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Factors Influencing Solar Photovoltaic Utilization for Energy Services among Residentials in Akure, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author JOA designed the study. Author AOF performed the statistical analysis, managed the literature searches and wrote the first draft of the manuscript. Author AAO managed the analyses of the study and wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Residential sector is the largest electricity consumer in Nigeria. But they also contribute heavily to the climate change through their choice of energy. Mostly prefer source is the fossil fuel for electricity generation despite the growing awareness of the need to reduce greenhouse gas emissions by embracing renewable energy technologies across the globe. Hence, this study investigated the factors influencing solar PV utilization in Akure.
Study Design: The study employed a survey research design.
Place and Duration of Study: Three residential estates in Akure, Ondo State, Nigeria formed the study areas. The study was conducted between June 2019 and July 2019.
Methodology: The study surveyed 292 households located in the three residential estates in Akure, Ondo State and 219 retrieved questionnaire were found usable for the analysis. Data was analysed using the mean ranking of the influencing factors.

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Results: The results revealed that the highest ranking factor influencing utilization of Solar PV for energy services is that Solar PV is a good backup against power failure. This is as a result of the erratic power supply in Nigeria which has not only failed to meet the need of household but also hampered economic growth. However, the least ranking factor influencing solar PV utilization for energy services is Ability to sell electricity to the national grid.
Conclusion: Cooperation between private enterprises and relevant government agencies supported by 'political will' is required to promote the aforementioned factors influencing the solar PV utilization for energy services in Nigeria. Utilization of solar PV as an energy source for energy service ensure access to affordable, reliable, sustainable and modern energy for all. The research recommended that government support for solar PV intervention should be further encouraged.

Keywords: Solar photovoltaic; energy services; energy supply; renewable energy; residential; sustainable development.

1. INTRODUCTION

The use of solar photovoltaic is increasing popular and affordable as the prices is reducing due to more findings from the research laboratories. The search for sustainable energy as contained in the sustainable development goals (SDGs) might have been responsible for this outcome [1]. Knowing fully well that the heads of states of various government even attested to the fact that SDGs is not attainable without access to efficient energy [2] which is able to mediate the reduction in poverty, good education and improvement in health services [3,4,5,6].

Nigeria is a nation that is endowed with both natural and human resources. The country boasts of over 200 million people with about 2.5 percent annual growth increase suffers from epileptic power supply [7]. However, the country is blessed with abundant of solar radiation every day, which could have been tapped to tackle the problem of electricity supply [8]. Nevertheless, the plan of the country in the drafted renewable energy master plan (REMP) revealed the supply of eighteen percent (18%) of electricity from solar energy by 2020 [9].

The most pursue renewable energy source is solar photovoltaics (PV) because it is environmentally and weather friendly, low maintenance, possibility of expandability, it requires no fuel, it has no pollution, and it also has no noise. This system works by converting sunlight into electrical power. It is achieved by using a thin layer of semi-conducting material, normally silicon, concealed in a plastic casing or glass. They could have different sizes ranging from small versions used to power-on wrist watches to a system of hundreds of square meters of solar PV panels integrated to power small or large buildings. It is one of the cleanest forms of energy as it doesn't release emissions to the environment and its source is inexhaustible. The potential for electricity generation from solar energy is enormous.

Nigeria has had its own share of the impacts of climate change. This effect can be seen in the constant erosion and flooding of the Niger-Delta region of the country, the desertification of the northern region and the drying up of Lake Chad. If actions are not taken to combat climate change, the cost of adaptation will certainly be more than the cost of mitigation. For instance, the post disaster assessment of the 2012 flood in Nigeria estimated the amount of damage caused to be around US$17 billion (Nkwunonwo, 2016). This amount is 2 percent of the real GDP in that year.

The mitigation of dangerous anthropogenic climate change is seen as one strong driving force behind the increased use of renewable energy such as wind, solar, hydro and biomass [10]. Renewable energy offers the opportunity to contribute to a number of important sustainable development goals among which are: social and economic development, energy access, energy security, climate change mitigation and the reduction of environmental and health problems [1].

According to Onasanya [11], Household energy consumption accounts largely for climate change. Energy conversion from traditional sources in households will play a major role in the mitigation of climate change and its effects. Electricity consumption is an important and large part of household energy consumption, therefore its production from a sustainable source will be hugely significant in combating the present climate change issues.

Nigeria consumers of electricity could be classified into three major groups which include: The industrial sector; the commercial sector and street lighting and the residential sector. Residential sector is by far the largest electricity consumer in Nigeria, followed by the commercial sector and street lighting then the industrial sector [8]. This however highlights the importance of sustainable residential energy use in the quest for curbing climate change.

