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Article

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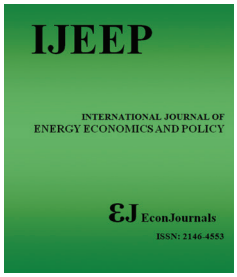

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Exploration of Renewable Energy Resources for Sustainable Development in Nigeria: A Study of the Federal Capital Territory

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ABSTRACT

This study examined renewable energy (RE) resources and their utilisation to achieve sustainable development (SD) in Nigeria. This was with the view of providing strategic assessment for sustainable energy development in the country consequent to the high level of environmental hazards which have trailed the path of many countries' economic growth and industrialisation. A survey method was adopted in the study whereby 300 copies of a single set of questions were distributed across the federal capital territory, Abuja. The results showed that most of the respondents perceived that the level of public awareness and publicity by the government on RE adoption is still relatively low. Majority of the respondents were not concern about reduction of greenhouse gas emissions as <20% were motivated to use RE due to environmental factors while more than 50% were motivated by economic factor. A strong political commitment of the government on RE and creation of enabling environment for the private sectors will go a long way to deliver social services such as health, education, clean water as well as employment creation which will foster the realisation of SD goals.

Keywords: Sustainable Development, Renewable Energy, Sustainable Development Goals
JEL Classifications: O13, O44, Q01, Q56

1. INTRODUCTION

Energy does not play a simple role to development of any country. The role of energy is so huge to the extent that there is no sector of the economy that does not require energy to create a value-added to whatever goods it produces or services it provides. This invariably is expected to improve the standard of living and reduce poverty of the populace. Uninterrupted energy supply is a critical issue for all countries today as future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly (Oyedepo, 2013). More so, the impact that energy has in achieving the entire sustainable development goals (SDGs) such as zero hunger, quality education, decent work and economic growth, sound health facilities and high literacy rates among others cannot be undermined. Many nations both developed and developing have increased their productivity through increased level of energy consumption. However, most of the energy sources that have been used to realise these economic growth are fossil fuel which are associated with environmental hazards that have exposed the entire world to toxic substances. There is a global effort towards reducing the level of greenhouse gas (GHG) emissions so as to save the entire universe from the negative consequences. This necessitates exploiting alternative sources of energy which are clean and environmental friendly unlike the conventional fossil fuels.

One of the greatest challenges facing the African continent is access to clean modern energy services, as energy is fundamental to socioeconomic development and poverty eradication. This makes provision of crucial services such as clean water, sanitation and healthcare, reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunications, difficult to provide. There is a strong relationship between the level of poverty and access to energy (Iwayemi, 2008; Akinwale et al., 2015). In Nigeria today, majority of the inhabitants ranging from 60% to 70% do not have access to regular supply of electricity and with more than 60% of the Nigerians living below the poverty line (NBS, 2016). A large number of few people living above the poverty line reside in the urban centres and rely mainly on self-generating power that mostly run-on fossil fuel because of the incessant power supply from the national grid. This system is not sustainable as these fossil fuel sources are exhaustible and at the

same time contribute to environmental degradation. The challenges of sustainability form the basis on which the study is done so as to provide information on other cleaner options to supplement the existing electricity supply at all levels (national, state, local and private). Renewable energy (RE) has been documented as a viable alternative to electricity generation as against the present predominant use of fossil fuel. There is a limited empirical study on harnessing RE for SD in Nigeria. Hence, this study seeks to contribute to the existing literature on the exploration of RE in Nigeria.

2. THE LINK BETWEEN RE RESOURCES AND SD

RE sources involve the harnessing of natural energy flows such as sunlight, wind, biomass and falling water, whose rates of replenishment are comparable to or greater than the human use rates (Akinbami, 2001). The potentials of RE sources have been documented to be in abundance globally and specifically in Nigeria (Akinwale et al., 2013). However, the level of utilisation of RE in Nigeria is still very low compare to its availability. Thermal generating stations constitute more than 60% of the Nigerian grid supply though the level of supply can also be said to be low (Iwayemi, 2008). The epileptic nature of grid power supply in the urban centre, high level of self-diesel/petrol generating sets and non-availability of electricity in the rural areas where the majority of Nigerians live have made the current system unsustainable (Akinwale et al., 2015). Though economic development has been strongly correlated with increasing energy use and growth of GHG emissions but RE can help decouple that correlation, contributing to SD (Sathaye et al., 2011). More so, RE offers the opportunity to improve access to modern energy services for the poorest members of society, which is crucial to the achievement of the 17 SDGs.

