Strategic Developments In Renewable Energy In Nigeria

By Abubakar S. Sambo*

Introduction

Energy is the mainstay of Nigeria's economic growth and development. It plays a significant role in the nation's international diplomacy and it serves as a tradable commodity for earning the national income, which is used to support government development programmes. It also serves as an input into the production of goods and services in the nation's industry, transport, agriculture, health and education sectors, as well as an instrument for politics, security and diplomacy.

Energy, and in particular, oil and gas, has continued to contribute over 70% of Nigeria's Federal revenue. National developmental programmes, and security, depend largely on these revenue earnings. Energy, especially crude oil, has over the past five years contributed an average of about 25% to Nigeria's Gross Domestic Product (GDP), representing the highest contributor after crop production. The contribution of energy to GDP is expected to be higher when we take into account renewable energy utilization, which constitutes about 90% of the energy used by the rural population [1]. It should be noted that Nigeria which is located between longitude 3^{o} and 14^{o} East of Greenwich and latitude 4^{o} and 14^{o} north of equator has about 140 million people and a total land area of 923,768 km^2 .

The energy sub-sector, especially petroleum, continues to maintain its prominence as the single most important source of government revenue and foreign exchange earner. Petroleum contributed an average 25.24% to the GDP between 2002 and 2006. However, despite the fortunes of the oil sector, other sectors of the economy are declining. For example, consumption of electricity actually declined by 13.4% between 2002 and 2006 even though the overall or total electricity consumption showed a marginal increase of 1.8% from 5.63GWh in 2002 to 7.47GWh in 2006. Only about 40% of households in Nigeria are connected to the national grid. There is high-energy loss due to the physical deterioration of the transmission and distribution facilities, an inadequate metering system and an increase in the incidence of power theft through illegal connections. Other problems of the power sector include manpower constraints and inadequate support facilities, the high cost of electricity production, inadequate basic industries to service the power sector, poor billing systems, poor settlements of bills by consumers and low available capacity, about 40% out of the installed capacity of about 6,000MW. Inadequate funding prevented targeted growth in the sector. Production activities in the solid minerals sub-sector were generally on decline.

The situation in the rural areas of the country is that most end users depend on fuelwood. Fuelwood is used by over 60% of Nigerians living in the rural areas. Nigeria consumes over 50 million metric tonnes of fuel wood annually, a rate, which exceeds the replenishment rate through various afforestation programmes. Sourcing fuel wood for domestic and commercial uses is a major cause of desertification in the arid-zone states and erosion in the southern part of the country. The rate of deforestation is about 350,000 hectares per year, which is equivalent to 3.6% of the present area of forests and woodlands, whereas reforestation is only at about 10% of the deforestation rate. [2]

The rural areas, which are generally inaccessible due to absence of good road networks, have little access to conventional energy such as electricity and petroleum products. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices 150% in excess of their official pump prices. The daily needs of the rural populace for heat energy are, therefore, met almost entirely from fuelwood.

With the ongoing restructuring of the power sector and the imminent privatization of the electricity industry it is obvious that for logistic and economic reasons especially under the privatized power sector, rural areas which are remote from the grid and/or have low consumption or low power purchase potential will not be attractive to private power investors. Such areas may remain unserved for the distant future.

Meanwhile electricity is required for such basic developmental services as pipe borne water, health care, telecommunications and quality education. The poverty eradication and Universal Basic Education (UBE) programmes require energy for success. The absence of reliable energy supply has not only left the rural populace socially backward but has left their economic potentials untapped. Fortunately, Nigeria is blessed with abundant renewable energy resources such as solar, wind, biomass and small hydropower potentials. The logical solution is increased penetration of renewables into the energy supply mix. The rest of this article contains some of the modest progress made in the promotion of renewable energy technologies in Nigeria towards ensuring sustainable development.

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The Status of Biomass Energy in Nigeria

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, heat or fuel for motive 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 country include: fuelwood, agricultural waste and crop residue, sawdust and wood shavings, animal dung/poultry droppings, industrial effluents/municipal solid waste.

The availability of biomass resources follows the same pattern as the nation's vegetation. The rain forest in the south generates the highest quantity of woody biomass while the guinea savannah vegetation of the north central region generates more crop residues than the sudan and sahel savannah zones. Industrial effluent such as sugar cane molasses is located with the processes with which they are associated. Municipal wastes are generated in the high-density urban areas. Table 1 shows the estimated biomass resources in Nigeria.

