW grid-connected solar power plant located in Bayelsa State, Nigeria. Omotayo, Olawuni,

Oyajide, and Babalola (2015) took measurements of over 21 months' period, using hourly average irradiance and cell temperature. It was observed that system degradation could be clearly monitored by determining the residual (the difference) between the output power predicted by the model and the actual measured power parameters. The study concluded that solar power is a cost-effective energy source for countries with solar insulation and weak grid. However, the study noted that it is very important that the system is designed for the specific facility and that the required maintenance is communicated with the operator in order to get a reliable system that will be in operation throughout its expected lifetime.

Oladeji (2014) examined the renewable energy resources available in Nigeria and their capabilities. The study also examined various factors militating against effective utilization and harnessing of these vast and abundant energy resources. The study concluded that renewable energy resources

were well abound in the country, but they were not effectively utilized and, if properly harnessed, will be a sure solution to perennial energy shortage in the country.

Efurumibe, Asiegbu, and Onuu (2014) examined the available renewable energy sources in Nigeria, the amount available and the possible use of such renewable energy sources in Nigeria. This is aimed at promoting the adoption of renewable sources of energy in Nigeria. From the findings of the study, it was observed that Nigeria is blessed with so many renewable energy sources, which can be regenerated naturally, such as wind, solar, hydro, bio and agro. The study recommended that government should encourage more researches in the area of renewable energy sources, since Nigeria is blessed with these. Further, the study recommended the need for foreign investors in the energy sector, particularly in the area of renewable energy, since these sources hold good for the future of the world.

Oghogho et al. (2014) examined solar energy potential for sustainable energy generation in Nigeria. Also, the study examined the numerous issues involved in harnessing solar energy and clearly articulates a road map to enable Nigeria tap into this huge potential. The study observed that lying in the tropics Nigerian economy , receives abundant sunshine, where about 1,500 PJ (about 258 million barrels of oil equivalent) could be available to Nigeria annually from solar energy if solar appliances with 5% conversion efficiency were used over only one percent of the total land area of the country for about six months. Due to the numerous disadvantages of conventional fuel sources when compared with solar energy and the recent giant strides in improving solar cell efficiency using a photovoltaic (PV) device that converts 40.8% of light that hits it into electricity, Nigeria needs to reposition itself by investing in this invaluable resource to secure the energy future of our economy.

Uzorh and Nnanna (2014) investigated two power supply conditions in Nigeria, namely:

1) cost of power supply backed up by energy from generator set;

2) cost of power supply backed up by solar energy.

The data used by the study were collected through questionnaire and personal interview. The findings of the study showed that the average cost per unit of power consumption per KWh is between N59.29 for solar energy, N20.88 for grid electricity and N83.50 for energy from generator. Comparatively, the results obtained showed that it is much cheaper and safer to provide reliable power for manufacturing activities using power supply backed up by solar energy as better alternative to solve problem of power shortages in Nigeria.

Aliyu, Sani, Muhammed, and Yakaka (2013) assessed the power sector reforms from the Obasanjo Administration (1999) to date with a view to bringing out the problems and prospects, challenges and defects associated with the reforms. The study explored better ways of ensuring the success of the reforms by identifying certain key issues that must be addressed by government. The study used documentary analysis method in sorting out relevant information. The study concluded that the government needs to aim at overhand rather than severing with the existing situations in the energy and power sector, respectively, as well as the overall national socio-economic and political order. Abdulsalam, Mbamali, and Mamman (2012) assessed the availability (measure of readiness) of the source through field survey and experiments. In this work, historical trends of solar radiation pattern of some locations were collected, studied and analyzed. The annual mean of monthly global solar radiation is 22.88 MJ/m2/day, 18.29 MJ/m2/day and 17.08 MJ/m2/day for high, medium and low zones, respectively, while 12.06 hrs/day, 12.04 hrs/day and 12.03 hrs/day were found to be the solar sunshine duration for high, medium and low zones, respectively. It also shows that the length of the sunny period during a day is about 13 hours, about 1½ hour longer when no tracking is used. This would provide the potential and valuable aid for sustainable development in the design and installation of photovoltaic systems in Nigeria.

Oladokun and Adeshiyan (2012) used demand management-based design approach for reducing the capital cost of residential solar power supply system. Utilities and energy demands of thirty randomly picked homes in selected residential areas were studied. The houses were classified into one, two and three rooms' residential apartments.

New energy efficient appliances that can deliver the same or higher utility values as those already in use in these houses were identified and proposed as replacement to cut energy demand. Cost analysis of replacement with these energy star appliances was carried out. Solar system designs and associated cost models were developed for both the existing demand system and the proposed energy efficient demand system. For comparative analysis, appliances replacement cost was factored into the associated solar system capital cost. The average total energy demands were 1,255 W, 1,785 W, and 2,185 W for one, two, and three bedroom flats, respectively, while equivalent demands for energy efficient system are 389 W, 820 W, and 851 W, respectively. The cost of designing and installing a solar power with the replaced appliances exhibits a significant reduction of 64.88%, 64.5% and 62.16% for the one, two and three rooms residential set up, respectively. The study concluded that an integrated demand management design approach is very useful in reducing the capital cost of residential solar systems.

Ismail, Ajide, and Akingbesote (2012) assessed the performance of installed solar PV system in Oke-Agunla, Akure local government of Ondo State in Nigeria. Visits were conducted to the village; equipments on ground were examined while the people were interviewed. Both functional and non-functional facilities were traced to their manufacturers using the identification data on them and rated to ensure their efficiencies. Energy demands were also prorated, and observed the need to improve on the present energy supplied. The results of the assessments showed that PV facilities used were inadequate, trained technicians were not available, giving room for quacks working on the facilities occasionally resulted in further complications and poor facilities maintenance. Also, the assessment result showed that just 14.52% of the 4.5 kW installed solar PV was utilized due to significant malfunctioning and deterioration in performance. The study concluded that the installed solar PV systems were inefficient as a result of poor maintenance, lack of technical know-how and inability of the project contractors or managers to take these factors into consideration while embarking on the solar PV installations.