One of such communities is Akure, the capital city of Ondo State in South-western Nigeria. The State is nicknamed “sunshine state” because of its equatorial location and the climatic condition, solar radiation is appreciable for a good part of the year. There are two distinct seasons: the rainy season which starts in April and peaks in June through September and the dry season which begins in November and lasts till April [12]. It is an agrarian and educational centre situated in the central part of the State. Akure is a medium sized city with population of 360, 268 people according to the 2006 National Population and Housing Census. It is home to the best university of Technology in Nigeria; Federal University of Technology Akure, Akure [13]. It is located about 311km North-east of Lagos, about 370m above sea level. In addition, the State is an oil producing state, and has been classified as a Millennium Development City. All these factors collectively influence population growth of the city.

The three housing estates are located within the city at different areas. Ijapo Housing Estate is located within the peripheral zone of the city in close proximity to Okeljebu roundabout. It is a mixture of prototype-housing design and site-and-services. Alagbaka Housing Estate Extension is also located in the peripheral zone of the city in close proximity to the Bishop's Court roundabout. It is a site-and-services estate where the residents purchased the land from the government in order to build by themselves while government provides the services. Conversely, Sunshine Gardens Housing Estate in located in a suburb of the Akure city called Oba-Ile. It is a prototype-housing estate built through Public-Private Partnership between the State government and a private developer, who built all the houses and provided the services, while the users purchased the already finished houses.

There is a need to investigate the status of the Solar PV system as well as the factors that could be influencing the use of solar PV for energy services. This is because appreciable number of Solar PV installation now exists in the communities. It has been documented in the industrialised countries that public acceptance of renewable energy technologies is crucial to their successful introduction into society [14]. This is because poor public acceptance of renewable energy technologies could hinder the implementation of sustainable energy technologies which hampers the attainment of important environmental and societal goals [15].

The article is divided into five sections. Section 1 introduces the article; section 2 presents the theoretical and empirical reviews as well as the status of Residential estates in Nigeria. Section 3 and 4 present the methodology used to carry out the study and results analyses respectively, while section 5 concludes the article.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This section provides the theories and empirical reviews of the study as well as the status of residential Estates in Nigeria.

2.1 Theory of Reasoned Action

The theory of reasoned action (TRA) provides a model and explains how and why attitude affects behaviour [16,17]. According to the theory, intention to perform certain behaviour precedes the actual behaviour. This intention is known as behavioural intention, and comes as a result of the idea that performing behaviour will lead to a specific outcome [18]. Behavioural intention is important to the theory because these intentions are determined by attitudes to behaviours and subjective norms as shown in Fig. 1. Feng [19] stated that an individual’s behaviour is determined by his/her attitude toward the outcome of that behaviour and by the opinions of others within his social environment. Based on this TRA, the first determinant is personal to each individual which is called “attitude towards the behaviour” and refers to *attitudinal factors.* The second determinant of intention is the individual’s perception of the social pressure put on him/her to perform or not to perform a particular behaviour and refers to *subjective norm.*

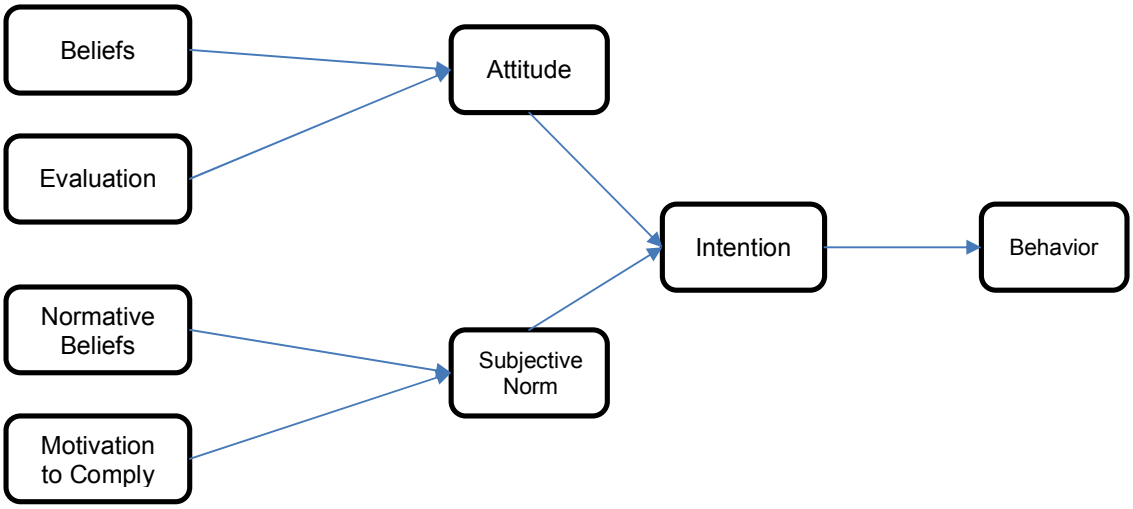

Fig. 1. Theory of reasoned action Source: Ajzen and Fishbein [16,17]

2.2 Empirical Literature on Factors Influencing Utilization of Solar PV for Energy Services

The community involvement which involved regular public meetings with the people in the community and funding policy to encourage the citizens was revealed in the study of Reinsberger and Posch (2014) as factors which influence photovoltaic utilization in Austria [20].

