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An Assessment of Solar Electric Power Systems Use in Some Public Buildings and Projects in Osun State

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Authors' contributions

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

Original Research Article

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ABSTRACT

The use of solar power in generating electricity is still very much at its infancy in Nigeria despite the abundant solar energy available in the country. The heavy dependence on cheap petroleum product has not helped matter as more investments are attracted to the oil sectors because of the huge returns. However the destabilizing effects of fuel price increments had pushed for alternative sources of energy with little uncertainties. This study was conducted to assess the use of solar power systems in public facilities where most of the solar power equipment is being used. Using random sampling, questionnaires were administered and the finding suggest that public knowledge of the solar equipment are still very low, the initial cost were high and the people would want it installed in their residence to solve their power needs.

Keywords: Photovoltaic cells; energy; electricity; solar cells; sunlight.

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1. INTRODUCTION

Since the advent of industrial revolution and the beginning of the machine age, a major source of concern has been the best way possible to power the machines. The post-industrial revolution era witnessed tireless efforts by technologists and developers to improve on their machines and efficiently power them.

In present day developments, every industry requires electricity to power machines, every home requires electricity for their household needs and equipment, and every office building needs elecricity to power their office equipment, lighting fittings and others. Therefore electrical power is a basic need in every advanced or developing society.

Over the years, the production of electrical power has evolved from the use of coal and steam engines to the use of Hydro- electric power generating stations and thermal power stations. There are several other recent technologies for electric power generation which include Wind-power generation (windmills) and Solar electric power generation.

There are two types of Solar electric power generation namely, photovoltaics (PV) and Concentrating Solar Power (CSP). The focus of this study is on the use of photovoltaics which are also referred to as Solar Panels.

Photovoltaic (PV) literally mean "light-electricity" and it is the process of converting sunlight into electricity. The term "photo" comes from the Greek word "phos" or light, and "volt" was derived from Volta (1745-1827), a pioneer in the study of electricity. Solar panels originated from the discovery that when some materials are exposed to sunlight, they release small amounts of electricity giving off what is known as the "photovoltaic effect." Sunlight is composed of photons, or particles of solar energy that contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a PV cell, the energy of the photon is transferred to an electron in a cell's atom. The cell is made of a semiconductor material. With its newfound energy, the electron escapes from its normal position on the atom and becomes part of the current in an electrical circuit. When this happens, the electron creates a "hole." Special electrical properties of the PV cell, specifically a built-in electric field, provide voltage that drives the current through an external load, such as a light bulb, a hairdryer or a television set [1].

In 1953, Bell Laboratories (now AT&T labs) scientists Gerald Pearson, Daryl Chapin and Calvin Fuller developed the first silicon solar cell capable of generating a measurable electric current. The New York Times reported the discovery as “the beginning of a new era, leading eventually to the realization of harnessing the almost limitless energy of the sun for the use of civilization” [2].

Solar power could boast few major gains through the first half of the 20th century, though interest in a solar-powered civilization never completely disappeared. In fact, Albert Einstein was awarded the 1921 Nobel Prize in physics for his research on the photoelectric effect—a phenomenon central to the generation of electricity through solar cells. In 1956, solar photovoltaic (PV) cells were far from being economically practicable. Electricity from solar cells ran about $300 per watt. (For comparison, current market rates for a watt of solar PV hover around $5.) The “Space Race” of the 1950s and 60s gave a modest opportunity for progress in solar systems, as satellites and crafts used solar panel for electricity [2].

It was not until October 17, 1973 that solar leaped to prominence in energy research. The Arab Oil Embargo demonstrated the degree to which the Western economy depended upon a cheap and reliable flow of oil. As oil prices nearly doubled over night, leaders became desperate to find a means of reducing this dependence. In addition to increasing automobile fuel economy standards and diversifying energy sources, the U.S. government invested heavily in the solar electric cell that Bell Laboratories had produced with such promise in 1953 [2].

The hope in the 1970s was that through massive investment in subsidies and research, solar photovoltaic costs could drop precipitously and eventually becomes competitive with fossil fuels. By the 1990s, the reality was that the costs of solar energy had dropped as predicted, but the costs of fossil fuels had also dropped—solar was competing with a falling baseline.

However, huge PV market growth in Japan and Germany from the 1990s to the present has re-energized the solar industry. In 2002 Japan installed 25,000 solar rooftops. Such large PV orders are creating economies of scale, thus steadily lowering costs. The PV market is currently growing at a blistering 30 percent per year, with the promise of continually decreasing costs. Meanwhile, solar thermal water heating is an increasingly cost-effective means of lowering gas and electricity demand. As seen, technologies have changed and improved for decades. Still, the basics of solar thermal and photovoltaics have remained the same [2].

Substantial expansion in quantity, quality and access to infrastructure services, especially electricity, is fundamental to rapid and sustained economic growth, and poverty reduction[3].Yet, for the past three decades, inadequate quantity and quality and access to electricity services has been a regular feature in Nigeria, a country with 140 million people with a majority living on less than US$2 a day. The electricity industry, dominated on the supply side by the state-owned electricity utility, National Electric Power Authority (NEPA), and succeeded by the Power Holding Company of Nigeria (PHCN), has been unable to provide and maintain acceptable minimum standards of service reliability, accessibility and availability.