Dikko and Yahaya (2012) evaluate the wind power potential of some selected towns in north east-

ern part of Nigeria (Gombe, Maiduguri and Yola) based on the Weibull and Rayleigh models using 12-year monthly wind speed covering the period from 1994 to 2005. The findings of the study showed that Weibull is the best-fit model that describes the wind speed data at 10 m height. The reference mean power density (based on the measured probability distribution) was compared with those obtained based on the Weibull and Rayleigh models. In calculating the percentage error, the results showed that Weibull provided better power density estimation in all twelve months than the Rayleigh model. From the evaluation, the study observed that the north eastern part of Nigeria has higher wind power density for the generation of wind energy and highest power density (377 W/m2) was found to be in Gombe.

2. AIMS

From all the empirical studies reviewed, it is obvious that virtually no authors focused on analyzing all the available alternative sources of electricity with a view to providing the needed guide to make appropriate choice by the households and other stakeholders. Instead, most of them discussed the capacity of solar energy only as an alternative source of electricity supply. However, this study aims at exploring all the available alternative sources of electricity supply, especially to the households, compare them with one another in terms of their strengths and weaknesses with a view to providing the stakeholders with empirically grounded facts to make appropriate choices of alternative source of electricity supply.

3. METHODS

The study is an exploratory research, which focuses majorly on analyzing the nature and structure of available ASES in order to guide households in making right choices and assist government and interested private organizations with empirically grounded justification to support the households in provision of ASES. Therefore, since it is not an impact analysis, descriptive statistics are majorly utilized to make the results easy to interpret and understand, because major stakeholders that will benefit from this research outputs are grassroots households.

4. AREA UNDER STUDY

A cross section of the households from all sixteen local governments in the State are examined. Empirical studies in the past have shown that most households that have access to alternative electricity supply reside in the urban areas (Omotayo, Olawuni, Oyajide, & Babalola, 2015), consequently, the attention of this study is driven towards the households in the headquarters of each of sixteen local governments in Ekiti State. This will provide template for reaching the rural areas.

5. THE STUDY POPULATION

The households in the urban centers in Ekiti State, which comprise all the households in entire sixteen local governments in the State. This constitutes the population of this study. According to National Population Commission (NPC) (2016), the total population of Ekiti State is 2,384,212, in which there are 476,834 households.

6. SAMPLE SIZE AND SAMPLE SELECTION

Since it is not possible to cover all the households in the entire 16 local governments, the famous Yamane (2000) sample selection technique is adopted by the study. The calculation of the sample size is done as follows:

$$n = \frac{N}{1 + N \cdot (e)^2}, \qquad (1)$$

where n is the sample size, N is the population size (total number of households in each local government), e is acceptable sampling error; * 95% confidence interval is assumed (p = 0.5). (* acceptance at 5% level).

By substitution in the formula for each of the local governments, Table 1 shows the sample size per local government.

Table 1. Sample size

Sources: Authors' survey (2017).

S/N	Local government	Sample size using Yammne
1	Ado Ekiti	397
2	Ekiti East	394

S/N	Local government	Sample size using Yammne
3	Gbonyin	395
4	Ekiti South West	395
5	Ekiti West	396
6	Efon Alaaye	391
7	Emure	392
8	Ise/Orun	393
9	Ido/Osi	395
10	Ijero	396
11	Ikere	395
12	Ikole	395
13	Irepodun/Ifelodun	394
14	Moba	395
15	Ilejemeje	384
16	Oye	394
Total		5,906

The implication of applying the Yamane method is that approximately 5,906 households across 16 local governments of the State are covered in this study.

7. RESEARCH INSTRUMENTS

Questionnaires are used to collect responses from the households for the study. The questionnaires are developed by the researcher based on ideas obtained from the interactions with the households on the level of satisfaction received currently from electricity supply by the Benin electricity distribution company (BEDC), which is the DISCO distributing electricity in Ekiti State. The questionnaire used for the study consists of two parts.

The first part consists of questions that make it possible for the bio-data of each household heads to be collected. This part of the questionnaire elicits information about the gender, age, working category and employment duration of the respondents. The second part consists of questions on structure and nature of alternative sources of electricity supply. This part is further divided into different sections. The first section deals with questions that delve on ownership of alternative sources of electricity. The second section contains questions that have to do with the types of alternative sources of electricity supply (ASES) owned by each household and the third section contains questions addressing issues on the extent and the frequency of usage of these alternative sources of electricity. Furthermore, fourth section contains questions that delve on the social status of the each household. The fifth

section contains questions that address the awareness of the households of the existence of various alternative source of electricity supply. The sixth section includes questions that delve more on the demographic characteristics of the households, which are not contained in the bio-data part, and the last section contains questions on other factors that have either immediate or remote influence on the accessibility of households to alternative supply of electricity.

8. INSTRUMENT SCORING SCALE

The scale of response on the questionnaire is tilted towards the nature of estimating techniques used for the study. Majorly, the bio-data questions have specific responses, which are clearly explicit enough for the respondents to answer. However, for the questions that address other variables, descriptive statistics are used. Questions follow 5-point Likert scale from strongly agree, agree, undecided, disagree to strongly disagree. The calibrations for the positive items are such that they are scored: 5, 4, 3, 2 and 1. The negatively structured items are scored as follows: 1, 2, 3, 4, and 5, depending on the way the questions are framed.

9. METHOD OF ANALYSIS

Descriptive analysis is utilized in this study, because it has to do with fact finding and investigation of situation on ground regarding the structure and nature of alternative sources of electricity supply (ASES) in the area under consideration. Therefore, tools of analysis such as bar charts, pie charts, histograms, as well as percentage and ratio analysis, are utilized to examine the nature and the structure of the usage of ASES in the State.