According to Fischer and Sauter [21], social references seem to influence both acceptance and resistance to renewable energy technologies as friends and neighbours seem to be important references for investing in solar panels.

Some studies pointed out that government policy is an important factor influencing utilization of renewable energy [22]. Solar Photovoltaic (PV) could face opposition and barriers due to public perception, policy design, Not In My Backyard (NIMBY) syndrome and lack of information about its impact on landscape and the environment [23]. Verbruggen et al. [24] argued that policies affect directly Solar Photovoltaic (PV) costs, prices, and technology innovation.

According to Graziano [25], education influences decision of utilising agents in various ways. Education affects the pre-utilization process in that it provides utilising agents with the tools to understand and be acquainted with the direct and indirect advantages of utilising Solar Photovoltaic (PV). Few studies have shown that higher education attainment and training increase the likelihood of Solar Photovoltaic (PV) utilization [26] as information plays a key role in the diffusion of Solar Photovoltaic (PV).

Shen, Lin, Yue, Liu, Chen, and Yang [27] examined factors influencing utilization and sustainable use of clean fuels and cook stoves in China. They found that household characteristics (such as family size, age, gender, household income, location and structure), knowledge and public awareness about the technology (such as higher education, publicity and demonstration), policy and regulations, financial support from the government and renewable energy market development are all significant in influencing the utilization of clean fuels and cooking stoves in China.

In Africa, Ng'eno [28] also conducted a study among household in Kenya on the factors affecting the utilization of solar power technology for domestic power usage. The study revealed that the level of knowledge and awareness of solar technology, level of income of households, and availability of substitute power source influence the utilization of domestic solar technology.

Akinboro, Adejumobi, and Makinde [29] in a review of solar energy system in Nigeria highlighted some problems confronting solar installations as affordability, the present level of research and development, lack of awareness, the technology of equipment and fabrication, government policy, the cost of generation among others. This was corroborated by Adeyemo [30] in a study of solar energy powered projects in Lagos state, analysing the failed projects and understanding the reasons for the failure of the

projects. He opined that security risks, poor understanding of the consumption rate/local need, maintenance, technical problems, price and economic sustainability, little awareness, communication challenges are the challenges facing solar energy projects in Nigeria.

In the view of Ohunakin, Adaramola, oyewola and Fagbenle [31], variability and intermittency of radiation, lack of awareness and information, high initial investment cost, grid unreliability, operation & maintenance cost, government policy & incentives, ineffective quality control of products, insecurity of solar plant infrastructure and competition with land use are some of the challenges facing the utilization of solar energy system in Nigeria.

Awogbemi and Komolafe [32] evaluated solar energy, hydropower and wind energy which are the major renewable energy sources in Nigeria and opined that major constraints to the expansion of solar utilization in Nigeria are cost, unfriendly government policy, solar technologies are not manufactured locally.

Akinbami [33] stated that besides hydro power and biomass, other sources of renewable energies have not been fully exploited. The current contribution of renewable energy is 0.6% of the total generating capacity in Nigeria (ECN, 2006).

According to Akinbami [34], there are five major barriers to the deployment of renewable energy technologies. These barriers are: Lack of technological capability, High cost of investment of renewable energy, financial constraints, low level of public awareness, and lack of a comprehensive national energy policy.

Table 1. Factors influencing utilization of Solar PV system by (residential) participants

Category	Factors	Description
Institutional factors	Lack of administrative assistance	Consumers sought for information regarding solar PV system themselves e.g. through seminars and professional advice. This may result in a situation where consumers may be ill-informed or exploited
	Inadequate policy	The absence of appropriate policy to expand the solar market and encourage adoption (for e.g. effectual government subsidies).
	Absence of feed-in tariffs	“The idea that solar PV system can generate money for users is fantastic, but unfortunately the grid system within the country is very poor and at the moment can't allow excess generated electricity by users to be transferred back to the grid to generate money”.
	Inability to access loans to purchase a solar system	“Using solar in Nigeria seems a thing for only the upper class in the society, as it is difficult to access grants/loans to facilitate acquisition of the system due to its exorbitant cost”.
Social factors	Pride of having solar PV system	“It gives a sense of class and pride. It gives a little social class”.
	Joy of having regular electricity supply	“The joy derived from not depending solely on the irregular electricity supply by Power holding company of Nigeria (PHCN). It is a comforting feeling”.
	Sustainability	“Environmental stewardship in my little way to reduce environmental impact
	Awareness of the technology	Awareness of the technology and its benefit through a seminar. (e.g. it's environmental benefit and low maintenance cost).
	Past experience	“A friend's experience with the technology encouraged my purchase of the system.”
	Awareness/information	“It was somewhat difficult to get right and detailed information regarding the system, it’s capacity and how it works etc.”.

