Investigation into the Maintenance Management Awareness on Solar PV Renewable Energy System in Nigeria

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ABSTRACT

The electric power insufficiency in Nigeria has caused Governments, Non-Governmental Organisations (NGOs) and individual home owners to consider various renewable energy sources such as small hydro, wind, biomass and solar photovoltaic (PV) systems. However, PV installations in Nigeria largely do not last up to one-half their lifespans. This empirical study investigates the reasons adequate maintenance is lacking in PV systems installation in Nigeria. The research was conducted via a questionnaire administered to solar PV system users, home owners and technical personnel using a web-based polling system. The questionnaire focused on awareness on: age of solar installation, functionality of solar system, future plans for investing on solar system, and maintenance of solar system. Statistical method (descriptive statistics) was used in analysing the data. The results show that majority of solar installations are less than 6 years old (94.5%). A large number of the respondents (70.2%) indicated there was no maintenance carried out in their solar installations while a good number (60.3%) indicated awareness for maintenance activity carried out on their solar system. Seventy-six percent of respondents were aware of nonfunctional solar system around. Ninety-five percent agreed that there was a lack of preventive maintenance on solar energy installations in Nigeria and all respondents (100%) agreed that introducing routine maintenance on solar installations will yield positive results. Many respondents did not see the connection between the lack of maintenance and short lifespan of solar systems.

KEYWORDS: Maintenance management, off-grid solar PV system, Nigeria, renewable energy, Solar cost, PV Sustainability.

1. INTRODUCTION

The electric power insufficiency in Nigeria has caused all stakeholders to embark on various means of energy provision. Government at all levels−Federal, State and Local−are considering various renewable energy sources such as small hydro, wind, biomass and solar photovoltaic (PV) systems. Non-Governmental Organisations (NGOs) likewise have commissioned various renewable energy systems in many rural areas. These activities are targeted at ameliorating the perennial energy insufficiency in the country.

Globally today, solar PV systems are gaining much attention worldwide (Chaurey & Chandra, 2010). One reason is because of the potentials of renewable energy sources to play a crucial role in reducing carbon emissions and fossil fuel consumption in all sectors across the global economy(Masini & Menichetti, 2012). PV systems has been effectively utilised in many developed and developing countries around the world and its development and utilisation is on the increase. In southern part of Nigeria, more homeowners are investing in solar PV system energy alternative. Many homeowners in Nigeria are also investing in renewable energy notably biomass and stand-alone solar PV systems. Among these two, solar PV is being more utilised. However, the continuous utilisation of solar PV system in Nigeria is being hampered by certain factors.

First is the prohibitively high cost of various component parts of the solar PV system (Akinboro, Adejumobi, & Makinde, 2012). Nigeria is classified as one country with majority of her population living below the poverty line. Thus, solar PV system components are still inaccessible to a vast majority of the population. Second is the shorter lifespan of PV installation occasioned by a lack of or inadequate maintenance(Ismail, et al. 2012). Several stand-alone, off-grid solar installations have been commissioned by government at various levels and NGOs in the past

which were expected to last a good number of years before being replaced. To the contrary, these PV installations in most cases do not last up to one-half their lifespan. For PV systems to satisfactorily perform to design specifications and last their lifespan requires adequate system maintenance practice (Rolland, 2011).

With the foregoing observations, this study was set out to investigate the reasons why adequate maintenance was lacking in PV systems installation in Southern Nigeria. In a complex society like Nigeria, many factors may be responsible for an observed scenario; hence an intertwined method of investigating the causes is necessary. This is important to be fashion out the necessary solution to the present problem of PV system utilisation facing the society. Thus, there is a need to design the study in a way to interact with personnel, people and organisations and to integrate them towards an effective policy formulation and planning towards the maximization of resources, human and material, and solar PV potentials in the country.

2. LITERATURE REVIEW

Most engineering infrastructures require regular maintenance to keep them up and running. This maintenance work required can either be preventative or routine, corrective or breakdown maintenance. Preventative maintenance includes routine inspection and servicing of equipment to prevent breakdowns and production losses. Corrective or emergency addresses equipment breakdowns after the occurrence. This "break and fix" method has low upfront costs, but bears the risk of unplanned downtime and higher costs on the back end. Corrective maintenance(Dhillon, 2006; Kouedeu & Mohafid, 2011) procedures should also be established to address items that require immediate repairs and items that can be repaired with routine maintenance visit. Another form of maintenance is the condition based maintenance. It is a type of maintenance that uses real-time data to prioritize and optimize maintenance and resources. When establishing a preventative maintenance schedule, it is important to do so based upon each component and system manufacturers' recommendations. When maintenance is being planned, the cost of actualizing it is very important to be considered (Yabsley & Ibrahim, 2008). But this cost is known to be far less than replacement cost. In addition, maintenance has a way of improving the ROI of the amount invested in installing and building of a system (Opeyemi & Hassan, 2012).