10. RESULTS

This section of the research report explains the presentation and the analysis of the primary data for achieving the objective of the study. From the methodology, 5,906 households are involved in the survey and the analyses of their responses are presented below.

10.1. Response rate

Out of the 5,906 questionnaires distributed, 4,758 questionnaires are returned completed, translating to about 81% of the respondents. Thus, the response rate is in order and enough to commence empirical analysis. The response rate per local government is also analyzed. The numbers of questionnaires allotted to each of 16 local governments are shown in Table 2. Also, the number of questionnaires completed and the percentages are also indicated in the table.

Table 2. Analysis of response rate by local government

Source: Authors' survey (2017).

S/N	Local government	Sample size	Questionnaires returned	Percentage
1	Ado Ektit	397	390	98.2
2	Ekiti East	394	291	73.9
3	Gbonyin	395	286	72.4
4	Ekiti South West	395	295	74.7
5	Ekiti West	396	302	76.2
6	Efon Alaaye	391	305	78.0
7	Emure	392	249	63.5
8	Ise/Orun	393	267	67.9
9	Ido/Osi	395	306	77.5
10	Ijero	396	288	72.7
11	Ikere	395	372	94.2
12	Ikole	395	300	75.9
13	Irepodun/ Ifelodun	394	301	76.4
14	Moba	395	252	63.2
15	Ilejemeje	384	267	67.7
16	Oye	394	287	72.8
Total			4,758	–

Table 2 shows that there is highest response rate in Ado Ekiti local government, recording about 98% response rate. Ikere local government, Ikole local government in that order follows this. The reason for this might not be connected with the level of awareness of the people about ASES. During the survey, it is discovered that Ado Ekiti being the state capital accommodates the largest percentage of the elites in the State, thus granting the local government the dominance in terms of the response rates. Ilejeme and Moba local government areas have response rates of 67% and 63%, respectively, thus making them the least response rate recorded during the survey. An important factor noticed during the survey that is responsible for this outcome is that the farther away the local government from the state capital (Ado Ekiti), the lesser their re-

sponse rate. For instance, Ikere is about the closest town to Ado Ekiti and it enjoys the second highest response rate after Ado Ekiti, the state capital.

10.2. Bio-data/demographic analysis of the respondents

The bio-data analysis of the respondents include gender, age, education, employment and family size, among others.

Table 3. Gender distribution of households

Source: Output of authors' data analysis (2017).

Gender	Frequency	Percent
Female	1,300	27.3
Male	3,458	72.7
Total	4,758	100.0

Table 3 indicates that about 73% of the respondents are male, while 27% are female, implying that most of the household's heads in Ekiti State are male. Notwithstanding, the results also show that some of the homes in Ekiti State are headed by females. Out of the 4,578 households surveyed, 1,300 representing about 27% are female.

Table 4. Age distribution of households

Source: Output of authors' data analysis (2017).

Age	Frequency	Percent
30-40 years	2,132	44.8
40-60 years	2,210	46.4
60 years and above	416	8.7
Total	4,758	100.0

Table 4 explains the age distribution of the households. The results show that Ekiti households are largely dominated by youth and young adults. Both accounted for about 91% of the households covered in the survey. However, 8.7% of the households surveyed are headed by elders with age above 60 years. The above information shows the nature of the demographic features of the households in the State.

Table 5. Employment distributions of households

Source: Output of authors' data analysis (2017).

Employment	Frequency	Percent
Farming	442	9.3
Trading/artisan	1,768	37.2
Civil servants	2,548	53.6
Total	4,758	100.0

The distribution of the questionnaire is employment biased, since elites are major focus in the survey due to nature and the structure of the questions contained in the questionnaire. The result from Table 5 shows that this has an effect on the employment distribution of the households. Ekiti State has been shown to be a civil-servant dominated state through the survey. About 54% percent of the households are civil servants, 37% are either traders or artisans, while the remaining 9% are farmers. The distribution reduces the level of assistance required in completing the questionnaires, as most of the civil servants and the artisans can read and understand the questionnaires and complete them independently. Most of the households who are farmers are assisted and guided by the enumerators to complete their questionnaires.

Table 6. Family size of households

Source: Output of authors' data analysis (2017).

Family size of the households	Frequency	Percent
2	26	0.5
3	728	15.3
4	1,300	27.3
5	1,014	21.3
6	1,040	21.9
7 and above	650	13.7
Total	4,758	100.0

The households covered in the survey are of relatively large family size and from Table 6 it is observed that about 2,704 out of 4,758 households representing 53.7% of the entire households had four children or dependents and above. Notwithstanding, about 42% of the households are with either two children/dependents or one child/dependent. The family size is an important factor used as part of the variables in the structure of ASES usage.

Table 7. Education qualification distribution of households

Source: Output of authors' data analysis (2017).

Education qualification of the households	Frequency	Percent
No formal education	52	1.1
Primary school certificate	728	15.3
Secondary school certificate	1,196	25.1
Higher institution certificate	2,262	47.5
Post-graduate certificate	520	10.9
Total	4,758	100.0

From Table 7, it is shown that more than 85% of the households are educated, that is having secondary school certificate and above. The results further show that about 48% of the households are higher institution graduates. Households with just primary school certificate or with no record of formal education are less than 18% of the households. This category can be attributed mostly to the farmers, which are just about 17% of the entire population of household surveyed.

Table 8. House ownership

House ownership	Frequency	Percent
Tenant	1,612	33.9
Landlord	3,146	66.1
Total	4,758	100.0

This shows that the households included in the survey are either landlords or tenants. About 44% of the households are tenants, while 66% are landlords. This feature is necessary for analysis of structure of usage of ASES as well.