Category	Factors	Description
	Fear of theft and vandalization	"If this is stolen or destroyed due to violence…it will be a big loss".
Technological factors	Appropriate roofing	"Solar installation was not considered in my initial roofing plan, redesigning takes up extra cash".
	Good backup against power failure	Solar PV system serves as a back-up supply when there is power outage
	Technological reliability	"The reliability of the technology makes it attractive, though expensive"
	Technological Risk	It is a new technology not so known and trusted, it is therefore a calculated risk.
	Technical configuration	"The technical know-how needed to use or set up the system".
Monetary/ Finance factors	High Cost	"The high cost of the system was a big issue to deal with".
	Access to financial assistance (loan)	Inability to access loan from banks
	High interest rates and short term loans	Interest rates ranging from 20%- 22% per annum and short period of payback from 1-3 years for energy efficient investments makes the conditions difficult.
	Unforeseen cost	"It's relatively a new technology, so one is unsure of what may happen with the technology in terms of repair".
	Future Income generation	"Regardless of inability to resell to the grid just yet, perhaps in the future one might be able to do so".
Environmental Factors	Safe for the environment	"To reduce emission from my diesel generator for the benefit of the environment".
	Exposure to solar radiation	"There is actually long hours of sunshine in my area, which is a good thing".

For the individuals that adopted the solar PV system, their decision type could be categorized as optional innovation-decision. According to Rogers [35] such decisions are choices to utilize or reject an innovation that are made by an individual independent of the decisions of the other members of the system. The range of factors is presented below in a Table 1.

There are few studies which have examined the awareness and attitudes of members of the public towards renewable energy usage in Nigeria [10,36]. However, there is a dearth of study being conducted on the utilization of solar PV among residential in Nigeria despite that this category of users consume the largest amount of energy in the Country. Majority of these households utilise privately owned fossil fuel energy generators to carry out their daily activities as there is a limited supply of electricity from the national grid. Hence, this study investigates the factors influencing Solar PV utilisation for energy services due to the importance of these factors and given the lack of study particularly among residential in Nigeria that would allow the dynamics of their use.

2.3 Status of Solar PV Utilization for Energy Service

The status of solar Photovoltaic market is a rapidly growing worldwide [37]. During the period between 2000 and 2015 the growth rate of photovoltaic installations was of 41%. It is observed that China and Taiwan since 2006 have been increasing the photovoltaic industry with strong growth rates. At the end of 2015, its market share was about 71% of global sales. The market for photovoltaic systems will likely continue to grow in the future as strongly as so far, due to the thrust of subsidies, tax breaks and other financial incentives. Support for R & D and photovoltaic technology change is crucial aspects in accelerating the widespread utilization of photovoltaic systems.

Europe contributed 40% of total cumulative PV installations in 2015 (in 2014 it was 48%). European countries such as Germany, Denmark

and Spain, in addition to Asian countries China and Taiwan, have used feed-in tariff (FIT) which is a political mechanism to encourage consumers to invest in renewable microgeneration. On the other hand, the United States, United Kingdom, Japan and Sweden, have used the RPS (Renewable Portfolio Standard), which is a regulation that requires that part of the energy consumed comes from renewable sources [37].

The facilities in China and Taiwan accounted for 21% of total cumulative installations (in 2014 was 17%). In 2015, Germany accounted for about 16% (39.6 GWp) of cumulative installed PV capacity worldwide (242 GWp). In 2015, the newly installed capacity in Germany was about 1.4 GWP; in 2014 it was 1.9 GWp. In total, 1.5 million photovoltaic systems were installed in Germany [37].

Jesuleye [38] analyzed the current status of Solar Photovoltaics (PV) for lighting in Danjiwa and Dahuwa remote villages that are pilot sites for rural electrification projects in Nigeria. Model for Analysis of Energy Demand (MADE-II) was used to analyze the primary and other secondary data obtained for the study. The results showed that the current contribution of solar PV in the lighting demand split for the villages was still very low in spite of various government interventions. Its usage level constituted an insignificant share of 16.4% and 5.5% of the total lighting requirement for Danjiwa and Dahuwa villages respectively. For each village, lighting with incandescent bulbs was about 10% of this total requirement, while that of fluorescent lambs stood at 7% and 6.5 respectively. The research results also revealed that kerosene maintained a domineering share of 66% and 77% of the total demand in the two villages respectively.