Nigeria's electricity crisis is striking for a variety of reasons. First is its occurrence despite the enormous endowments of non-renewable and renewable primary energy resources. The resource endowments of crude oil and natural gas currently estimated at 35 billion barrels and 185 trillion cubic feet, respectively, are more than adequate to fuel much of Sub-Saharan Africa (SSA) energy demand for several decades [4].Coal reserves are also substantial at 2.75 billion metric tons. Also, large amount of renewable energy resources including hydroelectricity, solar, wind and biomass energy are present. One of the many paradoxes in Nigeria is energy/electricity poverty amid plenty. Second, despite being a world ranking exporter of liquefied natural gas (LNG), Nigeria's gas-dominated electric grid experienced frequent collapse linked largely to inadequate gas supply. Gas pipeline vandalisation associated with resource control-linked militancy in the oil producing Niger Delta has compounded the supply problem. Huge gas flaring has been a regular feature of the Nigerian oil industry since production began in 1958[5].This wasteful gas flaring has consistently ranked Nigeria among the world's largest source of carbon emissions, a major factor in global warming. [6, 7, 8, 9].Third, the several billion dollars of public investment that went into generation and transmission capacity expansion in the past decade contrasts sharply with the extremely poor outcomes measured by frequent power outages and voltage variation[10].Fourth, there are the high social, economic and environmental effects of poor public power supply and its extensive substitution with highly polluting generators. Anecdotal

evidence suggests that Nigeria has one of the highest concentrations of generators globally. The negative impact of the ubiquitous generators on environmental quality and the health of the population has elicited major concerns particularly among environmental and health scientists. Fifth is the depth and duration of the electricity crisis despite the availability of energy resource endowment and two decades of major economic reforms that commenced with the adoption of the Structural Adjustment (SAP) in 1986.

In Nigeria, electricity consumers face a lot of challenges due to incessant power supply. A lot of businesses are dependent on electricity, factories also need electricity for their production plants and in the absence of it they are forced to consider other power options such as the use of generating sets (a recent statistics indicated that Nigeria was one of the largest importers of electrical generating sets in the world). These generators even though they sometimes serve their purposes of generating electricity have very large disadvantages such as the high risk of fire outbreaks, risk of damage to machines or equipment due to high voltages, noise, large consumption of fuels which is not cost effective and most importantly they produce a lot of pollution(carbon monoxide) which are detrimental to the health of humansand the environment, and the death of so many people.

The use of Solar Electric Power Systems in Nigeria however are still at their infancy and it is most commonly used in public buildings(government) and United Nations projects. This study is therefore aimed at assessing the efficiency of existing Solar Electric Power systems within Osun State.

2. METHODOLOGY

The purpose of this study is to assess the use of solar electric power used in some public buildings and projects within Osun State. The main source of data for this study was the survey carried out among the direct users or beneficiaries of solar electric systems within Osun State, Nigeria. A comprehensive questionnaire together with personal interviews and the researcher's experiences in the field were utilized to gather the data presented. The questionnaire was carefully designed to gather information on the types of solar systems which the respondents were using, their level of knowledge of the systems were also evaluated, their views on the effectiveness of the systems. The questions contained in the questionnaires were also the major questions used for the interviews conducted.

The sampling technique that was adopted was the random sample so as to draw conclusions on how the populace viewed Solar Electric power systems. There were 5 different locations found within the area of study and a total of about 80 people were interviewed in the various locations while 30 questionnaires were distributed across all the locations within the area of study.

The population consists of the following; students population residing in Adekunle Fajuyi Hall, Obafemi Awolowo University, Ile-Ife, Students and Workers population residing at Diganga area, Ile-Ife, workers and security officials working within the confines of the governor's office and Osun State secretariat, Osogbo, Osun State, and the residents around the Solar pump at Oloki, a settlement very close to Ede.

The samples represent the views of the population of people who are directly or indirectly using the Solar systems found within the area of study. A lot of the residents were asked questions relating to the use of the systems and their personal views on the issues relating the use of Solar Systems generally.

3. RESULTS AND ANALYSIS

3.1 Education

The level of education of the respondents were assessed and shown in Fig. 1. 3.33% were both non-educated and primary school leavers, 13.33% secondary school le , 23.33% were college and polytechnic graduates and 57.67% were both university graduates and undergraduate as some students from Adekunle Fajuyi Halls of residence were also sampled during the survey. With the majority highly educated, this suggests that most of the people sampled were literate and their opinions are of high importance.