10.3. The nature of alternative sources of electricity supply (ASES)

In this subsection, the study examines the nature, type and the level of usage of ASES among households in Ekiti State. This will enable us to determine the predominant type of ASES, as well as the extent of usage, among others. The analysis starts

by investigating the proportion of the households using ASES. This is important, because some of the households might not be using ASES.

Table 9. Proportion of households using ASES

Households using ASES	Frequency	Percent
No	572	12.0
Yes	4,186	88.0
Total	4,758	100.0

Table 9 shows that large proportion of the sampled households use ASES. Specifically, approximately 88% of the total sampled households in Ekiti State are using ASES. This shows that the selected population for the study is in order. Again, it shows that many of the households in Ekiti State just like other part of the country have improvised different means of surviving the epileptic supply of electricity from the national grid. This is further shown in Figure 1.

However, since there are different types of ASES, the study further investigates the distribution of these various types of ASES among the households (which is limited to rechargeable appliances, generating set, battery inverter and solar inverter).

10.4. Usage of rechargeable appliances as an ASES

The first type of ASES investigated is the rechargeable appliances. These appliances range from the
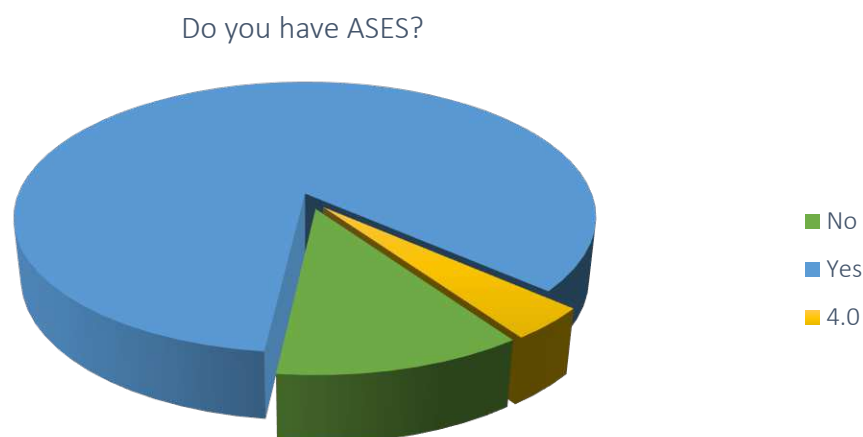
Do you have ASES?

Figure 1. Households using ASES

common electric bulbs, small radio, fans, and lamps, among others, that are recharged for usage.

Table 10. Ownership of rechargeable appliances

Ownership of rechargeable appliances	Frequency	Percent
No	572	12.0
Yes	4,186	88.0
Total	4,758	100.0

It is obvious from Table 10 that all the sampled households with ASES have rechargeable appliances. This is an indication that this is the most common type of ASES among the households in Ekiti State. Therefore, both Tables 9 and 10 confirm that about 4,186 out of the entire 4,758 sampled households in the study have different types of rechargeable appliances in their various homes. Afterwards, the rechargeable appliances are divided into two categories that are most common among households – torchlight/lamps and radio/fan. The distribution of their usage is presented in Table 11.

Table 11. Ownership of rechargeable lamps/torchlight

Ownership of rechargeable lamps/torchlight	Frequency	Percent
No	572	12.0
Yes	4186	88.0
Total	4758	100.0

Again, all the households using rechargeable appliances as their own ASES have lamps and torchlight. This further supports the claim that lamps and torchlight are the most common type of rechargeable appliances owned and used among the households in Ekiti State. The same Tables in 9 and 10 is presented in Table 11 showing that there is an overwhelming usage of these types of rechargeable appliance among the households.

Table 12. Ownership of rechargeable radio/fan

Ownership of rechargeable radio/fan	Frequency	Percent
No	3,276	68.9
Yes	1,482	31.1
Total	4,758	100.0

Table 12 shows that usage of rechargeable radio or fan is not common among the households. However, only about 31% of the households still have radios and fans that are recharged, while about 70% of the surveyed households do not have these types of rechargeable appliances in their various homes.

10.5. Usage of electricity-generating set as ASES

The second type of ASES investigated is the electric generating set commonly known as generator in Nigeria. The distribution of the usage among the sampled households is investigated and the result is presented in Table 13.

Table 13. Ownership of electric generating set

Ownership of generators	Frequency	Percent
No	728	15.3
Yes	4,030	84.7
Total	4,758	100.0

Table 13 shows the proportion of the households using electricity-generating set as ASES. About 85% of the households sampled are using electricity generator, while about 15% of the sampled households do not. From the above it appears that electric generator is also a common type ASES among the households in Ekiti State. Again, there are different types of electric generating sets. For this study, they are divided into three, namely small, medium and the big/installed type of electric generating set. The distribution of these types among the households is presented in Table 15.

Table 14. Distribution of types of electricity-generating set

Types of electricity-generating set	Frequency	Percent
Small	1,326	27.9
Medium	3,068	64.5
Big/installed	364	7.7
Total	4,758	100.0

The results in Table 14 reveal that medium size electricity-generating set is the most common among the households in Ekiti State having the

ownership proportion of about 65% of the entire households sample, thereby translating to about 3,068 households from the total 4,758 households. The results further show that the small type of electricity-generating set commonly called "I better pass my neighbor" has the second largest patronage by the households in Ekiti State.

10.6. Usage of battery/inverter as ASES

In recent years, it has been discovered that households in Nigeria have embraced the usage of battery/inverter as ASES. Ekiti State households are also not exempted in this new drive. The battery and inverter combine generate alternative electricity for households. The battery is recharged via either electric generating set or the national grid. The distribution of the ownership of such ASES is analyzed and presented in Table 15.

Table 15. Ownership of battery/inverter

Source: Output of authors' data analysis (2017).

