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RESEARCH ARTICLE

Potentials of renewable energy in a developing economy

***P. A. Nwofe[1]**
Department of Industrial Physics, Ebonyi State University, Nigeria

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***Corresponding Author**

P. A. Nwofe[1]

Abstract

Energy availability and sustainability is a fundamental step to achieving economic and social stability in a developing economy. In this study, the potentials of renewable energy for sustainable energy generation in developing economies (Nigeria, Ghana and Cameroon) have been discussed. The peculiarities of each country in terms of the numerous issues involved in harnessing renewable energy were highlighted. These are West and Central African countries, located in the tropics with huge amount of insolation which if carefully tapped will generate enough energy for herselves and for export. The study also explores the potentials of other renewables (wind and biomass), and compares the paradoxes of oil-rich Nigeria and the stark reality of a near-total decay of social infrastructure and economic focus to the other developing economies. The study then proposes a road map that Nigeria and by extension any developing country could adopt for a sustainable energy future.

Introduction

Natural resources are randomly distributed by nature with every country naturally blessed with her own share. In West Africa, Nigeria and Ghana, and Cameroun (Central Africa) are blessed with numerous natural recourses. These countries are located in the tropics. Nigeria is at latitude 10.0N and longitude 8.00E (Menakaya and Floyd, 1980), Ghana at latitude 8.0N and longitude 2.00W (www.mapsofworld.com) and Cameroun at latitude 6.0N and longitude 12.00E (www.mapsofworld.com). In Nigeria, the average solar insolation 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 (Oyedepo, 2014). The daily average insolation is estimated to be 5.5 kWh/m^2/day (Freling and Lahl, 2005, Uduma and Arciszewski, 2010). For Ghana, the average solar insolation is in the range 3.5-4.5 kWh/m^2/day (Forson et al. 2004, Energy Comission, Accra-Ghana, 2003; Christoph, et al., 2004, Arku, 2011 and Yiporo et al., 2012) and for Cameroun, the average solar irradiance is estimated to be 5.8 kWh/m^2/day, while for the rest of the country it is 4.9 kWh/m^2/day (Dennis and Lenora, 2013; David and Ngwa, 2013; Lealea and Tchinda, 2013; Tansi, 2011). These values indicate availability of abundant sunshine and thus serve as positive indicator that these countries are ideal candidates for investment in solar energy resource development. Another renewable energy source of interest that is abundant in these countries is biomass. It has been established that Cameroon has the third largest biomass potential in sub-Saharan Africa, with about 25 million hectares of forest covering 0.75% of its territory (Emmanuel, 2009; Ali et al., 2002). Despite this, the unsustainable use of this resource has led to significant deforestation throughout the country. It has been reported that the country records an annual clearance rate of 200,000 hectares/yr and regeneration of only 3,000 hectares/yr (David, 2014). As in common with other African countries, the primary uses for biomass in the country is fuelwood, mostly for heating and light for the majority of the rural population. Wastes to energy programme are not extensively and intensively practiced in Cameroun. In Nigeria, the scenario is not different. According to Omakaro (2008), the energy consumption pattern in Nigeria is dominated by fuel wood (50.45%), petroleum products (41.28%) and hydro electricity (8%) while biomass, solar, wind, geothermal, coal and nuclear sources are largely ignored. The potentials of biomass energy in Nigeria have been discussed extensively by different authors (Akinwade et al., 2013; Edward and Paul, 2013; Lawali and Bubuche, 2013; Abila, 2014; and

Nwofe, 2013). Studies done by Audu, (2013) indicate that Nigeria is losing about 38% of its total landmass to desertification due to overdependence on fuelwood for domestic energy needs. The intense demand for wood by construction, paper and furniture industries also add a reasonable quota to the depletion of Nigeria's biomass. Sambo (2005) noted that about 80 million cubic metres (43.4×10^9 kg) of fuelwood is consumed annually in Nigeria for cooking and other domestic purposes. Studies by Oyedepo, (2014) show that forage grasses and shrubs produce 200 million tons of dry biomass, which gives up to 2.28×10^6 MJ of energy. Ogwueleka (2009) reported that the waste density in Nigeria ranged from 280 to 370 kg/m^3 while the waste generation rates ranged from 0.44 to 0.66 kg/capita/day. Recent work on waste generation rates in some south-east states of Nigeria indicate that the generation rates of solid wastes is in the range 9.580 to 9.74×10^{-3} m^3 (Nwofe, 2013; and Nwoke, 2013). It has been reported that the rate of waste generation in Lagos is 9, 000 tonnes/day while in Kano State, the rate is 3, 849 tonnes/day (Tobore, 2012). Crop residues and waste in Nigeria produce an average estimates of 6.1million tons of dry biomass with energy content of approximately 5.3×10^{11} MJ (Akinbami, 2001). These values strongly indicate that Nigeria could generate a gigantic amount of energy if these wastes are managed in a sustainable manner. It has been reported that waste management has a sustainability goal to generate substantial renewable energy to power more than 2 million homes by the year 2020 (Scheutz et al., 2009).