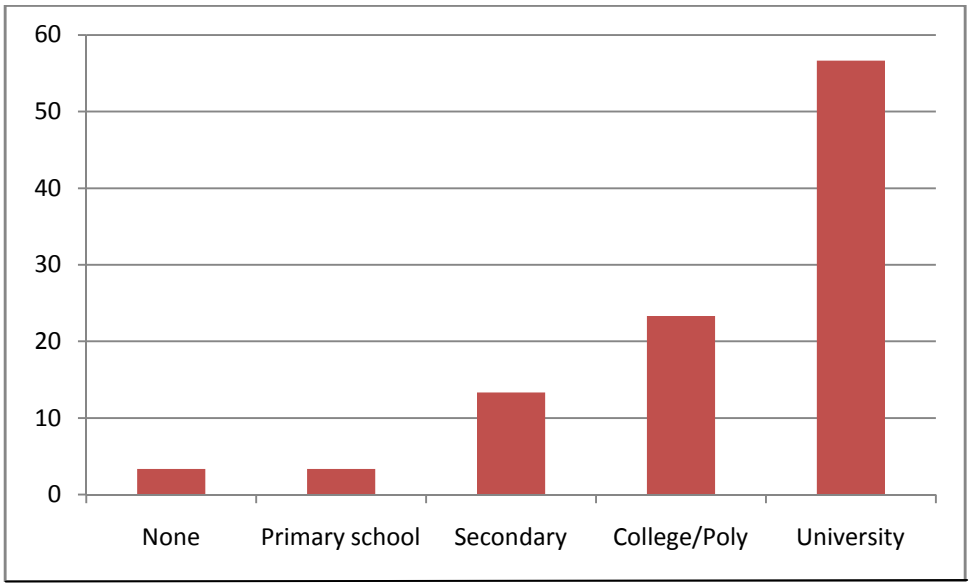

Fig. 1. Level of education of respondents

3.2 Equipment Types

The equipment powered by the solar systems are those that are used by the general populace and expected to run on uninterrupted power supply as the power supplied by Power Holding Company of Nigeria (PHCN) was very erratic. Hence, as indicated in Fig. 2, 55% of these equipment were pumping machine provided by the Federal Government for lifting water to overhead reservoir in the rural communities and some parts of Obafemi Awolowo University, Ile-Ife, 17.5% to power street light in both Oshogbo and its environ, while 17.5% were respectfully used for security and home/office lighting.

These equipment, particularly the pumps and street light were at convenient distances from the users as suggested by Fig. 3 where majority of the users,43.33%, indicated that the facilities were at a distance of between 100-300m from them, and 26.67% indicated that the equipment were less than 100m from them. Taking together from Fig. 3, 70% of the users of the bore holes and street light were less than 300m from them. This suggests that the facilities were accessible to the majority of the users who often use them if “often” and” very often” , that is 60%, were taking together(as suggested by Fig. 4). However, 64.29%, if “fair”

and “very fair” ,which constitute fairly a large majority of these users as suggested by Fig. 5, do not have adequate knowledge of these facilities but the probable cost of the equipment is known by a large proportion, 44.83%, of the users as suggested by Fig. 6. 80% of the users felt that these equipment are cost effective in the long run if genuine spare parts are used in their construction while 83.33 % felt that these equipment were not cost effective in the short run as shown in Fig. 7. That was why most of the existing equipment were government owned as shown in Fig. 8 where 54.84%, 32.25% of the equipment were respectively owned by the Federal and State Governments while very small 12.91% were owned by both the Non-governmental Organisations and Private individuals.