Ownership of battery/inverter	Frequency	Percent
No	3,848	80.9
Yes	910	19.1
Total	4,758	100.0

The results from Table 15 show that the level of patronage of battery/inverter is relatively low among the households in Ekiti State. Only 19% of the households are using battery/inverter as ASES, while about four-fifth of the sampled households do not to use battery/inverter as means of alternative source of electricity supply. The reason for the low patronage might not be unconnected with its awareness and cost. The study also discovers that most of the few households that claim to be using battery/inverter are domicile in the state capital – Ado Ekiti. This simply indicates that there appears to be a direct link between the usage of this type of ASES and urbanization.

10.7. Usage of solar/inverter as ASES

The only difference between this and the battery/inverter is that the solar/inverter can be charged through the sunlight. It means that apart from the national grid supply of electricity-generating set, the battery is also connected to solar panels

mounted where they have access to sunlight. The sunlight charge the battery through the solar panels. It means that without national grid supply of electricity-generating set, the owner of the solar device can still enjoy electricity supply once there is sunlight. The distribution of the usage of this type of ASES is presented in Table 16.

Table 16. Ownership of solar inverter

Source: Output of authors' data analysis (2017).

Ownership of solar inverter	Frequency	Percent
No	4,238	89.1
Yes	520	10.9
Total	4,758	100.0

Table 16 shows that only 11% of the households are using solar/inverter as their ASES. This shows a slight reduction in the usage compared to battery/inverter. The reason for the low patronage is also the same as what we discussed under the battery inverter, which is the level of awareness and cost. The cost of solar/inverter is higher than that of battery/inverter, hence, the reduction in the patronage compared to batter/inverter. This simply indicates that solar/inverter is the least patronized ASES among the households in Ekiti State.

10.8. The extent of usage of ASES

The study examines the rate of usage of a selected ASES. This is also to determine the nature of the ASES, because it is discovered that some households occasionally use their own due to the nature of the ASES and supply of electricity from the national grid. Table 17 shows the response of households on the frequent usage of their ASES.

Table 17. Rate of usage of a selected ASES by household

Source: Output of authors' data analysis (2017).

Rate of usage of a selected ASES by household	Frequency	Percent
Rarely	1,534	32.2
Frequently	1,716	36.1
Very frequently	1,508	31.7
Total	4,758	100.0

The implication of the results in Table 17 is that the households use their ASES frequently. The report shows that about 36% of the households use their
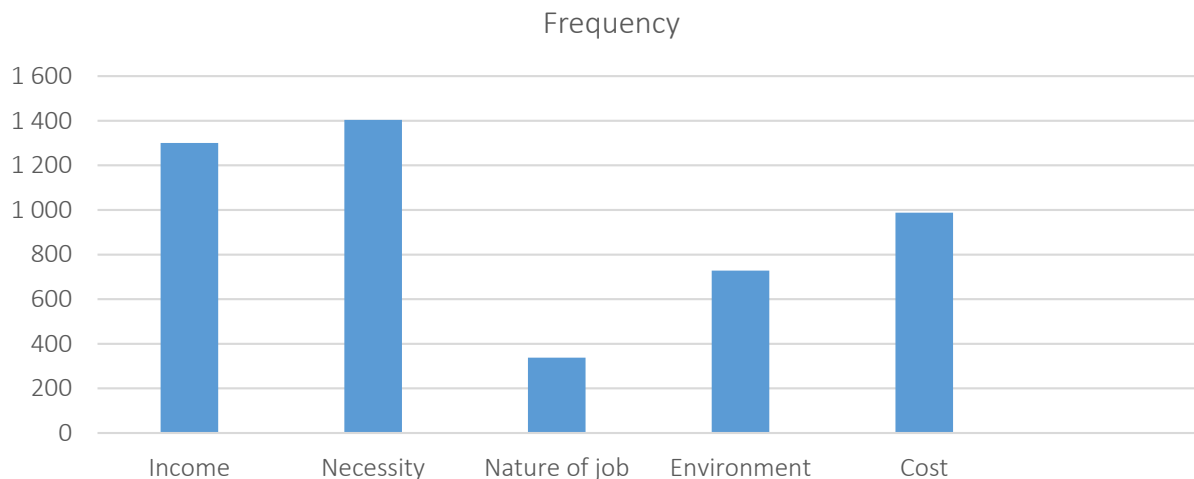
Figure 2. Factors influencing the choice of ASES

selected ASES frequently, while 31.7% use it very frequently. During the survey, interactions with the households show that the supply of electricity to different areas in Ekiti State is not the same. Some parts of the State rarely enjoy the supply of electricity from the BEDC, while some relatively enjoy steady supply. Consequently, the results in Table 17 might not be unconnected with this.

10.9. Factors responsible for selection of a particular ASES

Having identified four different types of ASES among the households in Ekiti State, the choice of any of four among the households is undoubtedly influenced by a number of factors. This is different from factors that are responsible for the usage of ASES, because these sets of households have been confirmed to be using ASES, but among the varieties of the ASES available, different factors may be attributed for the choice of a particular one amongst the four ASES identified in the study. The result of the investigation is presented in Table 18.

Table 18. Factor affecting choice of ASES

Factor affecting choice of a type of ASES	Frequency	Percent
Income	1,300	27.4
Necessity	1,404	29.5
Nature of job	338	6.1
Environment	728	13.5
Cost	988	23.5
Total	4,758	100.0

The study has shown that there are four prominent types of ASES among the households in Ekiti State, namely rechargeable appliances, electricity generating set, battery/inverter and solar/inverter. Out of these four categories, some factors considered by individual household before making their choice of ASES are analyzed and presented in Table 18 and Figure 2. It is observed from the table that income and necessity are the most important factors responsible for determining the choice of a particular type of ASES among the households. For instance, 27.4% and 29.5% of the households identify income and necessity, respectively, as the major factors that influence their choice of a particular ASES. The combination of two account for about 57% of the entire population of the households covered in the survey.