Ghana has a suitable climate for plantation growth of Jatropha Curcas which can be used for producing biodiesel. It has been established that Ghana's energy sector is characterised by huge dominance of traditional biomass resources (Duku et al, 2011). Research done by Afrane and Ntiamoah (2011), indicate that close to 90% of households in Ghana use either firewood or charcoal for cooking between 2000– 2008. Arthur et al (2011) asserted that wood fuel contribute about 72% of the primary energy supply in Ghana. Otu-Danquah (2012) noted that fuel wood and charcoal consumption rose from 8,663 kilo tonnes to 13,630 kilo tones between 2000 to 2011 and that fuelwood still remain the dominant source of domestic fuel for most households in Ghana. Most recently in Ghana, fuel wood and charcoal accounted for about 66% of the country's total annual energy consumption leaving 20% and 14% to imported petroleum and electricity respectively (Acharibasm and Apatinga, 2014).

Wind energy is also abundant in the study areas. Research has shown that wind energy in Nigeria is available at annual average speeds of about 2.0 m/s at the coastal region and 4.0 m/s at the far northern region of the country (Akpu, 2012). Sambo (2009) asserted that with an air density of 1.1 kg/m^3, the wind energy intensity perpendicular to the wind direction ranges between 4.4 W/ m^2 at the coastal areas and 35.2 W/ m^2 at the far northern region. Agbetuyi et al, (2012) reported an average wind speed in the range 1-6.0m/s depending on the location in Nigeria. It has been reported that the energy that could be tapped from Ghana's wind resources for electricity generation is in the range 500 -600 Gwh/year (Energy Comission, Accra-Ghana, 2003). In Cameroun, wind energy potential exists in the north of Cameroon and the littoral regions and it has been shown that the northern areas have average wind speed of 5-7m/s (Koaga et al 2014; Tansi, 2011; Tchinda et al 2003; Tchinda et al 2000; Tchinda and Kapatouom, 2003). These values again points to the huge reserves of renewable energy that are still lying unharnessed in these countries despite her national energy shortages.

This study identifies/compares the potentials of renewable energy in the selected tropical countries, analyses the bottlenecks hindering large scale deployment of renewable energy technologies in the study areas, and proposes the way forward with particular emphasis on Nigeria. This study will serve as a benchmark and necessary fundamental step towards effective utilisation of renewable energy for enhanced energy efficiency and sustainability in developing economies.

Material and Methods

This study was carried out using a literature based conceptual approach, thus the author reviewed literature on the potentials of renewable energy and issues hindering their successful and large scale deployment in the study areas. The study investigates the availability of renewable energy sources and suggests actions to promote and sustain its development in these countries. The work also emphasised on the potentials of the renewable energy sources: solar, biomass and wind which have been largely unharnessed in the study areas. The author then proceeded to develop a detailed road map of how these huge and un-utilised renewable energy potentials can be harnessed for sustainable energy generation and efficiency in these countries, giving particular emphasis to Nigeria.

Result and Discussion

Scratching through the literature, it was observed that many scholars have attempted several discussions, research/approach on why the huge renewable energy resources in these countries are either untapped or poorly exploited with majority of her citizenry still living in energy poverty. However, none of these attempts has provided a comprehensive answer to why this ugly scenario still persists. One of the major setbacks with most developing countries in Africa is the lack of will and commitment of her Governments to long term investments. Most Governments in developing countries often opt for "short term" and "quick gains" investments instead of exploring the seemingly hard way of developing the necessary technologies that will enable her to use her abundant locally available renewable resources in an efficient and sustainable manner. This trend has continued to put Africa behind as third world nations, a situation that will deteriorate unless African leaders sit up without further delay. This section of this paper will focus on the similarities on issues hampering on renewable energy development in the study areas, discuss the picture of their energy consumption mix, implications of unsustainable use of energy resources on the economy, industry, agriculture, social and political sectors and then propose a way forward.