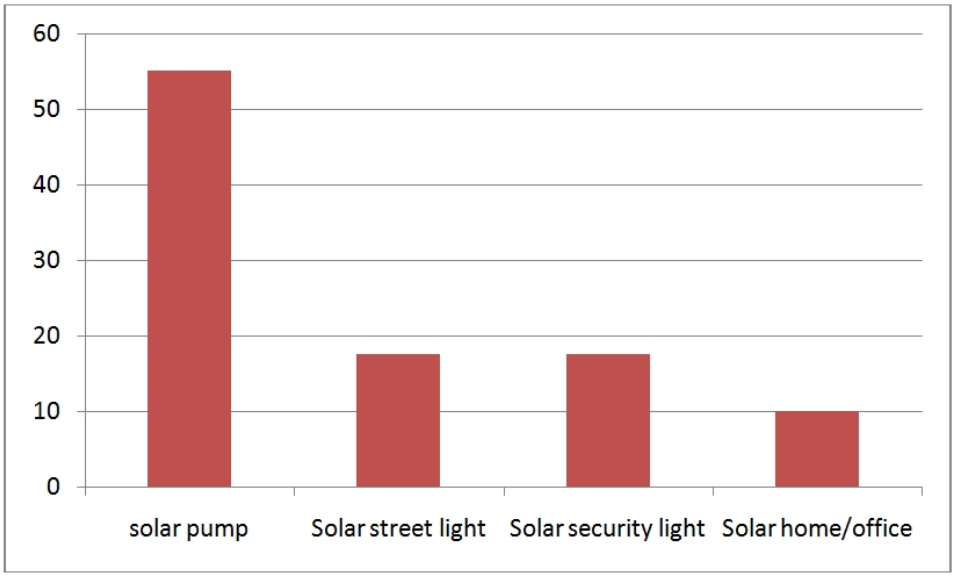

Fig. 2. Type of solar electric system

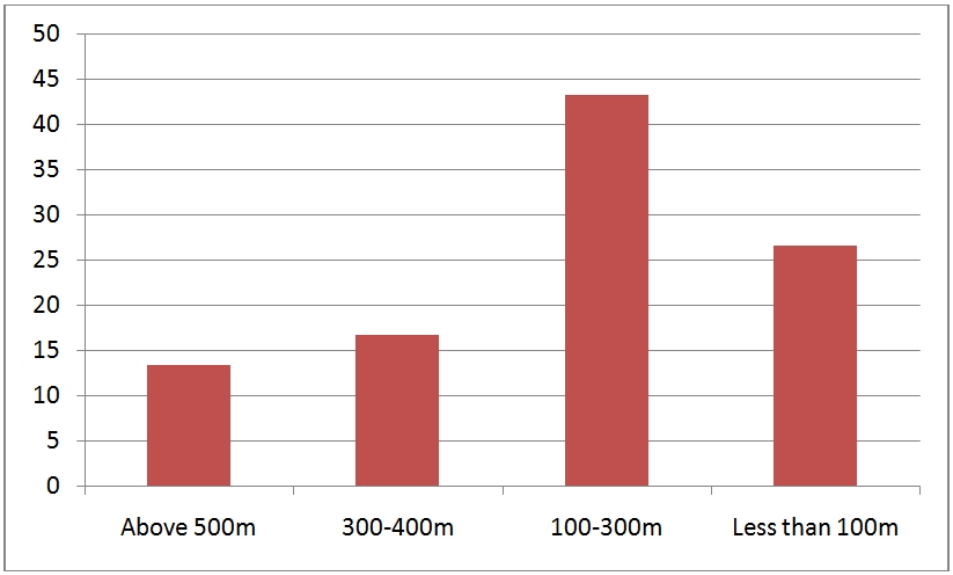

Fig. 3. Distance of system from users

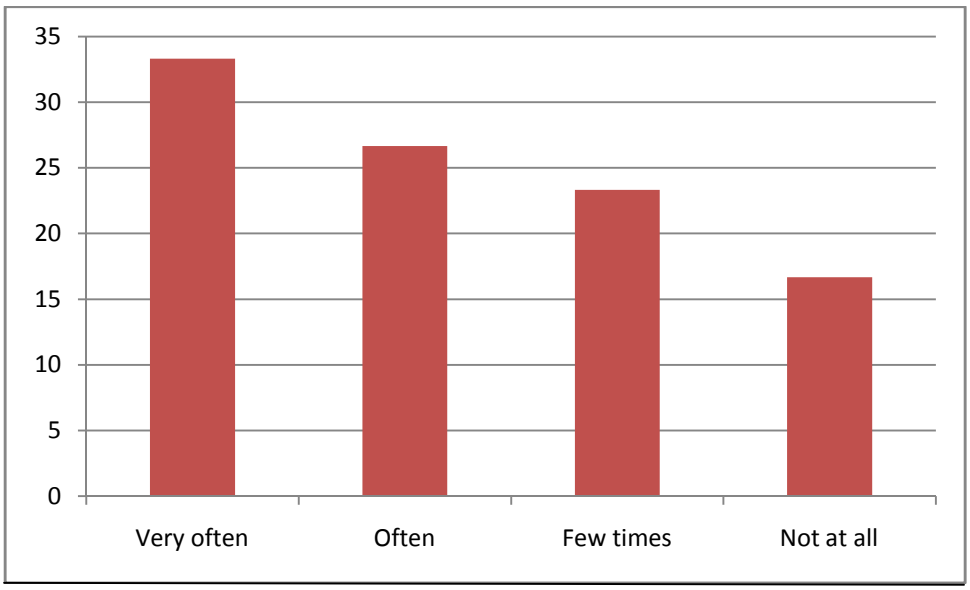

Fig. 4. Frequency of System users

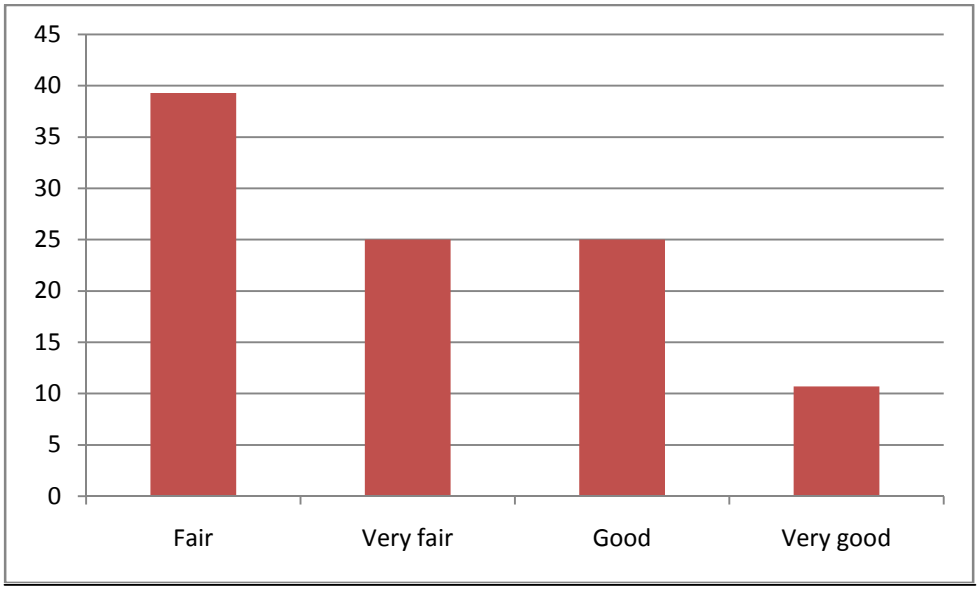

Fig. 5. Level of knowledge of system

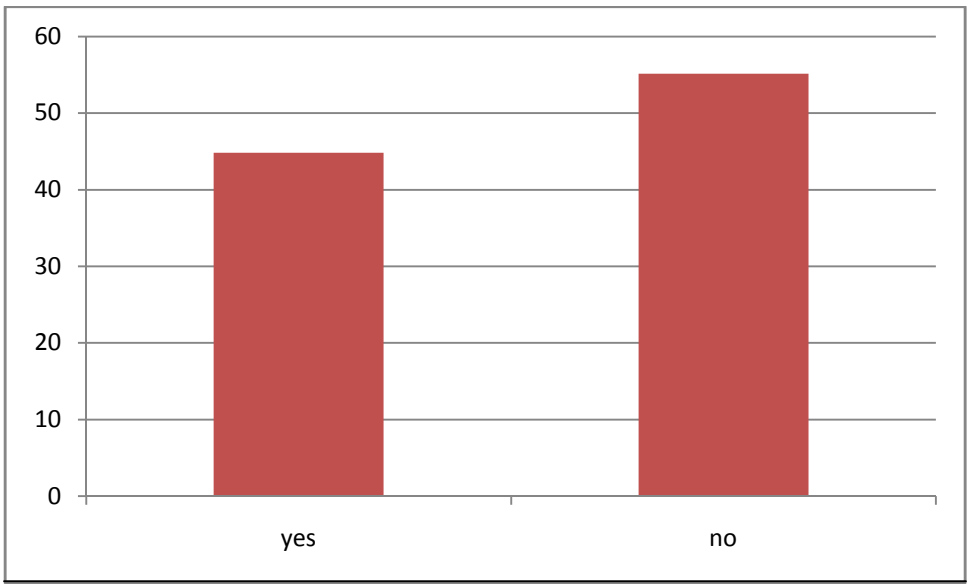

Fig. 6. Idea of cost

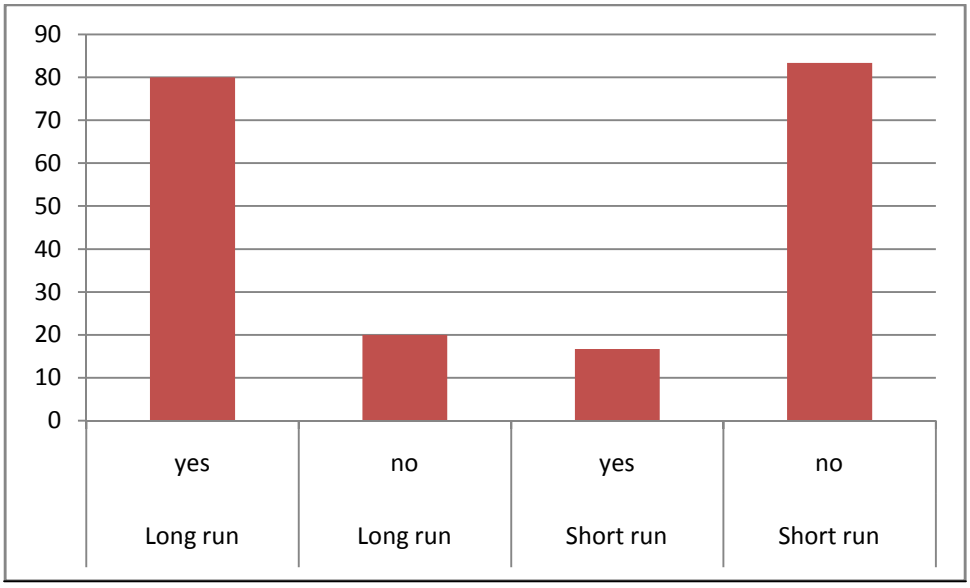

Fig. 7. Cost effectiveness

