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RENEWABLE SOLAR ENERGY UTILISATION BY DOMESTIC CONSUMERS IN NIGERIA: CHALLENGES AND SOLUTIONS

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ABSTRACT

Energy is the backbone of improved economy, technological advancement and attainment of Millennium Development Goals (MDG). In Nigeria, the demand for electrical energy is more than the supply and meaningful development has been crippled. In view of this, Nigerians in the industry, the academia and government circle have been involved in identifying and finding solutions to the lingering challenges of meeting the energy demands. In recent times, immense research efforts have been made towards enhancing renewable sources like solar, hydro, biogas, wind, etc. Even though there are many advantages associated with the solar renewable energy, it is not yet so popular among residential/domestic consumers. This paper focused on the challenges that hinder the wide acceptability of the solar energy source by domestic consumers. Oral interview was conducted for 147 respondents across various levels of education, age and income. With the use of frequency analysis, major challenges highlighted were summarized as affordability, lack of access, little or no public awareness, etc. The paper then recommended probable solutions aimed at overcoming these challenges for wider acceptability.

KEYWORDS: Renewable energy, solar, domestic consumers, oral interview, challenges, solutions.

I. INTRODUCTION

All over the globe, it is no more news that electricity is an indispensable ingredient of economic development and stability. The more the production of electricity, the better the quality of life, level of industrialization and creation of wealth (Gbadebo & Okonkwo, 2009). In other words, electricity is the pillar of economic development as it serves as the nucleus of operations and subsequently the engine of growth for all sectors of the economy (Ayodele, 2001). This statement is further buttressed by Okonkwo (2002) by affirming the correlation between electricity supply, industrialization and human effort. Also, Iwayemi (1998, 2008) submitted that electrical energy supply and its consumption have enormous impact on socio-economic development and quality of life of the population. Furthermore, Sambo (2008) stressed the view that inadequate supply of the energy restricts socio-economic activities, limits growth, adversely affects quality of life and reduces our chances of meeting the Millennium Development Goals (MDGs).

Nigeria electrical energy generation sub-sector has twenty-three (23) grid-connected generating plants in operation with a total installed capacity of 10,396 MW (but available capacity of 6,056 MW) with thermal based generation having an installed capacity of 8,457.6MW (but available capacity of 4,996 MW) and hydropower having 1,938.4 MW of total installed capacity (but available capacity of 1,060 MW) (NERC, 2017). New power plants are being commissioned but are faced with inadequacy of fossil fuel (natural gas) and proper planning for connection to national grid via the transmission network. However, in order to increase and diversify electrical power generation, and penetration into rural areas i.e. access to electricity, many suggestions have been made by active participants (through experience, exposure and research) in the power industry (Sambo, 2009). One of these suggestions is Energy Mix.

Energy Mix refers to using different primary sources of energy in different proportions according to countries to meet its energy demands. These primary energy sources are classified into two, viz (Total, 2015; Oyedepo, 2012):

1. Non-renewable Energy
2. Renewable Energy

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Non-renewable Energy includes fossil fuels – oil, natural gas and coal and nuclear energy. Nuclear means of power generation is not in operation in Nigeria at present. Research has shown that fossil fuels now have a limited stock and will get depleted within a few decades or a few centuries (Uppal & Rao, 2009). The fossil fuel energy resources and the reserves in Nigeria are presented in Table 1.

Table1: Fossil Energy Resources and Reserves

RESOURCES	Crude Oil	Natural Gas	Coal	Tar Sands
RESERVE	37.2 Billion barrels	187 TSCF*	2.7 Billion Tonnes	31 billion barrels of oil equivalent

TSCF*: Trillion Standard Cubic feet (Source: Bala, 2014)

Renewable Energy refers to energy that is naturally replenished. They do not deplete on consumption. The main advantages of this energy are little or no environmental hazard and little or no cost of obtaining the resources (Efurumibe et al, 2014). Also known as alternative or non-conventional energy, renewable energy sources are well suited for isolated stand-alone power plants (Uppal and Rao, 2009). Compared with natural gas which emits between 0.6 and 2 pounds of Carbon-dioxide equivalent per kilowatt-hour (CO2E/kWh), and coal which emits between 1.4 and 3.6 pounds of CO2E/kWh, wind emits only 0.02mto 0.04 pounds of CO2E/kWh; solar emits 0.07 to 0.2; geothermal 0.1 to 0.2 and hydroelectric between 0.1 and 0.5 (REN21, 2017). Since renewable energy is the core of this paper, it is important to shed more light on the renewable energy sources:

1. **BIOMASS ENERGY**: Biomass refers to energy derivable from sources of plant origin such as trees, grasses, agricultural crops and their derivatives, as well as animal wastes. As an energy resource, biomass may be used as solid fuel, or converted via a variety of technologies to liquid or gaseous forms for the generation of electric power. Biomass resources are considered renewable as they are naturally occurring and when properly managed, may be harvested without significant depletion. Biomass resources available in the Nigeria include: fuel wood, agricultural waste and crop residue, sawdust and wood shavings, animal dung/poultry droppings, industrial effluents/municipal solid waste (Sambo, 2009).
2. **HYDROELECTRICITY:** This comes from the conversion of potential energy of water into electricity by water turbines and electric generator system. Large hydro systems are those rated greater than 30MW while small hydro power (SHP) are the ones less than or equal to 30MW. SHPs are further classified into: Pico (less than 5kW); Micro (5 – 100kW); Mini (100kW – 1MW) and Small (1MW – 30MW) (Sambo, 2007). Existing hydroelectric power stations in Nigeria are Kainji (760MW), Shiroro (600MW) and Jebba (578MW) totaling 1938MW which represents about 14% of the nation's hydropower potential and represents more than 30% of current total electricity generation capacity. Other major hydroelectric power stations under construction are 3,050MW Mambilla Hydropower plant at Gembu in Taraba State, 700MW Zungeru Hydroelectric power project in Niger State and 350MW Gurara II hydroelectric power station also in Niger State.
3. **WIND:** Energy in wind is converted into electrical form in a Wind-Turbine Generator unit. Wind turbine is installed on a tall tower made of steel and has 1, 2 or 3 blades on it (Gupta, 2011). Wind speed in Nigeria ranges from a low 1.4 to 3.0m/s in the Southern areas and 4.0 to 5.12m/s in the extreme North. Initial study showed that total actual exploitable wind energy reserve at 10m height may vary from 8MWh/yr in Yola to 51MWh/yr in the mountain areas of Jos Plateau and it is as high as 97MWh/yr in Sokoto.
4. **SOLAR POWER PLANTS:** These plants make use of energy from the sun. This energy can be harnessed in two ways, viz (Akinboro *et al*, 2012; Adeniji, 2014; Eronimi, 2014):
   (i) Solar Photovoltaic cells: This is the commonest and most direct method. Photovoltaic (PV) panels or solar cells generate an e.m.f. when exposed to sunlight and are usually connected in series and arranged in a panel.
   (ii) Solar Thermal: This involves the use of curved reflecting surfaces to concentrate solar energy on a receiver to help raise water to superheated steam, which is used to drive a turbine and generate electricity

Research has shown that if only 1% of Nigeria's land area of 923,773km^2 could be harvested for solar power, Nigeria would generate about 1,400,000MW or 1,400GW of electrical energy using off-the-shelf photovoltaic technologies (Olurinde, 2015). Average sunshine hours in Nigeria are estimated at 6

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hours per day. The renewable energy resources and the reserves/prospects in Nigeria are presented in Table2.

Table 2: Renewable Energy Resources Potential and Reserves

Resource	Reserve		Utilization Level
Large Hydro Power	11,250MW		1,900MW
Small Hydro Power	3,500MW		64.2MW
Solar Energy	4.0 – 6.5 kWh/m^2/day (moving from the coastal latitudes to along the semi-arid areas in the far north)		15MW stand-alone solar PV; no solar thermal electricity
Wind Energy	2-4m/s at 10m height		10MW wind farm in Katsina; 5kW wind turbine in Sokoto
Biomass	Fuel Wood	11 million hectares of forest and woodlands	
	Municipal Waste	18.3 million tonnes in 2005 and about 30 million tonnes/yr now	
	Animal waste	243 million assorted animals in 2001	
	Energy crops and Agric waste	28.2 million hectares of arable land	

(Source: Bala, 2014)

II. METHODS OF THE RESEARCH

Due to low utilization and patronage of solar renewable energy in Nigeria by domestic users with electrical energy consumption of more than 50% of electricity produced annually (Nwachukwu *et al*, 2014; Azodo, 2014), a research was conducted to ascertain the challenges being experienced by these domestic users with the objective of recommending necessary solutions for better utilization of the abundant renewable energy in Nigeria. In order to achieve this, a sample size of 147 domestic users residing in Abeokuta, Ogun state capital were interviewed in a period of 9 weeks. The age range of interviewees was between 29 years and 48 years and all were employed, most being State Government workers and the rest were Federal Government workers and self-employed. Out of the 147, 8 were female, the rest being male. The minimum education level of those interviewed was Primary Six School Leaving Certificate while the most educated was Master's Degree holders. The direct interview approach provided in-depth knowledge and insight on respondents' attitudes and thoughts even though not all respondents were willing to be interviewed. However, direct interview approach was time-consuming and suffers from the difficulty of correct collation of responses.