One of the issues obstructing renewable energy development in developing economies is poverty. Poverty is a common disease in West and Central African countries. It has been reported that about 30 % of Ghana's population is living in poverty (www.World Bank, Abdulai et al, 2014) while the absolute poverty rate of Nigeria was 46% by 2010 (www.World Bank), and about 39.9% % of Cameroon's population is also still living in abject poverty (www.World Bank). Akinola and Bolaji (2006) noted that adequate supply of affordable and reliable energy is extremely important for economic development and also contributes immensely to the alleviation of poverty, improved health, and better quality of life. It could be argued that most renewable energy technology are capital intensive especially the initial cost of investment but it is also established that these technologies have short and sustainable pay-back times (Ayompe and Duffy, 2014). The payback time for solar PV devices is typically less than 12 months for thin film solar cells and between 3-5 years for silicon based solar cell devices (Miles 2006; Miles, 2007, Ginley et al, 2008). The payback time of biogas plants, landfill plants and other biomass-related technologies is in the range 1.5-2.5 years (Energypeadia). Wind technology based devices has payback times of typically less than one year (Haapala and Preedanood, 2014; Marimutu and Kirubakaran, 2013). This gives a clear and positive index to why Governments of these countries should invest intensively in such technologies for enhanced energy availability, efficiency and sustainability. Provision of soft loans by financial institutions, private partnership/donors, and non-governmental organization (NGO) participation in reducing poverty will also increase local investment/consumption of renewable energy related products.

Illiteracy is another general scourge in Nigeria, Ghana and Cameroon. The literacy rate in Ghana is 67% in 2010 (Ghana Fact Sheet) and 45.9% of adult population are illiterate (Fuseini et al 2014), for Cameroon it is 71% as at 2010 (Cameroon Fact Sheet), and Nigeria has more than 50% illiteracy rate (Yusuf et al 2013). With such large percentage of illiteracy in these countries, it will be very difficult to communicate effectively, the importance of using renewable energy over the convectional energy sources or on the need for energy conservation and sustainability. Energy conservation is an important tool for sustainable development. Sustainable development requires that a sustainable supply of energy resources which in the long term, will be readily and sustainably available at reduced cost and can be utilised for all required tasks without negative consequences on the environment and /or society. These measures can be easily implemented or communicated effectively in countries with very high literacy rate.

Lack of Government Will and Commitment is also a contributing factor. Most Governments in developing countries lacks the will and commitments to long term sustainable projects. They embark on "white elephant projects" mostly for the purpose of siphoning public funds for private use. In Nigeria, Government has made some significant attempt such as the establishment of Energy Commission of Nigeria in 1979 which has led to the establishment of five National Centres for Energy Research and Development which includes; National Centre for Energy Research and Development (NECRD) at the University of Nigeria, Nsukka and Sokoto Energy Research Centre (SERC) at the Usman Dan Fodio University, Sokoto which are both responsible for research in solar and renewable energy, National Centre for Energy Efficiency and Conservation (NCEEC) at the University of Lagos, Lagos which is responsible for research in energy efficiency and conservation, National Centre for Hydropower Research and Development (NCHRD) at the University of Ilorin for research in hydropower, and National Centre for Petroleum Research and Development (NCPRD) at the Abubakar Tafawa Balewa University, Bauchi for research in petroleum, oil and gas) in the country. However, it is unfortunate to note that there are little research facilities in these centres. Some important characterisation equipments such as: X-ray Diffractometer (XRD), Raman Spectrometer, X-ray photoelectron spectrometer (XPS), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Atomic force microscopy (AFM), Secondary Ion Mass Spectrometer

(SIMS), Solar Simulator, Spectral response/quantum efficiency measurements equipments, Magnetron/RF Sputtering equipments, etc are rarely seen in these centres. It is only in few places like SHEDA, Abuja and in Abeokuta that very few characterisation equipments exist throughout the country. Most Universities in Nigeria do not have these equipments either. All these are due to lack of Government commitment and Will otherwise the national budget should have captured it under R&D (research and development) and also ensure its proper implementation. These equipments are very fundamental to research in thin film solar cells, materials science and biomass energy. Renewable energy potentials can only be properly harnessed if there are adequate research facilities on ground to train enough manpower that will match the demand and as well develop the technology indigenously without importing it. It has been shown that 1% of Nigeria's landmass could be utilised for the generation of over 600,000 megawatts of electricity using solar energy, through deployment of solar photovoltaic panels of only 5% efficiency from 1% of her land mass (National Mirror; Oghogho et al, 2014, Nwofe, 2014). Several initiatives/programmes aimed at achieving sustainable energy in the country are always either on a low scale, shortlived, or in practice in newspaper headlines. Such include the SE_4ALL initiative (sustainable energy for all) (Vangaurd, 2012) and PAWA774 in Ondo State (Punch, 2012) to mention but few. In Ghana, schemes aimed at achieving sustainable energy development includes; Ghana Energy Development and Access Project (GEDAP), Strategic National Energy Plan (SNEP), Ghana National Energy Policy, and Renewable Energy Services Programme (RESPRO). Oyedepo (2014) noted that in Nigeria, there are several unfinished policies that require completion and harmonisation, resulting in gaps in the overall implementation of energy policies such that there is an overall reduced investment in new generation, transmission and distribution of power. This shows that poor resource management and lack of commitment by various levels of government to invest in energy development are also real challenges that may mitigate a successful implantation of any sustainable energy technology in third world countries.