Again, the cost of the ASES is another important factor considered by the households before making the choice of a particular ASES. About 24% of the households identify the cost of a type of ASES as the major factor responsible for their choices. The implication is that before a household in Ekiti State makes a decision of going for a certain type of ASES, it considers his income and necessity, as well as the cost of the ASES. Furthermore, the nature of their jobs and environment might not be important factors that influence their choice of ASES, as they only account for 6.1% and 13.5%, respectively, of the entire households in the study.

10.10. Nature of the challenges in the use of ASES

The study further examines the nature of problems faced by individual household in using selected ASES. Since the nature of the ASES varies, the nature of problem associated with each of them may vary. But these problems can be broadly categorized into the following: problem of charging the ASES; cost of maintenance which might be in terms of fuelling and servicing in the case of households using generator; durability – that is how long lasting they are and lastly limited capacity. The distribution of the responses of the households is presented in Table 19 and Figure 3.

Table 19. Common problems associated with ASES

Common problems associated with ASES	Frequency	Percent
Charging	702	14.6
Durability	260	5.5
Maintenance	962	20.3
Limited capacity	2,834	59.6
Total	4,758	100.0

It is obvious from Table 19 that the major problem faced by the households with their selected type of ASES is the limited capacity. About 60% of the households agree that the inability of their choice ASES to effectively power some of their electrical appliances at home is the major challenge they are facing using the ASES. However, 962 of the 4,758 household, which amount to about 20% believe that the major challenge they face in using their ASES is cost of maintenance. Out of the four identified ASES in the study, the households using electric generator are mostly prone to facing this type of challenge. Fuelling and servicing of the generator are the most challenging tasks faced by households using them.

It should be recalled that a sizable number of the households use rechargeable appliances. These sets of households have identified the problem of charging the appliances as their major challenge. Also, some of the households using either solar or battery inverter might also face the same problem. About 15% of the households in the survey face this kind of challenge, but it is obvious that those households using generator might not have anything to do with the problem of charging.

10.11. Analysis of strengths and weaknesses of various ASES

Furthermore, this study assesses the rate at which the households are affected by various limitations of the four identified ASES. General limitations identified by the respondents are regularity in supply, maintenance cost, limited capacity and affordability.

The percentage distribution of the ratings on major and common limitations associated with each ASES is shown in Figure 3 where 49% of the household's rate solar powered as the most regular form of ASES. This is followed by rechargeable appliances 21% and closely followed by battery, which is 20%. However, electric generating set receive the minimum rating of 10%. The implication of this result is that solar powered electricity generating system provides more regular supply of electricity than other ASES covered in the study while electric generating set (generators) offered the most irregular supply of electricity.

The maintenance of the ASES is viewed in terms of cost and ease of maintenance. To be able to ensure regular supply of electricity through these four types of ASES efforts are needed from the households to ensure adequate maintenance of these items. For instance, those households us-
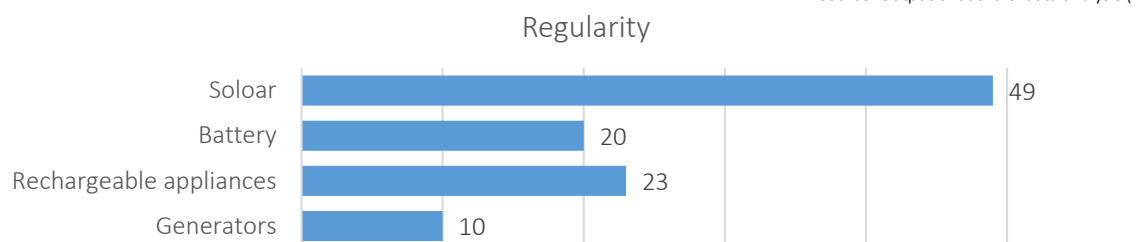
Figure 3. Ratings on regularity

Maintenance

Type	Value
Soloar	14
Battery	25
Rechargeable appliances	10
Generators	51
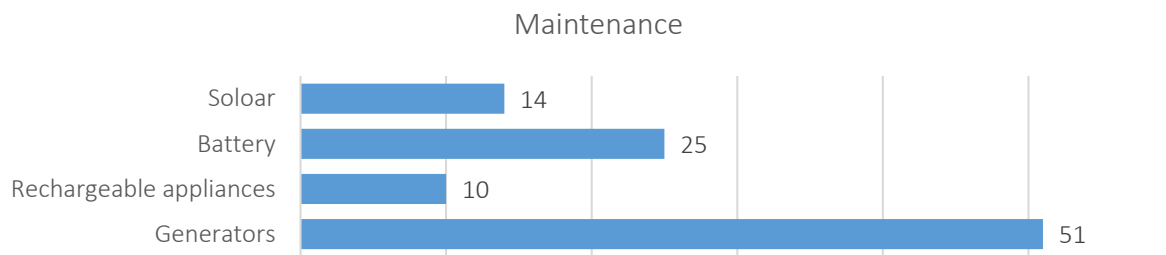
Figure 4. Ratings on maintenance

Capacity

Type	Value
Soloar	34
Battery	28
Rechargeable appliances	6
Generators	32
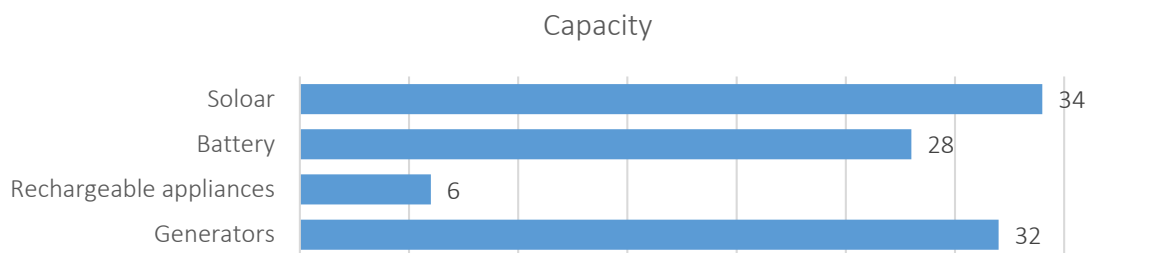
Figure 5. Ratings on capacity

ing electricity-generating set (generator) as ASES apart from supply of fuel to power the generator, also need to ensure that the generators is regularly serviced before supply of power can be guaranteed regularly. In Figure 4, 51% of the households believed that high cost of maintenance is associated with generator making it the type of ASES with the most challenging form of maintenance. For the remaining type of ASES charging them appears to be the most challenging form of maintenance faced by households.