Ismail, Ajide and Akingbesote [39] embarked on performance assessment of installed solar PV system in Okeagunla, Akure LG area of Ondo state in Nigeria, it was concluded that the 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.

Melodi & Famakin [40], in a study to determine the adequacy of solar electricity potential (SEP) for meeting the domestic demand of Akure, concluded that SEP in Akure is appreciable and sufficient as an alternative energy source for domestic needs.

3. METHODOLOGY OF THE STUDY

The methodology section contains the data and sample sub-section which is followed by the description of measurements of variables and method of data analysis.

3.1 Data and Sample Population

The population for this study comprises of Solar PV users in the three housing estates under study namely: Ijapo (IHE), Alagbaka Extension (AHEE) and Sunshine Gardens Housing Estates (SGHE). The number of housing units in IHE is 600, while for AHEE and SGHE are 308 and 176 respectively. This brings the total housing units for the study area to 1,084 buildings as shown in Table 2 [41].

The sample size for solar PV users using Using Yamane formula is;

$$n = \frac{N}{1 + N(e)2}$$

$$= \frac{1084}{1+1084(0.0025)}$$

=292 respondents

Using the bourleys formula this translates to sample sizes of 162, 83 and 47 for IHE, AHEE and SGHE respectively.

Table 2. Population distribution in the estate

S/N	Name of estate	Average number of household per estate	Average number of people per household	Total population
1	Ijapo Housing Estate (IJHE)	600	5	3000
2	Alagbaka Extension Housing Estate (AEHE)	308	5	1540
3	Sunshine Gardens Housing Estates (SGHE)	176	5	880
	Total	**1084**	**5**	**5420**

Sample size for Ijapo Estate= $\frac{600\ x\ 292}{1084} = 162\ respondents$

Sample size for Alagbaka Extension Estate=$\frac{308\ x\ 292}{1084} = 83\ respondents$

Sample size for Sunshine Gateway Housing Estate=$\frac{176\ x\ 292}{1084} = 47\ respondents$

4. RESULTS AND THE ANALYSES

This section presents the obtained background information of the household in the estates, and factors influencing solar PV utilisation. The response rate of the survey questionnaire collected was examined in line with the study of Cooper and Schindler [42], who explained that the collected raw data should be examined for correctness, accuracy and completeness. In this study, 300 copies of questionnaire were administered to respondents. 165 questionnaires were administered in Ijapo Housing Estate, and 128 were completed correctly and returned, representing a percentage response of 78%. 85 was distributed in Alagbaka Housing Estate, and 59 were completed correctly and returned representing a percentage response of 69% while 50 was shared in Sunshine Housing Estate, and 32 were completed correctly and returned representing a percentage response of 64%. A total of 219 were completed correctly and returned, representing a percentage response of 73%, as shown in Table 3. Mugenda and Mugenda [43], states that a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good, and a response rate of 70% and over is Excellent. Hence the response rate was satisfactory, as indicated in Table 3.

4.1 Descriptive Analysis

Demographic information of the households was gathered. First, the researcher sought to establish the gender of the respondents. Their responses are shown in Table 4. In Ijapo Housing Estate (IHE), 84.4% of the respondents are males, while 15.6% are female. In Alagbaka Housing Estate (AHE), 81.4% of the respondents are males, while 18.6% are female. In Sunshine Housing Estate (SHE), all the respondents are males. Overall 85.8% of the household heads were males while as 14.2% of the household heads were females. This implies that there were more male respondents than females. This may be so because of the dominance of male as head of household in Africa [44]. This, however, will not affect the responses from the respondents, thereby creating any form of biasness. Next, sought to establish the age of the household heads. Their responses are highlighted in Table 4. In Ijapo Housing Estate (IHE), None (0%) of the respondents were aged below 20 years, 10.9% of the household heads were aged between 21 to 29 years, 48.4% of the household heads were aged between 31 to 39 years and 40.6% of the household heads were aged 40 years and above. In Alagbaka Housing Estate (AHE), None (0%) of the respondents were aged below 20 years, and between 21 to 29 years, 76.3% of the household heads were aged between 31 to 39 years, and 23.7% of the household heads were aged 40 years and above. In Sunshine Housing Estate (SHE), None (0%) of the respondents were aged below 20 years, and between 21 to 29 years, 57.5% of the household heads were aged between 31 to 39 years, and 36.1% of the household heads were aged 40 years and above. Overall None (0%) of the respondents were aged below 20 years, 6.4% of the household heads were aged between 21 to 29 years, 57.5% of the household heads were aged between 31 to 39 years, and 36.1% of the household heads were aged 40 years and above. This shows that the largest population of respondents was young and matured enough; as a result, they were able to understand issues related to solar technology. Table 4 also reflect a compliment to their level of education as the study composition indicates clearly that in Ijapo Housing Estate (IHE), 71.1% of the respondents have already earned a bachelor degree, while 6.3%, 21.9% and 0.8% are holders of HND, Masters and PhD Respectively. In Alagbaka Housing Estate (AHE), 86.4% of the respondents have already earned a bachelor degree, while 5.1% and 8.5% are holders of HND, Masters Respectively and none (0%) are OND/Certificate and PhD holder. In Sunshine Housing Estate (SHE), 71.9.4% of the respondents have already earned a bachelor degree, while 3.1% and 25% are holders of HND, Masters Respectively and none (0%) are OND/Certificate and PhD holder. Overall, 75.3% of the respondents have already earned a bachelor degree, while 5.5%, 18.7% and 0.5% are holders of HND, Masters and PhD Respectively. This might be an implication that they are well informed, and possessed the ability to assess and process information (tangible and intangible benefit accrue to the use of Solar PV) toward making a decision in line with the utilization of a Solar PV.