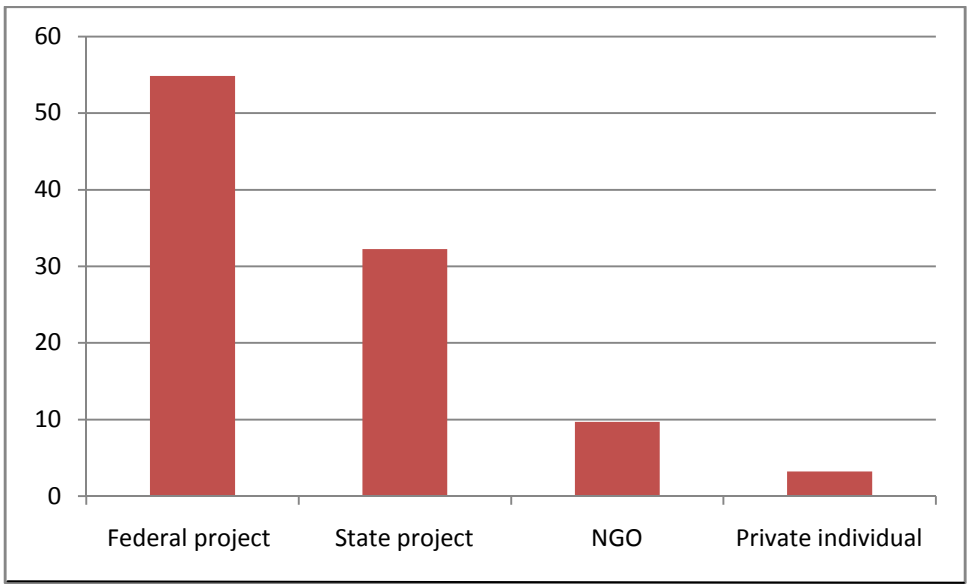

Fig. 8. System ownership

3.3 Durability of Solar Equipment

At the time of this study a large majority 62.07% as suggested by Fig. 9 claimed that they had known these equipment for less than one year while 37.93% said that they had known them for less than three years. A large majority, 63.33%,of these equipment as shown in Fig. 10 require between 4-6 hours to recharge.This was confirmed by 62.07% if “good” and “very