In Nigeria electricity generation, maintenance management faces a lot of barriers which has made it necessary to create awareness for people. Among such barriers are(Oyedepo & Fagbenle, 2011):

- Maintenance is not treated seriously at board level, or even by local management;
- Maintenance processes lack a business culture (e.g. no business plans, ineffective or superficial budgets and unfocused reports);
- Maintenance technicians and even team leaders lack adequate management skills;
- Pre-occupation with introducing advanced maintenance methods, while relevant basic maintenance practices are not being implemented.

Typical causes in power installations breakdown include causes before operation, forced outage, foreign influences, unknown causes, operation and maintenance, and others. Among these, operation and maintenance causes take the lion share as shown in Figure 1. Thus, it is imperative that energy installations such as off-grid solar PV systems have maintenance management put in place to prolong their lifespan and maintain their reliability.

2.1 Renewable Energy in Nigeria

Nigeria as a developing country with a population of over 200 million persons has not been able to provide necessary infrastructure for development(Adah & Abasilim, 2015; Lawal & Oluwatoyin, 2011; Smart, 2014). Electrical energy is not accessible to about 60% of the population as about 40% of Nigerians have access to grid electricity(Nigerian Energy Support Programme, 2015; Oseni, 2012). When electricity generated is improved the welfare of Nigerians as well as the country's per capita income would improve. Renewable energy as an alternative energy generation is a welcome idea for the country.

Renewable energy is being given much attention in Nigeria notably from hydro, solar, wind and biomass. However, Nigeria has not generated much energy from these sources. Thus the Nigerian authorities are targeting that

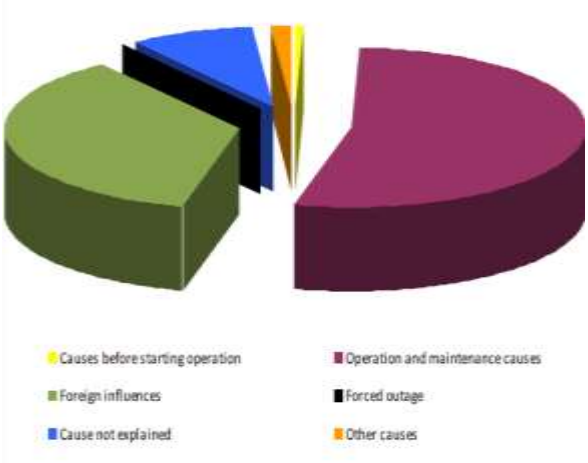


Fig. 1: Typical causes of failure in electric power systems (Gono, 2017)

the energy access for the population of 250 million to increase to 90 percent by year 2030 and 30 percent of this should be made available from renewable sources(Akinbami, 2001; The Nigerian Electricity Regulatory Commission, 2017). Indeed, the Nigerian Electricity Regulatory Commission (NERC) has a mandate to generate a minimum of 2,000MW of electricity from renewables by the year 2020(The Nigerian Electricity Regulatory Commission, 2017). Thus it is expected that renewable energy installations as such as solar PV will increase in the foreseeable future. For that reason there should be put in place processes that will ensure the sustainability and longevity of the projects.

3. METHODOLOGY

3.1 Research Design

The empirical research was designed by an investigation conducted via a questionnaire using a qualitative research approach. Before the questionnaire was administered, an interaction between some technical personnel was carried out. Subsequently, a web-based survey questionnaire was developed, and administered to a sample of individuals among who were solar PV system users at home and in the workplace, homeowners and technical personnel. The whole period of data acquisition covers about four weeks.

3.2 Sample and Selection Characteristics

The sample for the study was carefully selected from Nigeria using randomized sampling technique. The respondents were from various age grades, professions and locations. Since the subject of interest, solar energy, has become a household item among the educated few in the society, a web-based polling system was adopted to obtain the data needed from the identified population. Respondents targeted included students, workers, homeowners, solar system technical personnel, solar PV end-users and those that are likely to invest in solar energy in the future.