Table 3. Response rate of questionnaires distributed and retrieved

Questionnaires	IHE	AHE	SHE	Total
Number Distributed	165	85	50	300
Number Received and used	128	59	32	219
Percentage	**78%**	**69%**	**64%**	**73%**

Researcher's Field Report (2019)

Table 4. Demographic information of respondents

Characteristics	IHE	%	AHE	%	SHE	%	Total	Percentage
Gender								
Male	108	84.4	48	81.4	32	100	188	85.8
Female	28	15.6	11	18.6	0	0	31	14.2
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**
Age Group (Years)								
Below 20	0	0	0	0	0	0	0	0
21 -29	14	10.9	0	0	0	0	14	6.4
30 – 39	62	48.4	45	76.3	19	59.4	126	57.5
40 and Above	52	40.6	14	23.7	13	40.6	79	36.1
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**
Respondent's educational qualification								
OND/Certificates	0	0	0	0	0	0	0	0
HND	8	6.3	3	5.1	1	3.1	12	5.5
BTech/BSc	91	71.1	51	86.4	23	71.9	165	75.3
Masters	28	21.9	5	8.5	8	25.0	41	18.7
PhD	1	0.8	0	0	0	0	1	.5
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**

Next, socio-economic information of the respondents was gathered. First, the researcher sought to establish the Family structure of the households. Their responses are highlighted in Table 5. In Ijapo Housing Estate (IHE), 75.8% of the respondents are married with dependents, 13.3% are single with no dependent, 7.8% are single with dependents, and 3.1% are married with no dependent. In Alagbaka Housing Estate (AHE), 94.9% of the respondents are married with dependents, 3.4% are single with dependents, 1.7% are married with no dependent, and none (0%) are single with no dependent. In Sunshine Housing Estate (SHE), 93.7% of the respondents are married with dependents, 6.3% are married with no dependent, and none (0%) are single with dependents and single with no dependent. Overall, 83.6% of the respondents are married with dependents, 3.2% are married with no dependent, 7.8% are single with no dependents, and 5.5% are single with dependents. This shows that the largest population of the respondent has high energy demand. Table 5 further reveals the number of people per household. The result shows that in Ijapo Housing Estate (IHE), 77.3% of the respondents have 2 – 5 people living in their house. 11.7% have 6 -9 people living in their house, 0.8% have above 9 people living in their house, and 10.2% are staying alone. In Alagbaka Housing Estate (AHE), 93.2% of the respondents have 2 – 5 people living in their house. 6.8% have 6-9 people living in their house, none (0%) are staying alone and have above 9 people living in their house. In Sunshine Housing Estate (SHE), 96.9% of the respondents have 2 – 5 people living in their house. 3.1% have 6 -9 people living in their house, none (0%) are staying alone and have above 9 people living in their house. Overall, majority (84.5%) of the respondents have 2 – 5 people living in their house. 9.1% have 6 -9 people living in their house, 0.5% have above 9 people living in their house and 5.9 % are staying alone. This align with the work of Olaniyan, McLellan, Ogata and Tezuka, [45] that in the urban areas there are fewer people per household. Table 5 also shows the income distribution of the household. The result also shows that in Ijapo Housing Estate (IHE), 48.4% of the respondents earns #100,000 - #250,000 per month, 32% earns #250,000 - #500,000 monthly, 11% earns below #100,000, 6.3% earns #500,000 - #1,000,000 and 1.6% earns above