good” were taken together who said that the performance of the equipment was good (Fig. 11).

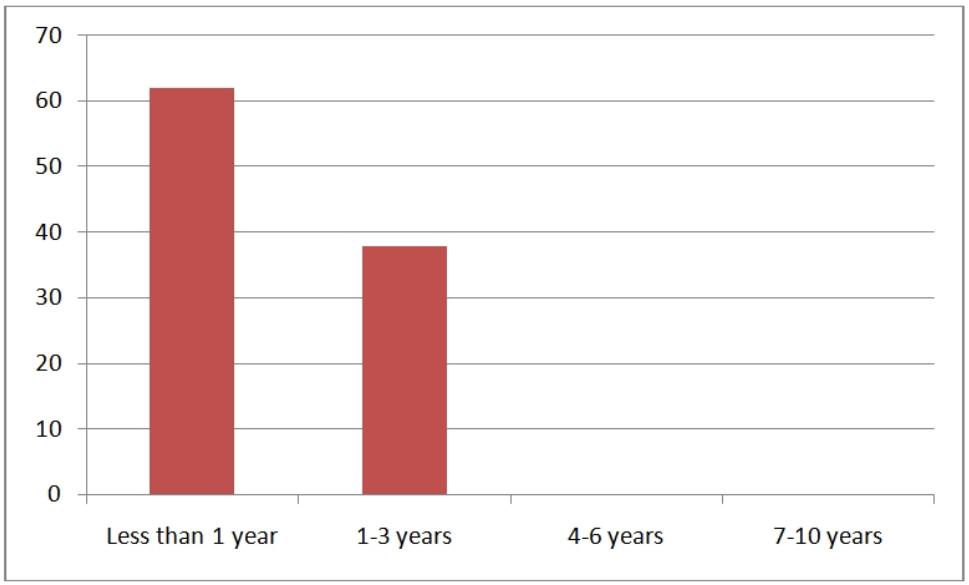

Fig. 9. Length of system use

However, there were a strong consensus of 70% of the people if “agree” and “strongly agree” are taken together from Fig. 12 that these equipment could help alleviate the power problems in Nigeria and they all agreed to have the equipment installed in their homes (as suggested by Fig. 13).