Resource	Quantity (million tonnes)	Energy Value ('000 MJ)
Fuelwood	39.1	531.0
Agro-waste	11.244	147.7
Saw Dust	1.8	31.433
Municipal Solid Waste	4.075	-

Table 1: Biomass Resources and the Estimated Quantities in Nigeria.

Fuelwood

Over the period 1989-2000, fuelwood and charcoal constituted between 32 and 40% of total primary energy consumption [3]. In year 2000, national demand was estimated to be 39 million tonnes of fuelwood. About 95% of the total fuelwood consumption was used in households for cooking and for cottage industrial activities, such as for processing cassava and oil seeds, which are closely related to household activities. A smaller proportion of the fuelwood and charcoal consumed was used in the services sector.

About 350,000 hectares of forest and natural vegetation are lost annually due to various factors, by the beginning of the last decade, with a much lower afforestation rate of 50,000 hectares/yr. With the depleting natural wood reserves, women and children have to travel as far as six kilometres to collect wood, sometimes fresh trees are cut down and allowed to dry for harvest as fuelwood thus putting further pressure on the vegetation. Recent studies show that national demand for traditional energy (mostly fuelwood and charcoal) is 39 million tonnes per annum (about 37.4% of the total energy demand and the highest single share of all the energy forms). It is projected to increase to 91 million tons by 2030 [4]. The deforestation rate is expected to similarly increase if no special programme is put in place to discourage the use of fuelwood, promote the use of its alternatives and replenish through deliberate afforestation and fuelwood lots. This has grave implications on sustainable environment, food security and the health of the low income households who depend on fuelwood. The strategic development in this regard is a two-prong approach of reducing consumption rate through promotion of more efficient wood stoves and deployment of alternatives to fuelwood through policy instrument and pilot demonstration renewable projects.

Fuelwood lot is being established, while improved wood stoves of various configurations are being promoted. Under an integrated rural energy supply project, selected communities are assessed for renewable energy resources, energy requirement and available human resources, and an integrated energy supply system is then designed that utilizes the available renewable energy resources to supply the energy requirement. For sustainability, the local human resources are trained to maintain the system.

The three-stone stove commonly used in the households have efficiencies as low as 15%. Improved versions have been developed locally by the ECN through its energy research centers at the University of Nigeria, Nsukka and Usumanu Dan Fodiyo University in Sokoto. These stoves which could reduce fuelwood consumption for a particular process by 50 % are already being adopted. For instance the International Institute for Tropical Agriculture (IITA) cottage cassava industry at Moniya, Ibadan adopted these technologies. Indeed the improved wood-burning stoves are found in many local markets in the northwestern part of the country.

Agricultural Residue and Municipal Solid Waste

Residues associated with agriculture either as on-the-farm crop wastes such as cornstalks or as processing waste such as rice husk, corn shells, palm kernel shell, cassava peels, etc., are also good sources of fuels. They are currently burned directly as starter or supplement material in addition to fuelwood. There are potentials for further processing for higher energy contents. There is, however, other competing demand for crop residues for feeding livestock and roofing thatched houses in the villages. Animal wastes (e.g., cow dung, poultry droppings and abattoir wastes) are also available at specific sites.

Biogas digester technology has been domesticated and a number of pilot biogas plants have been built. Considerable local capability exists for building both floating dome and fixed dome biodigesters using a variety of bioresources. Examples include a human waste biogas plant at the Zaria prison, cow dung based biogas plants at the Fodder farm of the National Animal Production Research Institute (NAPRI), Zaria and Mayflower Secondary School Ikenne, Ogun State; an 18m3 capacity pig waste biogas plant at the pigry farm of the Ojokoro/Ifelodun Cooperative Agricultural Multipurpose Society in Lagos State. A number of indigenous outfits are producing economically viable systems for converting municipal waste to energy.

Saw Dust

Sawdust and wood wastes are other important biomass resources associated with the lumber industry. Small particle biomass stoves already exist for burning sawdusts and wood shaving. Biomass utilization as energy resources is currently limited to thermal application as fuel for cooking, crop drying, tobacco curing, etc. Opportunities exist in power generation from biomass resources in the following: fuelwood lot, biogas generation/biofertilizer production, electricity generation from industrial effluents such as bagasse and ethanol production. There is no existing biomass fired power plant in Nigeria and so no local experience. However, there is considerable experience in biogas generation and utilization of fine particle biomass. Opportunities also exist for briquetting of saw dust and other fine particle biomass.