#1,000,000 per month. In Alagbaka Housing Estate (AHE), 81.4% of the respondents earns #100,000 - #250,000 per month, 13.6% earns #250,000 - #500,000 monthly, 5.1% earns #500,000 - #1,000,000 and none (0%) earns Below #100,000, and above #1,000,000 per month. In Sunshine Housing Estate (SHE), 68.8% of the respondents earns #100,000 - #250,000 per month, 31.2% earns #250,000 - #500,000 monthly, and none (0%) earns below #100,000, between#500,000 - #1,000,000, and above #1,000,000 per month. Overall, 60.3% of the respondents earns #100,000 - #250,000 per month, 26.9% earns #250,000 - #500,000 monthly, 6.8% earns Below #100,000, 5% earns #500,000 - #1,000,000 and 0.9% earns above #1,000,000 per month. Table 5 further reveals that in Ijapo Housing Estate (IHE), 27.3% pay #5,000 - #10,000 for electricity bill per month. 35.2% pay #10,000 - #15,000, 19.5% pay #15,000 - #20,000, 6.3% pay above #20,000 and 11.7% pay below #5,000 for electricity bill per month. In Alagbaka Housing Estate (AHE), 67.8% pay #5,000 - #10,000 for electricity bill per month. 23.7% pay #10,000 - #15,000, 5.1% pay #15,000 - #20,000, and 3.4% pay above #20,000 and none (0%) pay below #5,000 for electricity bill per month. In Sunshine Housing Estate (SHE), 62.5% pay #5,000 - #10,000 for electricity bill per month. 6.3% pay #10,000 - #15,000, 31.2% pay below #5,000 and none (0%) pay #15,000 - #20,000 and above #20,000 for electricity bill per month. Overall, 43.4% pay #5,000 - #10,000 for electricity bill per month. 27.9% pay #10,000 - #15,000, 12.8% pay #15,000 - #20,000, 4.6 % pay above #20,000 and 11.4% pay below #5,000 for electricity bill per month.

4.2 Factors Influencing Solar PV Utilization in the Study Area

The usage of Solar PV utilization has been influenced by several Factors, which has hampered Solar PV usage as a source of energy among households in Akure. Ranked first among this factor is that Solar PV serves as a back-up supply when there is power outage. The erratic power supply in Nigeria has not only hampered economic growth but also failed to meet the need of household. The decision to use Solar PV as a back-up supply when there is power outage posed a very high factor influencing solar PV utilization in Ondo State. This is shown

Table 5. Socio-economic Information of the respondents

Characteristics	IHE	%	AHE	%	SHE	%	Total	%
Family Structure								
Single (no dependent)	17	13.3	0	0	0	0	17	7.8
Single (with dependents)	10	7.8	2	3.4	0	0	12	5.5
Married (no dependent)	4	3.1	1	1.7	2	6.3	7	3.2
Married (with Dependents)	97	75.8	56	94.9	30	93.7	183	83.6
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**
Number of people per household								
1	13	10.2	0	0	0	0	13	5.9
2-5	99	77.3	55	93.2	31	96.9	185	84.5
6-9	15	11.7	4	6.8	1	3.1	20	9.1
above 9	1	0.8	0	0	0	0	1	.5
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**
Monthly Income								
Below #100,000	15	11.7	0	0	0	0	15	6.8
#100,000 - #250,000	62	48.4	48	81.4	22	68.8	132	60.3
#250,000 - 500,000	41	32.0	8	13.6	10	31.2	59	26.9
#500,000 - #1,000,000	8	6.3	3	5.1	0	0	11	5.0
above #1,000,000	2	1.6	0	0	0	0	2	.9
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**
Average monthly electricity bill								
Below #5,000	15	11.7	0	0	10	31.2	25	11.4
#5000- #10,000	35	27.3	40	67.8	20	62.5	95	43.4
#10,000- #15,000	45	35.2	14	23.7	2	6.3	61	27.9
#15,000-20,000	25	19.5	3	5.1	0	0	28	12.8
above #20,000	0.8	6.3	2	3.4	0	0	10	4.6
Total	**128**	**100**	**59**	**100**	**32**	**100**	**219**	**100.0**