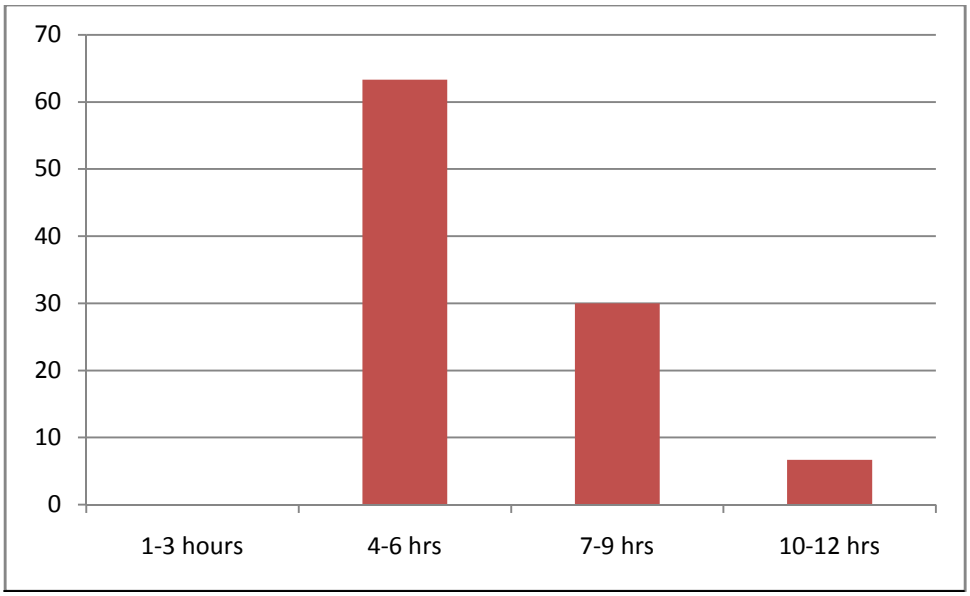

Fig. 10. Charging duration of panels

Fig. 11. System Performance levels

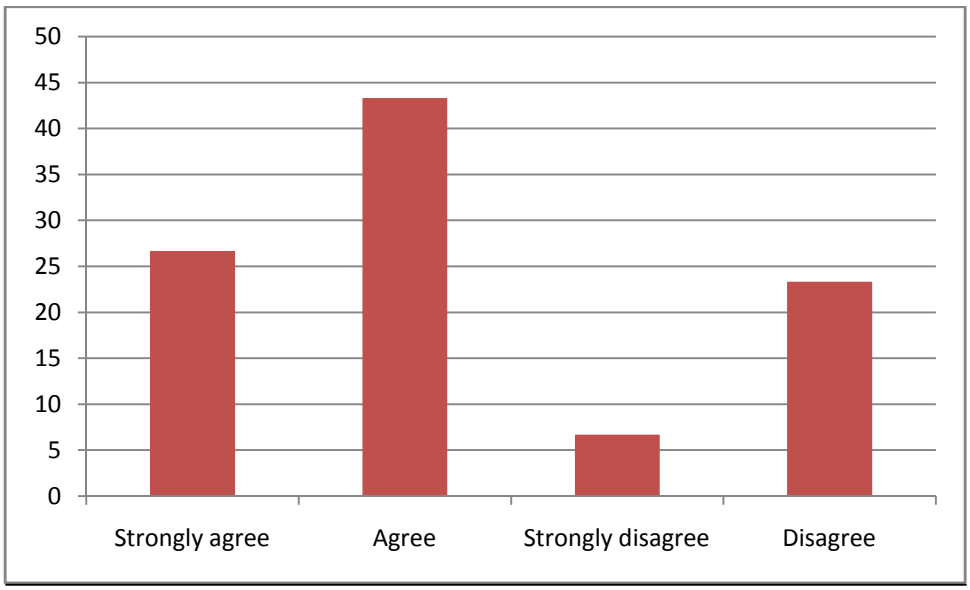

Fig. 12. Solving of Nigerian Power Problem through Solar Power

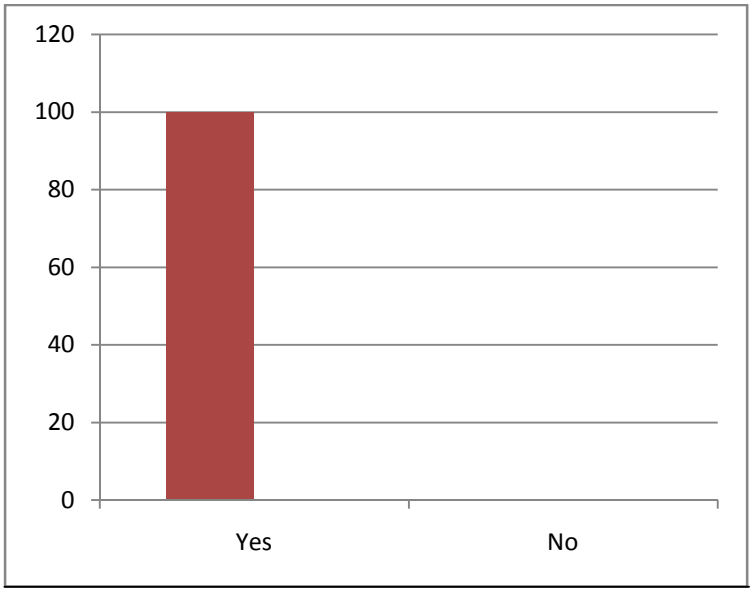

Fig. 13. Individuals who want to have such systems in homes

4. CONCLUSIONS

From the information gathered from this research it has been observed that the level of the public knowledge on the use of Solar Electric power Systems is still very low. The populace still have a misguided thinking that the Solar electric power generation systems are so expensive that even corporations cannot afford them, whereas they do not know that the price of these systems vary with their individual size. There are considerably cheap systems

which can successfully power the basic needs of a home such as lighting, ventilation and entertainment.