3.3 Data and Instrument for Data Collection

The survey questions were largely on the respondents experiences with solar power installation. Apart from bio-data, some of the key questions focused on solar installation, age of installation, functionality of the installation, investment on solar, maintenance carried out, and awareness of solar installation in the community. Sampled

opinions also include futuristic aspect of solar system with questions on the respondents' opinions on possible investment option and preventive measures to be adopted. This was to elicit the required information on the level of awareness on solar system generally and more importantly the maintenance culture on solar PV system. The goal is to identify causes of frequent out-of-use experiences often associated with solar installation and to identify whether or not solar PV systems users and technical personnel are aware of need for maintenance on the system.

The survey approach was employed in generating data from the study. This was achieved through the circulation of questionnaire electronically administered on 61 numbers of respondents after personal interviews with certain personnel. Information collected from textbooks and internet constitutes secondary data for the study. Statistical method was used in analysing the results. The responses were grouped according to the answers given to each question. The completed questionnaire was automatically processed through software and the results were presented in percentages using descriptive statistics.

A well-structured questionnaire consisting of twenty-three questions was designed and administered electronically via a link generated online from Google form. The respondents easily supplied the required information through the form. The social media platform WhatsApp was used to distribute the link because of wide acceptance and popularity across society. Though the link could as well be received via e- mail, but its limitation is the challenge of getting the mail addresses of respondents due to the anonymous nature of the respondents.

The results from the respondents received electronically were in well-arranged tabular form on Excel format for presentation. However, due to the size of the data, it cannot be printed out. The data was collated for analysis after a period of one week. Descriptive statistics using pie charts and bar charts were used to present the results.

4. RESULTS AND DISCUSSION

The demographics of the respondents shown in Table 1 indicate majority of the respondents were male. This is an indication that the solar world is predominantly male, with the majority (86.9%) of the respondents males with only 13.1% female. The age bracket also indicated that the age group 26-35years of age has the highest numbers of respondents. The data obtained from the web-based survey was analysed and the results presented as follows. A descriptive analysis was employed to show the results. Table 2 shows the results of how much connected were the respondents to solar energy.

From the survey, 60% of the respondents indicated they had made no investment in solar energy in the past as shown in Table 2. This is an indication that solar application is still just gaining ground in Nigeria and not yet in majority. To the question: "Have you carried out any routine maintenance on your solar system you invested in?" Majority of the respondents (70.2%) indicated there was no maintenance carried out in their solar installations (Figure 2). Perhaps, the popular assumption that solar system is maintenance free may be the possible reason for this coupled with poor economic factor. On why their installations were not functional, majority indicated not applicable (Figure 3) shows that they are not using solar installation at that moment in time, or their installation is still working and those using it cannot diagnosed or have no clue on the possible cause of why their installations were not working.

Table 1: Respondents' demographics

Gender		***Age***					
Male	***Female***	***Years of age***	***18-25***	***26-35***	***36-45***	***46-55***	***>55***
86.9	13.1	%	11.5	47.5	16.4	21.3	3.3

Table 2: Respondents' readiness for PV use/installation

Assessment of readiness of respondents for solar installation					
Any investment in solar energy? (%)		*Plan to invest in solar energy in the future? (%)*		*Solar system at home office, or neighbourhood? (%)*	
Yes	*No*	*Yes*	*No*	*Yes*	*No*
40	60	98.3	1.7	72.1	27.9

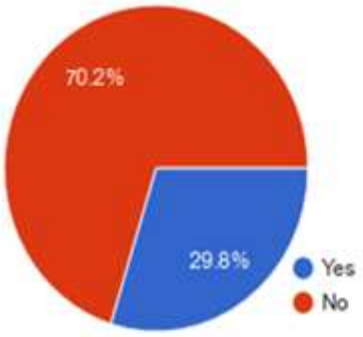


Fig. 2: Maintenance on solar installation

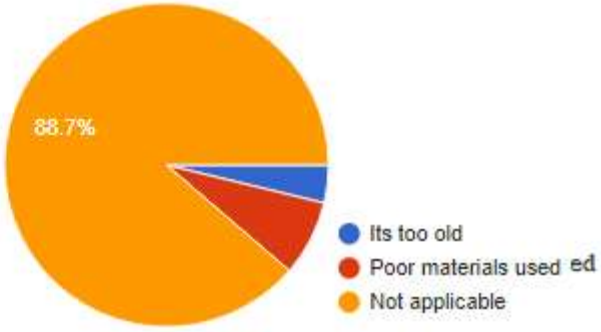


Fig. 3: Reason for nonfunctional solar system

As shown in Figure 4, majority of the respondents indicated interest in future investment on solar installation with less than 2% indicating unwillingness. This shows that renewable energy such as solar in particular has brighter prospect Nigeria as many people are willing to invest in it. Government should think of establishing solar manufacturing plant in the country as a matter of urgency. The results also show that there was strong awareness on solar installation as over 72% signified they are aware of solar in their environments. However, as indicated in Figure 5, majority of the respondents are yet to make any contributions towards solar projects in their community. This is likely to be as a result of bad economy and over-dependency on Government on of the populace.