Table 6. Factors influencing solar PV utilization in Ondo State

S/N	Factors	Very Low	Low	Moderate	High	Very High	Mean	Remark
		1	2	3	4	5		
1	Solar PV system serves as a back-up supply when there is power outage	0	0	1	11	207	4.94	Very High
2	The absence of appropriate policy to expand the solar market and encourage adoption (e.g. government subsidies)	0	1	6	5	207	4.91	Very High
3	Cost of the system	0	1	7	6	205	4.89	Very High
4	The reliability of the technology makes it attractive	0	0	4	19	196	4.88	Very High
5	Access to right information regarding solar PV system	0	0	8	13	198	4.87	Very High
6	Cost of maintenance	0	4	5	12	198	4.84	Very High
7	The Joy derived from not depending solely on the irregular electricity supply by electricity distribution company (BEDC)	3	0	5	33	178	4.75	Very High
8	There is long hours of sunshine in my area, which is a good thing	0	0	5	47	167	4.74	Very High
9	Awareness of the technology and its benefit	0	1	5	45	168	4.74	Very High
10	high interest rate from banks and short period of payback	6	1	11	17	184	4.70	Very High
11	The technical know-how needed to use or set up the system	0	1	12	39	167	4.70	Very High
12	It is a new technology not so known and trusted, it is therefore a calculated risk	2	0	12	38	167	4.68	Very High
13	Environmental stewardship in my little way to reduce environmental impact	0	2	7	54	156	4.66	Very High
14	The idea that solar PV system can generate money for users by allowing transfer of excess generated electricity by users back to the grid	0	4	17	30	168	4.65	Very High
15	A friend's experience with Solar encouraged my purchase of the system	0	2	8	57	152	4.64	Very High
16	To reduce emission from my diesel generator for the benefit of the environment	1	1	15	46	156	4.62	Very High
17	If this is stolen or destroyed due to violence. It will be a big loss	2	2	9	53	153	4.61	Very High
18	It gives a sense of class and pride	0	1	15	62	141	4.57	Very High
19	Solar installation was not considered in my initial roofing plan, redesigning takes up extra cash	4	1	19	41	154	4.55	Very High
20	Ability to access loan from banks	6	5	16	37	155	4.51	Very High
21	Ability to sell electricity to the national grid	5	4	27	35	148	4.45	Very High

in Table 6 by a mean score of 4.94 and ranked very high. The absence of appropriate policy to expand the solar market and encourage adoption (e.g. government subsidies) is also ranked very high as a factor influencing solar PV utilization in Ondo State with a mean score of 4.91. Table 6 also reveals Cost of the PV system ranked Very high as a factor influencing solar PV utilization in Ondo state. 205 respondents rated that cost of the system posed a very high threat to use Solar PV as an energy source in the household. However, one of the respondents stated that cost of the system is a low factor influencing solar PV use as energy source for powering various energy services. This is shown on Table 6 by a mean score of 4.89. Table 6 also shows that the reliability of the technology makes it attractive, access to right information regarding solar PV system, cost of maintenance score a mean rank of 4.88, 4.87 and 4.84 respectively. Table 6 further reveals a friend's experience with Solar encouraged my purchase of the system, to reduce emission from my diesel generator for the benefit of the environment, if this is stolen or destroyed due to violence. It will be a big loss, it gives a sense of class and pride, solar installation was not considered in my initial roofing plan, redesigning takes up extra cash, ability to access loan from banks score a mean rank of 4.64, 4.62, 4.61, 4.57, 4.55 and 4.51 respectively. This is shown on Table 6. Ability to sell electricity to the national grid also posed as a factor influencing utilization of Solar PV for energy services and ranked the lowest with a mean rank of 4.45 as stated by respondents. This is shown on Table 6.

5. CONCLUSION

It is well documented that Solar Photovoltaic has been found to be the most widely accepted alternative to the currently dominated fossil fuel across the globe. While many developed and emerging countries are fully integrating renewable energy into their national grid system, most developing countries still lag behind. Since residential energy user occupied the largest proportion of the Nigerian energy consumption, this study therefore examined the status of solar PV utilization for energy services and factors influencing solar PV utilization for energy services. Theory of reasoned action was adapted in evaluating some of the factors influencing Solar PV utilization for energy services. The study found that the current status of Solar PV utilization in the study area is still low in spite of various government interventions. The number of household Connected is 219, which makes 20.2% of the households in the state. The most common application is solar home system installation with a Total capacity of 364.5KW which were installed between 2011 and 2019. The installation comprises of Solar Panel, Storage Battery, Inverter, Charge controllers and ELCB Breaker. The PV Installation is used as an alternative Energy source. The PV installations are Self-sponsored and 61.6% of the PV system is working very well and last an average of 6 hours. The users are responsible for monitoring and sustainability.

Consequently the study showed factor influencing solar PV utilization for energy service. Ranked first among this factor is that Solar PV serves as a back-up supply when there is power outage. The erratic power supply in Nigeria has not only hampered economic growth but also failed to meet the need of household. The decision to use Solar PV as a back-up supply when there is power outage posed a very high factor influencing solar PV utilization in Ondo State. Followed closely by the absence of appropriate policy to encourage utilization and expand the solar market (e.g. government subsidies). The utilization and efficient implementation of solar PV in Nigeria is expected to increase if the factors measured to be statistically significant in this study are given utmost consideration. Both the private enterprise and relevant government need to cooperate so that each plays its roles towards improving the use of solar PV as an energy source for energy services. The study recommends that government support for solar PV intervention in Residential should be further encouraged.

CONSENT

As per international standard written participant consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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