The SDGs are the world's time bound and quantified targets for addressing extreme poverty in its many dimensions–income poverty, hunger, disease, lack of adequate shelter, and exclusion-while promoting gender equality, education, and environmental sustainability. The SDGs was given birth to in 2015 after countries adopted the 2030 Agenda for SD and its 17 SDGs (UN, 2017). In 2016, the Paris agreement on climate change entered into force, addressing the need to limit the rise of global temperatures (International Energy Agency, 2016).

Access to an affordable energy has been highlighted as one of the major factor to eradicate poverty of the local population (Matera et al., 2009; Akinwale et al., 2015). According to the report from the UN on energy and environment, there is a clear relationship between access to RE and achieving the development goals (Bugje, 2006; UN, 2017). Meanwhile, lack of adequate energy services is a constraint to development as it limits the potentials of meeting basic needs of those who require energy to undertake essential domestic, agricultural and educational tasks, to support health and transport services, and to initiate or develop manufacturing or trading enterprises (Bugje, 2006). Utilization of RE should be given a top priority in Nigeria especially taking into consideration the increased awareness of the adverse environmental impacts of fossil-based generation across the globe. The need for sustainable energy is rapidly increasing in the world. A widespread use of RE is important for achieving SD in both developing and industrialized countries.

SD has been defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Bundtland, 1987; Sathaye et al., 2011). SD comprises three main integrated components *viz*.: Economic development, social development and environmental protection (UN, 2005). These three components are expected to operate as interdependent and mutually reinforcing one another so as to achieve a strong sustainability. These components though complementary but are also conflicting. There is a need to properly manage these components so as to bring about a SD for a nation. RE has an important role to play in meeting the future energy needs in both rural and urban areas (Lior, 2008). Sustainable energy involves the provision of energy services in a sustainable manner, which in turn necessitates that energy services be provided for all people in ways that, now and in the future, are sufficient to provide the basic necessities, affordable, not detrimental to the environment, and acceptable to communities and people (Rosen, 2002; Haberl, 2006; Lior, 2008). Thus, RE play a pivotal role to achieve SD by balancing economic and social developments with environmental protection so as to meet the present and future needs of the citizens in all aspects of life without any detriment to the environment. A major driving force behind increased use of RE technologies worldwide is mitigation of dangerous anthropogenic climate change to the extent at which climate change stabilization levels - such as a maximum of 550 ppm CO_2eq atmospheric GHG concentration or a maximum of 2°C temperature increase with respect to the pre-industrial global average - are accepted. Generally, RE offers the opportunity to contribute to a number of important SD goals which include social and economic development, energy access, energy security, and climate change mitigation and the reduction of environmental and health impacts (Sathaye et al., 2011). RE also serve as a good opportunity of creating employment for the local residents and actively promoting structural change in the economy as it has been witnessed in some of the industrialized nations.

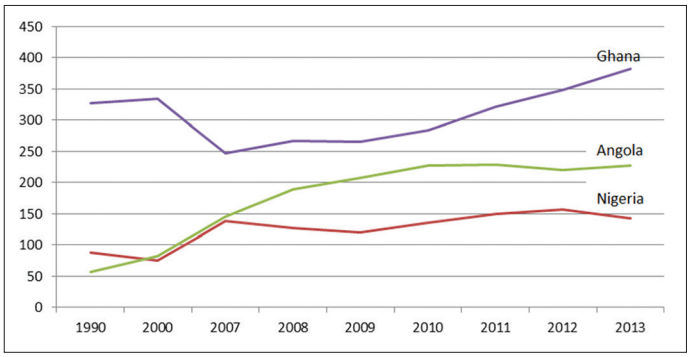
3. ENERGY SITUATION AND RE POTENTIALS IN NIGERIA

This section briefly discusses the energy situation in the country and various RE potentials available in the country.