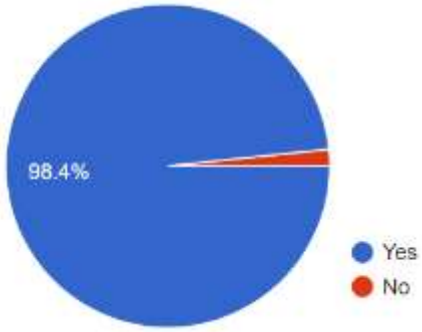


Fig. 4: Possible future investment in solar

(a) Awareness or lack of it (b) Funding or contribution

Fig. 5: Presence of solar installation in the environment

From the results on Table 3, the question regarding the age of the installation, either at home, office or community, it was discovered that the highest categories of installation age for the solar system is in ages 3-5 years representing about 40%. 1-2 years has about 36% and less than one year is about 19%. This means that less than 5 years forms the majority (94.5%) with 6-10years taking the rest. No installation is greater than 10 years from the study and this shows that solar system is relatively new in the country.

Table 3: Age of solar installations

Age of Solar system Installation				
Less than 1 year (%)	***1-2 years (%)***	***3-5 years (%)***	***6-10 years (%)***	***More than 10 years (%)***
18.9	***35.8***	***39.6***	***5.9***	***0***

Regarding the general awareness on maintenance for solar PV systems, the majority of the respondents' (60.3%) indicated awareness for maintenance activity carried out on their solar system installation. The remaining 39.7% did not know of any maintenance work carried out on their installation. Figure 6 presents this result. Figure 7 gives the results for respondents' awareness of nonfunctional solar system in the community for rural electrification, street lighting, or water pumping system in response to the question. The results In Figure 7a pointed to the fact that the majority of the populace is taking cognizant of nonfunctional solar system in the environment while Figure 7b is indicative that lack of maintenance is responsible for nonfunctional solar system installations. A total of 76.7% of the sampled was aware of nonfunctional solar system around. However, on the perceived reasons for the nonfunctional solar installations, lack of maintenance has the highest number followed by incompetence personnel. This shows that people generally have perceived a lack of maintenance on solar installations.

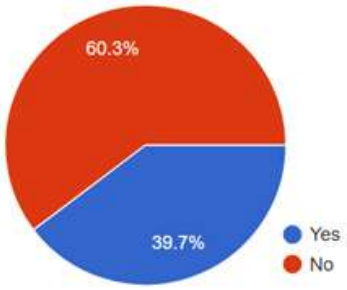
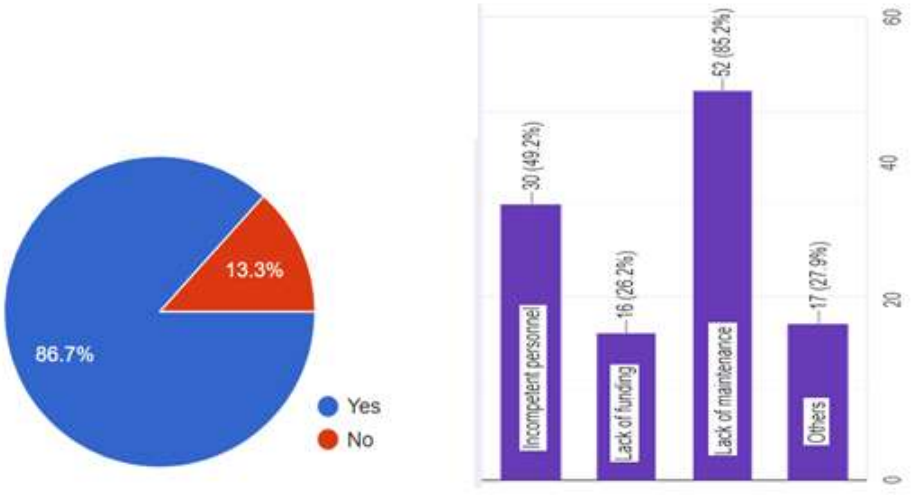