25% of the households report that battery/inverter have the second most challenging form of maintenance. This is because battery/inverter usage have the most daunting task of being charged by BEDC (national grid supplied electricity) or generator. Without the presence of power supply from the national grid or the generator, the inverter cannot supply electricity to the household. The solar type of ASES is the next on this line, because it uses sunlight, which they don't need to pay for but seasonal changes affect the usage of solar, but it is very efficient during the dry season. Finally, 10% of the household's rate rechargeable appliances as the ASES with the least challenging form of maintenance. The reason for this might not be unconnected with its portability especially with items such as rechargeable lamps and bulbs, which can

be very mobile and thus enable the household to move them from one place to the other to charge them.

The problem of limited capacity remains the most common challenge affecting all the ASES. The households sampled in the survey rated solar and generator similarly in terms of their capacities. Both are rated 34% and 32%, respectively, as having high capacity. It should be noted that some domestic electric appliances such as refrigerators and air-conditioners might be consuming more voltage that will not permit the usage of some ASES. However, solar and generator can still power some of these high voltage consuming appliances depending on the size (AMPs) of the generator and the AMPs of the solar panels, but this also comes with increasing cost. Usage of battery/inverter receives 28%, as it can also be upgraded to power some high voltage consuming electrical appliances but charging the battery is a major problem. The ASES least rated in terms of capacity is the rechargeable appliances. These items are limited mostly to illumination (rechargeable bulbs and lamps), small radio set and fan.

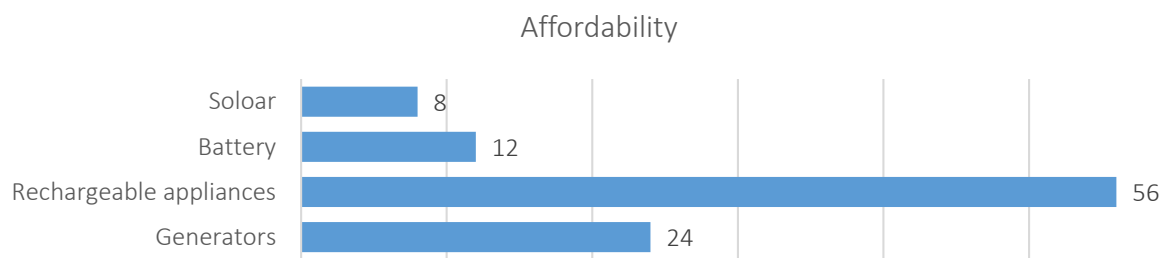It is obvious from Figure 6 that 56% of the respondents' claim that the most affordable form

Affordability

Figure 6. Ratings on affordability

of ASES are the rechargeable appliances. The cost of purchase of this ASES is the cheapest of all the costs of the four ASES. However, battery and generator with 12% and 24%, respectively, are the next in the rating. The financial implication of mounting a solar powered electricity generation appears to be the highest, hence the least affordable to the households. In spite of all the limitations associated with the rechargeable appliances, it is the most affordable to the households.

11. DISCUSSION

Considering the first objective of this study, the results have shown that there exist four major types of ASES with different features. It was found out that the dominance of each of the ASES is predicated on many factors ranging from the households demographic structures, education, social status and geographical location among others. The four are rechargeable appliances, electric power-generating set (generator), battery/inverter and solar/inverter. These four types of ASES are predominantly used among the households, although their usage vary across different communities, levels of work and social status, among others. Furthermore, the usage of some of these ASES is regular among the households. In other words, the usage of ASES is very common among the households. Furthermore, the study discovers that a good number of the households in Ekiti State have access to ASES and the usage of it is very rampant and prominent among them. Surprisingly, a few number of households residing majorly in the rural areas show ignorance on the existence of some types of ASES like solar and battery/inverter. The study finds out that few of these households have the financial capacity to have these types of ASES, but lack proper awareness of their usage debar them from using them.

The second objective of the study is to do with the hypothesis that: "All the alternative sources of electricity supply do not have the same strengths and weaknesses". Findings from the study have shown that the hypothesis is accepted, which indicates that all the four identified ASES have varying degrees of weaknesses and strengths in terms of their usage. For instance, the households identify low level of income, as well as lack of proper awareness of the existence of some of the ASES as the major factors that limit their accessibility to them. According to the findings of the study all the households would have loved to have solar type of ASES, but the constraints imposed by their levels of income and proper awareness of usage are major snags preventing them from using it.

Again, the study discovers that there are four major challenges faced by the households in usage of ASES and they are rated differently with respect to the four major forms of ASES identified in the study. In terms of regularity, the study concludes that solar and rechargeable appliances offered the most constant alternative supply of electricity among the four ASES, while electricity-generating set is rated the lowest in this category. With respect to capacity, rechargeable appliances are rated the least. Again, solar offers the highest supply of voltage among the ASES, this is followed by electric generating set but their capacity depends on the expenses on them.