3.1. Current Energy Situation

Nigeria is the most populous country in Africa and belongs to the group of countries with the lowest electricity consumption per capita in the continent. Nigeria is also ranked among the less developed countries in the world as the electricity consumption per capita is approximately 142 kWh as at year 2013, which is below that of Ghana (382 kWh) and Angola (227 kWh) in Sub-Sahara Africa as shown in Figure 1, despite her potentials in the energy sector. Despite the recent reform of Nigerian electricity market, the gap between the electricity demand and supply continues to get wider on a yearly basis as industrialisation and population

Figure 1: Electricity consumption (in kWh) per capita in selected Sub-Sahara African countries



Source: World Bank Development Indicators, 2017

increase. <40% of Nigerians have access to electricity (Energy Information Administration, 2016), with only about 30% of their demands being met. Virtually all the members of manufacturers association of Nigeria and a significant number of household residential depend mainly on self-generating diesel plants which have negative impact on the environment.

Meanwhile, the largest percentage of Nigerians live in the rural area which is out of the reach of the national grid connection and those that are connected to the grid are living below the poverty line, and thus could not afford to self-generate power for their houses. According to NBS (2012), the estimated total installed generation capacity of the Nigerian grid is 8,900 Megawatts (MW) out of which large hydro and thermal power plants accounted for 22% and 78% respectively. There are three large hydro and seven thermal generating power stations in Nigeria. It is very saddening that the readily available electricity generation is not more than 3500 MW for the entire population of more than 170 million people. It becomes very clear that the demand for electricity far outstrips its supply. Thus, exploiting alternative and cleaner options, such as RE, to supplement the current electricity generation in Nigeria in order to meet the demand of the teeming population becomes very important.

3.2. RE Potentials

3.2.1. Hydropower

Hydropower is generated from the conversion of potential energy of water into electricity by water turbines and electric generator system (Aliyu and Bawa, 2011). The potential of hydropower depends on the amount of available water and suitable terrain. According to IJHD (2010), the percentages of undeveloped potentials range from 47% in Europe, 62% in North America, 80% in Asia to 92% in Africa. This implies that there is large opportunity for hydropower development worldwide. The total technically exploitable large scale hydropower potential of the country is estimated at over 12,000 MW, capable of producing 36,000 GWh of electricity annually while the small scale hydropower potential is estimated at 3,500 MW (RE Master Plan, 2013; Sambo, 2008; Akinbami, 2001). Thus, current hydropower generation is about 14% of the nation's hydropower potential and represents about 30% of the total installed grid connected electricity generation capacity. This means that there are still lots of hydro potentials which have not been harnessed. Small-scale hydro is mainly 'run of river,' and thus not requires the construction of large dams and reservoirs. This is a ready-made replacement of fossil fuels since it can generally produce some electricity on demand (at least at times of the year when an adequate flow of water is available) with no need for storage or backup systems. It is also in many cases cost competitive with fossil-fuel power stations, or for remote rural areas, diesel generated power. The majority of the small hydropower has not even been exploited in Nigeria.

Hydropower projects in many countries had brought socio-economic development such as flood control, irrigation, tourism, local employment and skills development, rural electrification and the expansion of physical and social infrastructure such as roads and schools or rather as a whole, the opening up of interior areas of the country to other economics (Mohamed and Lee, 2006). On the other hand, the development of a hydropower dam is overwhelmingly complex which is not only limited to the issues of design, construction and operation of dams themselves but also involve social, environmental and political issues. This includes the displacement of large number of people and other aquatic natures by dams as well as huge initial cost of hydropower plants (The World Commissions on Dams, 2000).