Small Hydropower (SHP) Development in Nigeria

Rural electrification is given high priority in government's efforts to increase the standard of living in rural areas, reduce rural-urban migration trends, and realize other development objectives. However, the three key challenges for rural electrification are:

a. how to provide sustainable energy (electricity) services to the poorest of the poor, who have no purchasing power to pay for the services?
b. how to offer the most cost-effective, clean and reliable electricity to those who are currently spending a significant share of their income on energy ?;
c. how to set up the commercial infrastructure to provide these services?

In Nigeria, where rivers, waterfalls and streams with high potentials for SHP development is abundant, harnessing of these hydro-resources leads to decentralized use and local implementation and management, thereby making sustainable rural development possible through self-reliance and the use of local natural resources. This can be the most affordable and accessible option to provide off-grid electricity services. Based on Nigeria's level of hydropower development, small hydropower station is defined as follows: Small = installed capacity of between 2 MW and 10 MW; Mini $\leq$ 2 MW ; Micro $\leq$100 kW . In recent studies carried out in twelve states and four (4) river basins, over 278 unexploited SHP sites with total potentials of 734.3 MW were identified. However, SHP potential sites exist in virtually all parts of Nigeria with an estimated capacity of 3,500 MW.

Recent initiatives by the ECN have focused on creating awareness among Nigerians on the huge SHP potentials of the country. Several workshops have been held. In November 2002, the ECN , in collaboration with the United Nations Industrial Development Organization (UNIDO) and other relevant government agencies and ministries organised a National Stakeholders Forum on Renewable Energy Technologies specifically for SHP for rural industrialization. The objective was to formulate strategies to provide access to clean and reliable energy services to the rural populace for promoting rural industrialization, which in turn will lead to employment generation and rural development. During the Forum, a Memorandum of Understanding (MOU) was signed between ECN and UNIDO – IC-SHP, Hangzhou, China, for further cooperation in tapping the currently identified potential of 734.2 MW of SHP through technical assistance, training and establishment of demonstration projects. Thus, the framework for training of trainers in SHP was put in place in 2003 in conjunction with IN-SHP and UNIDO.

Pre-feasibility studies and reports had already been prepared for 12 identified sites and are awaiting investments. Further to preliminary selection of the possible sites, socio-economic and load surveys were carried out in the beneficiary communities with assistance from ECN and the respective River Basin Development Authorities. A private company, the Nigerian Electricity Supply Company (NESCO) and the government have installed eight (8) SHP stations with aggregate capacity of 37.0 MW in Nigeria. Most of these stations are found around Jos, where a 2 MW station at Kwall Falls on the river Kaduna and an 8 MW station at Kurra Falls are located. These stations were developed more than 75 years ago.

The "Power Vision 2010" of the Federal Ministry of Power and Steel (2004) set the National Power

Target for 2010 at 10,000 MW with SHP contributing 10% or 1,000 MW, the development of which will be in phases. The financial implication of this target for SHP of 1,000 MW, when computed using a system cost of US$ 1,500.00/kW, and an exchange rate of US$ 1.0 = ₦150.00 gives ₦225 billion.

Nigeria receives assistance from international institutions for the development of its SHP resources, some of which include:

- The Chinese government through the Chinese Embassy in Nigeria offered to assist Nigeria in electro-mechanical equipment for a 30 kW capacity of SHP demonstration project at Anambra-Imo River Basin Development Authority in Abia State.
- In July 2003, UNIDO sponsored a Chinese Expert Mission for Feasibility Studies on SHP Pilot and Refurbishment projects in Nigeria.

Solar Energy

Nigeria lies within a high sunshine belt and thus has enormous solar energy potentials. The mean annual average of total solar radiation varies from about 3.5 kWhm–2day-1 in the coastal latitudes to about 7 kWhm–2day-1 along the semi arid areas in the far North. On the average, the country receives solar radiation at the level of about 19.8 MJm –2 day-1. Average sunshine hours are estimated at 6hrs per day. Solar radiation is fairly well distributed. The minimum average is about 3.55 kWhm–2day-1 in Katsina in January and 3.4 kWhm–2day-1 for Calabar in August and the maximum average is 8.0 kWhm–2day-1 for Nguru in May.