There are many advantages of using PV systems, which are:-

1) PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, or endanger animal or human health.
2) Photovoltaic systems are clean, quiet i.e. to generate electricity or heat with solar energy all you need only the sun rays. There is no need for fossil fuel in conjunction with sun rays to produce electricity or heating. All that is needed is a solar energy collector or solar power panels.
3) Solar energy can be the solution for those that live in a rural area where there are no power-lines. There are rural areas where power companies have no means to access their homes
4) Solar energy is a locally available renewable resource. All that is required is for the sun to shine.
5) Low/ no maintenance-Solar Energy systems are virtually maintenance free and will last for decades. Once they are installed, there are no recurring costs. Expansion plans are also easily accommodated as more solar panels can be easily added in the future according to growing family needs.
6) Money saving - once the initial investment has been recovered, the energy from the sun is practically FREE.

The recovery/ payback period for this investment can be very short depending on how much electricity the household uses.

If people understand the idea behind these systems which is Big investment and Gradual returns. The price for purchasing these systems is high but people should realize that in as much as there is day and night and the sun shines, power will be generated and they do not need to pay electricity utility bills and little or no maintenance is required.

5. RECOMMENDATIONS

Public awareness of the advantages of using Solar Electric systems should be increased and people should be educated about how the system really works.

Government should put measures in place which will allow cheaper importation of these products so as to help cut down the prices of the components of the system.

Solar Energy, if well harnessed can also be used by the government for many other uses such as street lighting (as already done in some places), security lightings and thereby reduce the load or requirements on the national power grid.

There are new developments such as solar generation integrated buildings which are designed to use solar energy for all its basic needs. This should also be included in the curriculum of Nigerian Architecture Schools.

COMPETING INTERESTS

Authors declare that there are no competing interests.

REFERENCES

1. Center for Sustainable Energy. Introduction To Solar Power Generation, accessed May 2nd, 2009. Available: www.energycenter.org
2. solarenergy.com 2008: SOLAR ENERGY: Your Infinite Resource accessed. May 2nd, 2009. Available: http://www.solarenergy.com/
3. Adenikinju A. Analysis of the cost of infrastructure failures in a developing economy the case of electricity sector in Nigeria. African Economic Research Consortium AERC Research Paper 148, February 2005 Nairobi. In IwayemiA. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. International Association for Energy Economics.2008:37:42. Accessed June 11th 2013

   Available: https://www.iaee.org/en/publications/newsletterdl.aspx?id=38
4. Ayogu M. Infrastructure Development in Africa: Prospects and Challenges. Paper presented on Economic Development in the Millennium. AERC-AfDB Project on Africa's Development. African Development Bank, Tunis, November 2006. In IwayemiA. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. International Association for Energy Economics.2008:37:42. Accessed June 11th 2013.

   Available: https://www.iaee.org/en/publications/newsletterdl.aspx?id=38
5. Energy Commission of Nigeria (2002) National Energy Policy. Abuja. August. In Iwayemi, A. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. International Association for Energy Economics.2008:37:42. Accessed June 11th 2013.

   Available: https://www.iaee.org/en/publications/newsletterdl.aspx?id=38
6. Jeffery K. Global warming and energy efficiency. Sun World. 1990:14(2):44:52.In:.Shaahid S.M, Elhadidy M.A. Prospects of autonomous/stand-alone hybrid(photo-voltaic + diesel + battery) powersystems in commercial applications in hotregions. Renewable Energy. 2004;29:165-177.
7. Ali S. Global progress in renewable energy2001 In: Proceedings abstracts, 7th Arab InternationalSolar Energy Conference, Sharjah, UAE, 19–22 Feb. 2001. p. 4.In: Shaahid S.M, Elhadidy M.A. Prospects of autonomous/stand-alone hybrid (photo-voltaic + diesel + battery) power systems in commercial applications in hot regions. Renewable Energy. 2004;29:165-177.
8. Coiante D, Barra L. Renewable energy capability to save carbon emissions. Solar Energy. 1996;57(6):485–91.In: Shaahid S.M, Elhadidy M.A. Prospects of autonomous/stand-alone hybrid (photo-voltaic + diesel + battery) power systems in commercial applications in hot regions. Renewable Energy. 2004;29:165-177.
9. Roger HB. The environmental, health, and safety implications of solar energy in central station power production. Energy. 1993;18(6):681–5.In:.Shaahid S.M, Elhadidy M.A. Prospects of autonomous/stand-alone hybrid (photo-voltaic + diesel + battery) power systems in commercial applications in hot regions. Renewable Energy. 2004;29:165–177.

10. Energy Commission of Nigeria. Renewable Energy Master Plan. Abuja. November 2005. In Iwayemi A. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. International Association for Energy Economics. 2008;37:42. Accessed June 11th 2013.
Available: https://www.iaee.org/en/publications/newsletterdl.aspx?id=38

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