3.2.2. Solar power

This involves technologies of generating electricity from the energy of the sun. Solar systems provide electricity for rural dwellers, homes, hospitals, schools and businesses among others. Globally, solar energy is abundant and has a huge potential for cleaner climate environment (Tsilingiridis et al., 2004). Nigeria is squarely located in the tropics, with its land mass stretching between latitudes 5° South and 15° North of the equator (Uduma and Arciszewski, 2010). Consequently, the country enjoys abundant amounts of sunshine. It has been well documented in the past relevant studies that the potential and viability of solar energy sources in Nigeria show that the country has nearly 290 days of sunlight in a year. The average solar insolation in Nigeria is estimated to vary between 4.0 kWh/m^2/day at the Southern coasts and 7.0 kWh/m^2/day at the northern coasts of the country (Freling and Lahl, 2005). The daily average is estimated at 5.5 kWh/m^2/day which shows that availability of abundant sunshine is a positive indicator that Nigeria is an ideal candidate for investment in solar energy resource development.

Nigerian government has started operation "Light up Rural Nigeria" in year 2014 with the aim of providing constant electricity supply to the rural areas through an off-grid system. The first phase is to extend the solar-powered initiative to remote parts of the country that are yet to be connected to the national grid. More people especially the rural dwellers that do not have access to electricity are expected to benefit from this. This is still at the infancy stage in Nigeria but it is expected to reduce poverty by ensuring a high quality service that guarantees the realisation of SDGs. Government commitment to this will go a long way to achieve SD in Nigeria.

3.2.3. Biomass

Biomass is any material which once was living and which can be utilized for energy production (Ahmad and Tahar, 2014). It is

usually a plant-derived organic matter as well as animal wastes available for energy generation. It can be used as solid fuel and can also be converted to liquid or gaseous forms for electric power generation, heat or fuel using different technologies. According to Rahman (2011), the use of biomass for energy production is on rise worldwide. In Nigeria, the biomass resources consist of wood, forage grasses and shrubs, animal wastes arising from forestry, agricultural, municipal and industrial activities as well as aquatic biomass. The total land available in Nigeria for agriculture and under vegetation is a measure of biomass potential. According to National Bureau of Statistics (2016), the biomass energy resources of the nation have been estimated to be 144 million tones/year. It is estimated that Nigeria consumes about 43.4 × 109 kg of fuel wood annually. Over 60% of Nigeria's population depends on fuel wood for cooking and other domestic uses. The consumption of fuel wood is worsened by the wide spread use of inefficient cooking methods, the most common of which is still open fire. This traditional method is not sustainable as the rate of consumption of fuel wood far exceeds the replenishing rate thus resulting in desert encroachment, soil erosion and loss of soil fertility. The rural dwellers should be enlightened so as to use an improved wood-burning stove which could reduce fuel wood consumption for a particular process by 50%. Also, the government should work towards providing the modern high-efficiency bio energy which uses more convenient solids, liquids and gases as secondary energy carriers to generate heat, electricity, combined heat and power and transport fuels for various sectors (Chum et al., 2011). Nigerian government should ensure that power generation through biomass does not affect food production as the usage of land and crops become competitive between food or energy production.

3.2.4. Wind

Wind is an effect from heating of the earth's surface by the sun. The resultant force inequalities are always available at the annual rate of 4.0 m/s at the far northern region and 2.0 m/s at the coastal region of the country. The potential for wind energy generation generally depend on the availability of wind resource that varies with location. Understanding the site specific nature of wind is a crucial step in planning wind energy project (Shafie et al., 2011). Detailed knowledge of wind on site is needed to estimate the performance of wind energy project. Wind energy technologies convert the energy from wind for practical purposes such as pumping water, grinding grain, charging batteries and generating electricity among others. The main technical parameter determining the economic success of a wind turbine system is its annual energy output, which in turn is determined by parameters such as average wind speed, statistical wind speed distribution, distribution of occurring wind directions, turbulence intensities, and roughness of the surrounding terrain among others. However, the most important and sensitive parameter is the wind speed which increases with height above the ground. The wind speed varies between a low 1.4 and 3.0 m/s in the Southern areas and 4.0-5.12 m/s at 10 m height in the extreme North of Nigeria. There is high potential of wind energy in Nigeria especially in the Northern part. There are few evidences of small wind power plant for water pumping and village electrification in Northern Nigeria. There are constraints such as location of site, public resistance, technology incapability of the local people, acoustic noise emission, visual impact on the landscape and impact on bird's life. There is need to carry out a comprehensive environmental impact analysis before siting the wind turbine so as to avoid some of these problems.