With respect to maintenance, electric generating set is adjudged the most difficult ASES to maintain as it requires fuelling and constant servicing. According to the results from the survey, solar and rechargeable appliances are the easiest to maintain among the four ASES. However, charging them is the major challenge faced by the households. In terms of affordability, it is discovered

that rechargeable appliances are the most affordable among the ASES, while solar is the most expensive among the ASES. The solar powered form of ASES is also the most preferred, but the cost is the major hindrance.

The third objective of the study is to investigate the structure and nature of the ASES and the implication on the households' choices. Findings from the study have shown that analyzing the structure and the nature of the ASES is very important in making appropriate choice of ASES by the households. For instance, it is confirmed from the study that out of all the positive ratings such as regularity in supply, ease of maintenance and capacity, solar powered source of alternative electricity supply appears to be the best.

CONCLUSION

It can be concluded from the findings that the only rating that is unfavorable to the solar type of ASES is in the area of affordability making it the most suitable for the households provided governments can come in to cushion the effect of the high cost. Consequently, the state government in conjunction with some interested private organizations can embark on establishment of solar powered stations for some communities or distribution of solar panels and inverters at subsidized rate to households in the State. This should be accompanied with aggressive awareness program to familiarize the inhabitants of rural areas on the usage of solar type of ASES. This will go a long way to improve the socio-economic well-being of the households in the State and in Nigeria in general.

ACKNOWLEDGEMENT

REFERENCES

1. Abdulsalam, D., Mbamali, I., Mamman, M., & Saleh, Y. M. (2012). An Assessment of Solar Radiation Patterns for Sustainable Implementation of Solar Home Systems in Nigeria. *American International Journal of Contemporary Research, 2*(6), 238-243. Retrieved from http://www.aijcrnet.com/journals/Vol_2_No_6_June_2012/27.pdf

2. Al-Salaymeh, A., Al-Hamamre, Z., Sharaf, F. M., & Abdelkader, M. R. (2009). Technical & Economical Assessment of the Utilization of Photovoltaic Systems in Residential Buildings: The case of Jordan. *Energy Conversion and Management, 51*(8), 1719-1726. https://doi.org/10.1016/j.enconman.2009.11.026

3. Aliyu, I., Sani, M. K., Muhammed, A. A., & Yakaka, A. (2013). An Assessment of the Power Sector Reforms in Nigeria, *International Journal of Advancements in Research & Technology, 2*(2), 1-37. Retrieved from http://www.ijoart.org/docs/An-Assessment-of-The-Power-Sector-Reform-in-Nigeria.pdf

4. Dikko, L., & Yahaya, D. B. (2012). Evaluation of wind power density in Gombe, Yola and Maiduguri, North eastern Nigeria. *Journal of Research in Peace, Gender and Development, 2*(5), 115-122. Retrieved from http://internationalresearchjournals.org/full-articles/evaluation-of-wind-power-density-in-gombe-yola-and-maiduguri-north-eastern-nigeria.pdf?view=inline

5. Efurumibe, E. L., Asiegbu, A. D., & Onuu, M. U. (2014). Renewable Energy and Prospect in Nigeria. *Scholarly Journal of Scientific Research and Essay (SJSRE), 3*(6), 73-76. Retrieved from http://scholarly-journals.com/sjsre/publications/2014/July/pdf/Efurumibe%20et%20al.pdf

6. Ismail, O. S., Ajide, O. O., & Akingbesote, F. (2012). Performance Assessment of Installed Solar PV System: A Case Study of Oke-Agunla in Nigeria. *Engineering, 4,* 453-458. Retrieved from https://pdfs.semanticscholar.org/72ab/d49477b1ed83dd7f09596ca78a39e0d31be2.pdf

7. Karekezi, S., & Kithyoma, W. (2002). Renewable energy strategies for rural Africa: is a PV- led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa. *Energy Policy, 30*(11-12), 1071-1086.

https://doi.org/10.1016/S0301-4215(02)00059-9

8. NERC (2014). Nigeria Electricity Regulatory Commission. Quarterly reports, 2014.

9. NERC (2016). Nigeria Electricity Regulatory Commission. Quarterly Reports, 2016.

10. Oghogho, I., Sulaimon, O., Adedayo B. A., Egbune, D., & Kenechi, A. V. (2014). Solar Energy Potential and Its Development for Sustainable Energy Generation in Nigeria: A Road Map to Achieving this Feat. *International Journal of Engineering and Management Sciences (IJEMS), 5*(2), 61-67. Retrieved from http://science-andnature.org/IJEMS-Vol5(2)-Apr2014/IJEMS%20Vol5(2)-2.pdf

11. Oladeji, J. T. (2014). Renewable Energy as a Sure Solution to Nigeria's Perennial Energy Problems- an Overview. *Researcher, 6*(4), 45-50. https://doi.org/10.7537/marsrsj060414.11

12. Oladokun, V. O., & Adeshiyan, S. A. (2012). Demand Management Based Design of Residential Solar Power Supply System: A Techno-Economic Evaluation. *American Journal of Scientific and Industrial Research, 3*(1), 21-26. https://doi.org/10.5251/ajsir.2012.3.1.21.26

13. Omotayo, M. E., Olawuni, A., Oyajide, D. O., & Babalola, F. A. (2015). Economic effect of connecting renewable energy to Grid Station in Nigeria. *American Journal of Research Communication, 3*(6), 142-149. Retrieved from http://www.usa-journals.com/wp-content/uploads/2015/05/Emmanuel_Vol36.pdf

14. Uzorh, A. C., & Innocent, N. (2014). Solution to Power Generation Shortages Using Solar Energy. *The International Journal of Engineering and Sciences, 3*(6), 23-27. Retrieved from http://www.theijes.com/papers/v3-i6/Version-2/D0362023027.pdf

15. Villavicencio, A. (2002). *Sustainable energy development: the case of photovoltaic home systems*. Report for UNEP Collaborating Centre on Energy and Environment, Riso National Laboratory, Roskilde, Denmark.