Given an average solar radiation level of about 5.5 kWhm–2day-1, and the prevailing efficiencies of commercial solar-electric generators, then if solar collectors or modules were used to cover 1% of Nigeria's land area of 923,773km2, it is possible to generate 1850x103 GWh of solar electricity per year. This is over one hundred times the current grid electricity consumption level in the country.

Solar thermal applications, for which technologies are already developed in Nigeria, include: solar cooking, solar water heating for industries, hospitals and households, solar evaporative cooling, solar crop drying, solar incubators and solar chick brooding.

Solar electricity may be used for power supply to remote villages and locations not connected to the national grid. It may also be used to generate power for feeding into the national grid. Other areas of application of solar electricity include low and medium power application such as: water pumping, village electrification, rural clinic and schools power supply, vaccine refrigeration, traffic lighting and lighting of road signs, etc. Several pilot projects, surveys and studies have been undertaken by the Sokoto Energy Research Center (SERC) and the National Center for Energy Research and Development (NCERD) under the supervision of the ECN. Several PV-water pumping, electrification, and solar-thermal installations have been put in place.

Wind Energy

Wind, which is an effect from the uneven heating of the earth's surface by the sun and its resultant pressure inequalities 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. Assuming an air density of 1.1 kg/m^3, 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.

Wind energy conversion systems (wind turbines, wind generators, wind plants, wind machines, and wind dynamos) are devices which convert the kinetic energy of the moving air to rotary motion of a shaft, that is, mechanical energy. The technologies for harnessing this energy have, over the years been tried in the northern parts of the country, mainly for water pumping from open wells in many secondary schools of old Sokoto and Kano States as well as in Katsina, Bauchi and Plateau States. A 5 kW wind electricity conversion system for village electrification has been installed at Sayyan Gidan Gada, in Sokoto State. Other areas of potential application of wind energy conversion systems in Nigeria are in "green electricity" production for the rural community and for integration into the national grid system. It has been reported that an average annual wind speed of not less than 5 m/s at a height of 10m above ground level is the feasible speed for the exploitation of wind energy at today's cost. Tractors and Equipment (T & E), a Division of the United African Company (UAC), at one time, produced windmills in Nigeria. Promising attempts are being made in Sokoto Energy Research Centre (SERC) and Abubakar Tafawa Balewa University, Bauchi, to develop capability for the production of wind energy technologies.

Even though there is a reasonable level of use of the renewable energy in the country, a significantly higher level could be attained. Nigeria surely needs the technical assistance from pro-active countries especially from the industrializing developing nations in:

(a) The widespread establishment of renewable energy data recording stations.
(b) Acquisition of small scale solar cells producing plant
(c) Acquisition of a manufacturing plant for components of the small hydro turbines.
(d) Acquisition of a manufacturing plant for components of wind turbine and generators and
(e) Infrastructure for bottling biogas for cooking and it use for generation of electricity.

Conclusion

Renewable energy is considered a viable solution to the energy challenges of Nigeria especially in the rural areas of the country and to the restrictions posed by the rising cost of conventional or traditional energy. In this article, the role of renewable energy technologies in meeting the energy challenges is discussed. Also consideration has been given to the factors affecting developments in the renewable energy sector, and efforts made to ensure capacity building for renewable energy, stimulation of the private sector, developing the markets for renewable energy, obtaining the necessary finance for renewable energy projects and the assistance of multilateral institutions in advancing renewable energy technologies in the country.

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Member Get A Member Campaign A Success

Yi-Ming Wei Wins Complimentary Registration at the San Francisco IAEE International Conference

IAEE's *Member Get a Member* campaign was a smashing success with 42 new members added in the March to May period.

Members had their membership expiration date advanced three months for each new member referred. Advancements ranged from three months to one year as 31 members referred new members.

Professor Yi-Ming Wei, Dean and Professor of the School of Management and Economics, Beijing Institute of Technology, China, referred the most new members – 4! He won complimentary registration to the San Francisco International Meeting. In the process, he was able to establish the Chinese Committee for Energy Economics (CCEE), one of IAEE's newest Affiliates.

The program was such a success the IAEE Council has decided to run it again in the near future. Stay tuned.