Nigeria is bestowed with abundant RE resources such as solar, wind, biomass, large and small hydropower potentials. However, the level of penetration of renewable energies is still very low in Nigeria (Sambo, 2008). Though the initial cost of investment of some of these RE sources may be high but the maintenance costs of most of them are relatively low.

4. METHODOLOGY

The data for this study was obtained from a survey conducted on the households across the six local councils at the federal capital territory (FCT), Abuja, Nigeria in year 2015. The FCT is the seat of the Nigerian federal government. The study employed a structured questionnaire to collect data from various households through a random selection. A total number of 300 questionnaire was administered with 50 questionnaire in each local councils. The councils include Abaji, Abuja Municipal, Gwagwalada, Kuje, Bwari and Kwali. The primary survey was conducted to sample opinion of people about their awareness, usage, government support, and attitudes toward RE at the FCT which is a Northern part of the Country. A total of 216 out of 300 questionnaire distributed was filled correctly which represents 72% of the total respondents sampled. Some of the questions were likert scale type and multiple choice questions. The likert scale ranges from strongly agree to strongly disagree. Furthermore, 50 out of the respondents were also interviewed on certain RE issues in order to have an in-depth perception of the respondents.

A descriptive analysis is then carried out to analyse the understanding and attitude of the public towards RE sources.

4.1. Analysis of Results

The qualification of the respondents as can be seen in Table 1 shows that majority of the respondents (52%) possessed HND/BSc degree which means that the large proportion of the respondents should have a basic understanding of the subject matter.

The type of RE the respondents are aware of was inquired. Larger proportions of the respondents are aware of mainly hydro (89%) followed by solar (86%), biomass (73%), and wind (58%) as shown in Figure 2.

Table 1: Academic qualification of the respondent

Qualification	Frequency (%)
Senior School Certificate	11 (5)
Colleges of Education	24 (11)
National Diploma	17 (8)
Higher National Diploma/Bachelor of Science	112 (52)
Masters	42 (19)
Doctorates	10 (5)
Total	216 (100)

When further enquiry was made on the respondents' awareness, it was found out that most (88%) of those that are aware of the hydro are mainly aware of large hydro which may be due to the fact that it is one of the two major contributors to the national grid, whereas only 25% of those that claim of such knowledge are only aware of small hydro. Also, the majority (92%) of those that claim to be aware of biomass are mainly aware of firewood while few (14%) of them are aware of bio-digesters.

The respondents were also asked about their current usage of RE. Figure 3 shows that 62% of the respondents claimed to be using hydro which is mainly large hydropower followed by biomass (52%) and solar (42%) with the least wind (2%). This is in line with the study conducted in south western Nigeria by Akinwale et al. (2014), where similar result was found for those living in the South-western part of the country.

The respondents were also asked about the factors that motivate their usage of RE. Three major factors that were considered are economic, social and environmental factors. While economic factor has to do with improvement in businesses; social factor has to do with improvement in wellbeing of the local communities; and environmental factor deals with the reduction in GHG emissions. This is shown in Figure 4 which depict that 51% of the respondents are motivated by economic factors, 32% are motivated by social factors while only 17% of them are motivated by environmental factor.

This implies that the respondents sampled have not really seen reduction of GHG emission as the crucial reason for adopting RE usage. However, most of them believed that RE will serve as a good alternative for fossil fuel in supporting their economic and business activities. The sampled respondents were also queried whether Nigerian government is doing enough to support and finance RE. Figure 5 shows that the largest percentage (88%) of the respondents perceived that the government is not doing enough to support RE in areas such as research and development, funding, training indigenous people in various RE technologies and creating enabling environment for the private sectors. Though there is RE master plan drafted by the Energy Commission of Nigeria in 2013 but most of the plans are yet to be implemented by government if at all any of them will be implemented. The political commitment of the government to RE could be perceived to be weak in Nigeria.