III. RESULTS AND DISCUSSION

In order to provide descriptive information, the statistical technique adopted was frequency analysis due to its simplicity. The respondents can be categorized into two, viz: those who are using or have used it before and those who have not used it before. The respective responses of these groups are provided in Tables 3 and 4 below:

Those who are using it or have used it before:

Table 3: Responses from those who are using or have used the solar panel technology before

Number of interviewees	% of those who are using it or have used it before	% of total respondents	Response/ summary of challenges
1	25%	0.6803%	Theft
2	50%	1.3605%	Technical problems: maintenance of the device, intermittency of the sun in the rainy seasons
1	25%	0.6803%	Inadequate land area to mount the solar panels

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TOTAL = 4	**100%**	**2.7211%**	

Those who have not used it before:

Table 4: Responses from those have not used the solar panel technology before

Number of interviewees	% of those who have not used it before	% of total respondents	Response/ summary of challenges
76	53.1469%	51.7007%	Affordability
14	9.7902%	9.5238%	Lack of access to providers
21	14.6853%	14.2857%	Inadequate information/ignorance
8	5.5944%	5.4422%	Neglect by government
5	3.4965%	3.4014%	Discouraging reports from those who have used it before
19	13.2867%	12.9252	Fear of trying something different/fear of change
TOTAL= 143	**100%**	**97.2789%**	

For the purpose of better understanding and clarity, the listed challenges from various respondents in Table 3 and Table 4 are expounded below:

Affordability: Since many that were interviewed were low income earners, many complained about the initial high cost of the panels and other accompanying devices. Solar renewable energy usage requires high initial investment with very low operating/running cost.

Non-availability and Access to Purchase: The solar Photovoltaic cells are not easy to acquire. Only few providers are available and are far from places of residence.

Inadequate information/complete ignorance: Many respondents did not have any information about solar energy before. Also, some respondents have wrong information about it.

Inadequate Technical Expertise/manpower: There are not enough expert engineers and technicians on ground to develop, deploy and manage the renewable energy.

Neglect by Government: Some were discouraged to use the solar energy technology, nursing the fear that it may not be a viable means of electricity generation because government buildings.

Inadequate Land area: To get substantial electrical energy from the photovoltaic cells, large land area will be required and this meets the great brick wall of the land use act.

Bad experience or reports from those who have used it before due to poor quality and standard

Technical Challenges: There is a need to buy extra back-up/storage facilities due to intermittency of the sun. Scaling up of immature technologies and proper siting also poses additional burden on those using it.

A case of theft of solar panels placed outside was reported.

Fear of Change: Some who have not tried using the method before are so scared of change. They fear that changing from the conventional and secure energy sources they are very familiar with to intermittent and uncertain renewable may not be the best decision after all.

Finally, from literature, another common challenge is reduction in the efficiency of the solar cells due to dust and sand accumulation. Research confirms that 10 mg/cm^2 of dust deposition decreases the power output by more than 90 percent (Gastli *et al*, 2010). Also, 4 grams of dust per square meter can reduce a solar panel's efficiency by 40 percent (Gastli & Charabi, 2011). This is secondary data obtained from a journal (Akinboro et al., 2012).

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From literature (Saka, Olawuni & Omoboye, 2017; Adebayo, 2014; ECN-UNDP (REMP), 2005) and inferences from the research results above, below are the recommended solutions aimed at overcoming the challenges of solar renewable energy utilization in residential buildings in Nigeria.

1. Proper awareness and advocacy should be made at all times by those saddled with the administration of renewable energy management in the country and other stakeholders.
2. Government can encourage incentives in terms of subsidies and tax incentives to consumers and those who trade in the industry (local suppliers and manufacturers).
3. Government can also lead by example through heavy investments in the renewable energy industry. This is expected to encourage other consumers and allay their fears.
4. Adequate intensification of research into renewable energy electricity technology to further bring down costs.
5. Establishment of regulatory framework or policy for the renewable energy industry.
6. Approval and institutionalization of the National Energy Masterplan.
7. Nigerian engineers and technicians in should show interest toward and demonstrate expertise in renewable energy technology by ensuring proper design, installation and usage.

IV. CONCLUSION

Nigeria, due to its geographical location, is blessed with abundant renewable energy resources which are grossly under-utilized. These resources should not be allowed to waste away, more so, when they have been considered to produce energy lacking in carbon products which can pollute the environment and increase the level of atmospheric hazards. Fossil fuels will deplete and be exhausted someday. We need to start looking in the direction of clean, abundant renewable energy for sufficient power supply in Nigeria by making all efforts to surmount the enormous challenges being faced by consumers of electrical energy.

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