Lack of awareness of the potentials of renewable energy technologies and energy sustainability is another significant factor. Most citizens of developing countries are not aware of the merits of renewable energy technologies. This could be attributed to poor Government policies/implementation of renewable energy incentives that could have driven down the cost such that it will be easily affordable to the masses. Since a greater percentage of the citizens of developing countries are relatively poor, incentives such as the "feed-in tariffs" as practiced in the United Kingdom and other developed economies will serve as bait and will enhance awareness and increased consumption of renewable energy related products. Lack of awareness on energy sustainability can be solved through; programmes/incentives that will lead to reduced cost of renewable technology related products, extensive media programmes by Government, social institutions (private and public schools) and through information dissemination by authorised mobile network providers. Also the need for energy efficiency amongst consumers is suffering from poor information and dissemination on energy efficiency technologies.

It is a known fact that Nigeria is the largest oil producer in Africa, the tenth largest producer of oil in the world, and a key member of OPEC (organization of petroleum exporting countries). Nigeria export approximately 2million barrels of oil per day (www.cenbank.org). According to CBN report in 2009, Nigeria oil reserves is estimated to 36.2 billion barrels with gas reserves of more than 5000 billion cubic meters (CBN, 2009). It is not a new fact that Nigeria economy relies heavily on oil which accounts for more than 95% of export income and also accounts for almost 85% of the nation revenues. However acute shortage of power is experienced in almost all sectors. Accordingly, the possible reasons responsible for these endemic energy shortages in Nigeria include but not limited to;

- gross mismanagement of natural resources,
- Vandalisation of oil pipelines especially in the oil producing areas (Okoli and Orinya, 2013; Okolo and Etekpe, 2010). To buttress this further, it has been reported recently that the Nigeria Government under the leadership of Dr Goodluck Ebele Jonathan has committed one billion United State dollars to the fight against oil theft and pipeline vandalism in Nigeria (www.cnbc.africa).
- Recurring ethnic violence and eruption in different parts of the country (Sule, 2010),
- Total disregard by subsequent Nigerian governments to invest in the energy sector and adapt energy development that will suit local needs,
- Poor distribution systems and even poorer maintenance of the few existing distribution systems (Sambo, 2005; Oroge, 1991),
- Transmission lines sabotage and thefts (Lawal, 2008),
- Gross incompetence of managers appointed on political basis in the power sector, inadequate manpower and poorly trained workers,

- Bribery and corruption in almost sectors of the Nigeria system- In the power sector, this makes it possible for people to connect to the grid without meter, some rich/super rich class hardly pay their bills, distribution of transmission line equipments not done on merit, local producers of transmission line poles produce weak poles that does not stand test of time, deliberate re-adjustment of meter readings by customers at the detriment of Government, deliberate diversion/reduction of power allocated to some place to another, etc.
- Favouritism amongst those related to the super-rich/upper class.
- Ethnic sympathy with the consequences of employing wrong hands to manage sensitive sectors (Mustapha, 2006).
- Lack of skilled manpower to carry out thorough periodic energy audit studies in the six geo-political zones in the country and advise Government accordingly.

In lieu of the above, Nigeria should strive to overcome the aforementioned obstacles through;

- extensive research and development in renewable energy technologies,
- equipping existing centres with adequate and suitable equipments,
- establishment of more renewable energy research centres,
- inculcation of renewable energy in the education curricula (secondary schools and renewable energy as a first degree course in the university),
- training and education to build local technical capacity through increased scholarships in renewable energy for under-graduate, postgraduate and University lecturers,
- diversification of energy mix and scaling up of renewable energy utilisation,
- aggressive capacity building in all areas of energy development and creation of enabling environment that will attract investment in energy infrastructure to boost the economy,
- provision of soft loans and/or policies that are synonymous to the feed-in-tariffs as obtained in advanced countries. This will boost investment in renewable energy and consumption of products of renewable energy related technologies,
- and finally more effort by Government to reduce bribery and corruption in all sectors.

There is no doubt that if any developing country with such enormous renewable energy resources put these options into practice, that it will definitely lead to enhancement of energy availability and sustainability in such country.

From the discussion so far, it could be argued that these countries (Ghana, Nigeria and Cameroon) do not only share common endowment of abundant natural renewable resources but also similar bottlenecks militating on the large scale utilisation of the resources. The study further revealed that; poverty, illiteracy, lack of awareness, lack of technical skills/adequate manpower, energy infrastructures, financial incentives and lack of Government commitment to long term and sustainable projects are some of the major factors hindering the judicious management/exploitation of these resources in the selected study areas. The steps suggested in this study is pivotal to achieving a sustainable energy future in developing economies.

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