Furthermore, 50 respondents out of those that filled the questionnaire were carefully selected and interviewed on their perception of feed in tariff (FiT) strategy which supports the producers and users of energy from renewable sources. 92% of such respondents opined that Nigerian government should encourage the use of RE in all local government through the proper implementation of FiT mechanism. The general respondents were also asked about the RE sources that can help solve electricity problem in their community. Figure 6 shows that majority of the respondents (52%) believed that solar photovoltaic is the RE source that could help solves electricity problems most, followed by hydro (35%), biomass (11%) and wind (2%). The hydro that is considered here are mainly small hydro power plants and the biomass is the modern high-efficiency bio energy.

Figure 2: Level of awareness of renewable energy sources by the respondents

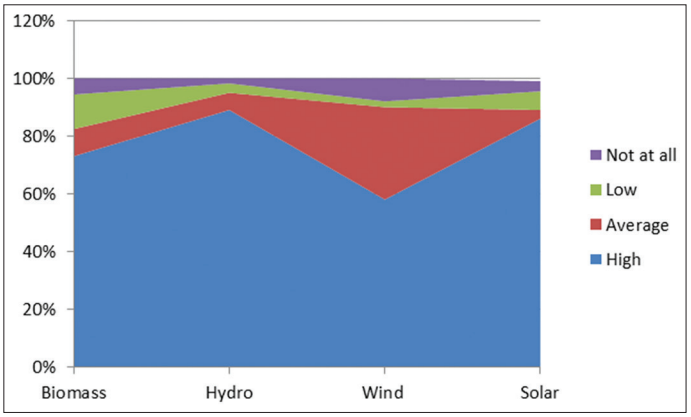


Figure 3: Renewable energy current use by the respondents

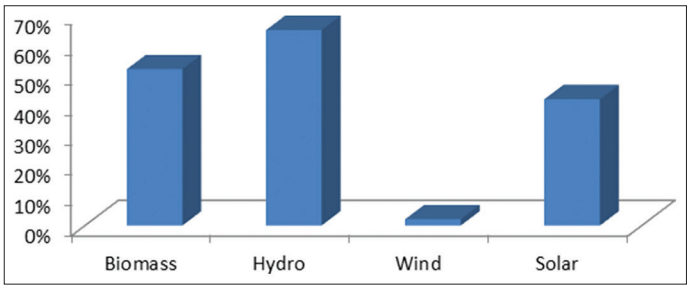


Figure 4: Factors motivating the usage of renewable energy

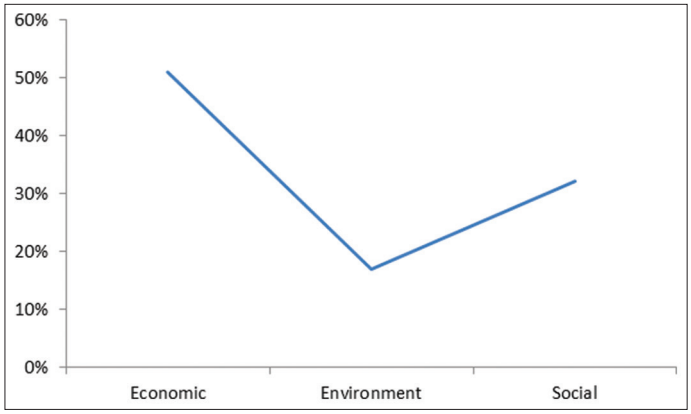


Figure 5: Extent of agreement to the level of government support of renewable energy