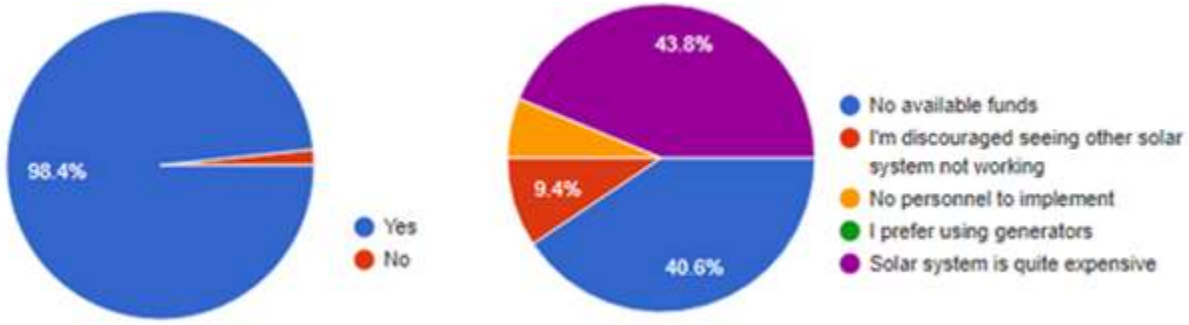
Fig. 6: Awareness on maintenance action carried on solar system installation

Majority of the respondents signified interest on investment in solar system in the future with less than 2% indicating otherwise. A possible reason for this is not unlikely to the loss of faith in public power supply by the citizen. In actual fact, prohibitive initial cost is the major obstacle hindering many from switching to solar system entirely. Figure 8 presents this result. It is seen that unavailability of funds and high cost of solar material are the real reason why majority of the respondents have not invested in solar system installation. As a matter of fact, no respondent preferred using generating set. On the opinions on lack of routine maintenance and possible effect of introducing it on solar installations, about 95% agreed that there is lack of preventive routine maintenance of solar energy installations in Nigeria while all the respondents agree that routine preventive maintenance in solar installations is capable of increasing the lifespan of the installation. Thus, all respondents (100%) agreed that introducing routine maintenance on solar installations will yield positive results. This is presented in Figure 9.



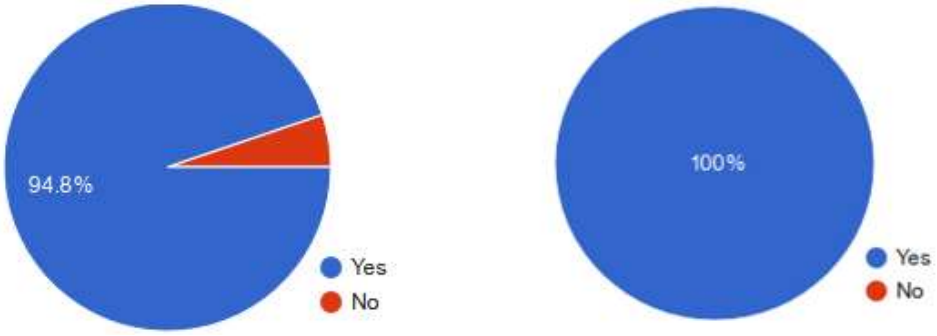
(a) Awareness (b) Reason for nonfunctional systems

Fig. 7: Results on nonfunctional solar system installation



(a) Future possible investment in solar (b) Reason for no-future-plan on solar investment

Fig. 8: Future investment plan in solar system



(a) Is there a lack of routine preventive maintenance on installations

(b)Will introduction of preventive maintenance help to increase their lifespan?

Fig. 9: Opinion on the introduction of preventative maintenance to solar installations

5. CONCLUSIONS

This study has clearly revealed the general perception that solar PV installations do not need maintenance. It shows that the Nigerian citizens generally are unaware of the need to carry out maintenance on solar installations. Many respondents do not see the connection between the lack of maintenance culture and short lifespan of solar systems installation. The awareness of the Southern Nigerian people regarding solar energy maintenance management is revealed to be quite low. Thus there is the need to put in place a sensitization campaign to bring the valuable information regarding maintenance management to the people's attention.

Government, government institutions and NGOs are the largest financiers of solar renewable energy systems for rural communities in the country. Thus, they are the first that need to be sensitized on the need for maintenance management in Nigeria for solar PV installations. Moreover, there is the need for government and NGOs to employ solar PV maintenance personnel to take care of the maintenance management of small and large solar installations across the country. In the same vein, large organisations, both private and public, and many homeowners in the country using solar system need to be adequately sensitised on the benefits of maintenance management in solar system. This will make the effort and resources being put into the installation of solar PV system worthwhile. Furthermore, when maintenance management is embraced on solar systems, more jobs shall be created for the populace given the numerous solar installations in the country.

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