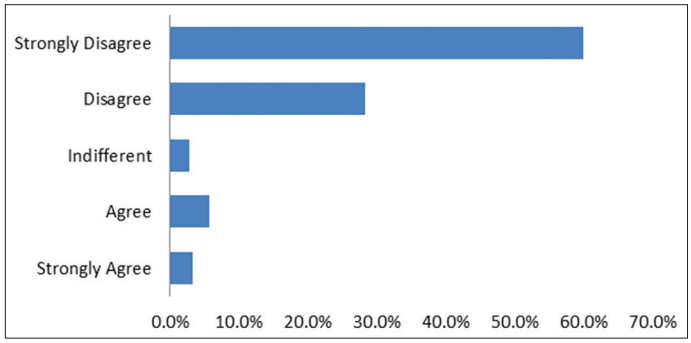
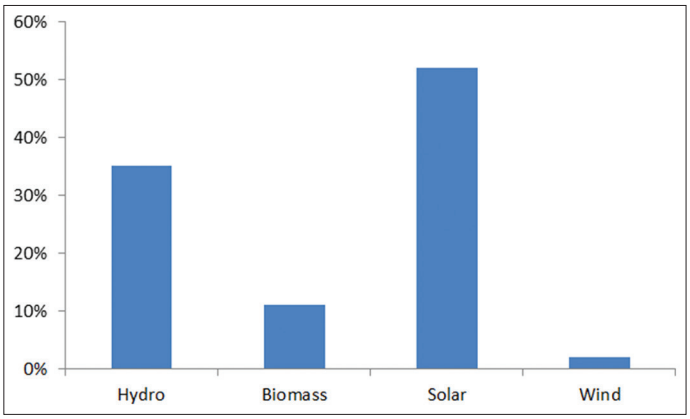


Figure 6: Perception about renewable energy sources that can solve local electricity crisis



5. CONCLUSION AND RECOMMENDATIONS

The level of poverty and environmental degradation increases daily in Nigeria as the gap between energy generation and consumption continues to get wider. Alternative energy is being sought globally, especially in developing nations, to complement the present energy supply as well as ensuring a cleaner environment. Energy supply mix must therefore be diversified in order to incorporate the RE sources in the country. In contrast to fossil fuel plants which belong to government and big companies, RE can actually be set up in small units which are easier to manage by the members of the community. The rural areas which are not connected to the national grid can easily be electrified through RE. This paper has been able to show that Nigerians though aware of some sources of RE but some of them do not know how these renewable energies operate. The use of traditional biomass fuels (firewood) for cooking which are not sustainable is very rampant among the respondents. Most of the respondents are motivated mainly by economic factors. However, the concern about reduction of GHG emissions is still relatively low as <20% perceived to be motivated by environmental factor. Majority of the respondents believed that the Nigerian government is not doing enough to support RE in areas such as research and development, funding, training indigenous people in various RE technologies, and creating enabling environment for the private sectors. It can be deduced that the level of government commitment to RE can be said to be low as some of their pronouncements are not backed by realistic actions.

This paper suggests solar energy as the main RE that most community can use to solve electricity problems based on the respondents' perception. This is followed by hydro but in this case small hydro; biomass (modern high-efficiency bio energy) and wind respectively. Since Nigeria has huge potentials in all these renewable energies, it will go a long way to deliver social services such as health, education, clean water as well as employment creation which will foster the realisation of SDGs. We also suggest that Nigerian government should legislate the implementation of incentives such as FiT for renewable energies as their investment cost is huge. The FiT is a mechanism that priorities electricity generated from indigenous RE resources to be purchased by power utilities at a fixed premium price and for a specific duration. It is a mechanism which will encourage the companies and individual to invest in renewable energies in Nigeria. This scheme intends to stimulate investments by providing financial incentives to renewable power producers and reducing the carbon emission.

There is low level of publicity on the need for RE as small number of respondents chose environmental factor as the motivating factor for using RE. Nigerian government should create public awareness on RE through different media such as social media, television, radio and other means so as to achieve SD. The main stakeholder like government, institution, industry and society should discuss RE issues in depth so that everyone will be able to understand and support the adoption of RE technologies for SD. This paper is also recommending that Nigerian government should develop and fully implement a comprehensive and coherent energy policy which is essential in guiding the citizens towards an efficient usage of its energy resources. This energy policy should take into consideration the electricity crisis and RE potentials in each community so as to know the best technologies to deploy in each community. RE technologies offer opportunities for modernization of energy services and contribute to energy security by diversifying energy sources as well as reducing dependence on a limited number of suppliers.

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