

PROMOTING RENEWABLE ENERGY TECHNOLOGIES FOR RURAL DEVELOPMENT IN NIGERIA

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ABSTRACT

Currently a high proportion of the world's total energy output is generated from fossil fuels such as oil and coal. In general, the quest for an option to conventional power schemes for extension to remote and rural locations of developing countries like Nigeria arises from the high costs associated with the extension, as well as maintenance, of the power grid system to rural areas. It is universally accepted that fossil fuels are finite and it is only a matter of time before their reserves become exhausted. The need for supplementary or even alternatives that ideally will be non-depletable energy sources have since been recognized. These non-depletable energy sources are replenishable and are also referred to as renewable energy sources as they are available in cyclic or periodic basis. These include: Solar Energy which has estimated world wide average power potentials of 24 W /m^2 of the earth's surface; Hydropower, major sources which are still under developed, has an estimated potential of the range of 2-3 TW. Available also in limited areas of the world are Wind energy and Biomass. This paper reviews the availability of renewable energies and their current level of usage in rural communities of Nigeria with a view to put forward necessary policy measures that are essential in order to promote the use of these technologies.

Keywords: rural communities; fossil fuels; biomass; energy consumption; man-hour

INTRODUCTION

It is clear that energy is an essential input to all aspects of modern life. It is indeed the live-wire of industrial production, the fuel for transportation and for the generation of electricity in conventional thermal power plants. Currently, a high proportion of the world's total energy output is generated from fossil fuels such as oil and coal. In general, the quest for an option to conventional power schemes for extension to remote and rural locations of developing countries like Nigeria arises from the high costs associated with

the extension as well as the maintenance of the power grid systems to rural areas (Sambo, 2001). The close relationship between the proximity of energy researches to potential users compiled with the high cost of conventional energy sources have led to a considerable interest in the development and application of renewable energy resources such as: Solar, Wind, Biomass, Wave, e.t.c, obtained from continuous current of energy occurring in natural environment (Babakano, 2000).

Energy Consumptions in Nigeria

Energy consumption patterns indicated that, human and other animal power provides the bulk of the energy requirements for agricultural production. An assessment of the energy unit adopted, that is *man-hours*, showed that sharp variations exist in the magnitudes of the *man-hour* figures from place to place. Evidence of use of petroleum products for agricultural production has been recorded. This, though small when compared with human and animal power is significant because it showed the use of motorized irrigation pumps and diesel powered tractors for mechanical agricultural activities, (Sambo, 1991)

Fuel wood was found to be the predominant energy source in the household sector with about 70-80 % of households depending on it as their cooking fuel in both the remote villages and the towns. The consequence of this to the natural environment is that unchecked felling of trees to provide the fuel wood requirements will exacerbate desert encroachments, soil erosion and loss of soil fertility problems. In the interim, it would not be practical to stop the use of fuel wood rather the short term solution is the adoption of the efficient wood burning stoves together with the widespread establishment of fast growing trees. In the long term one would suggest the introduction of other fuels like Liquefied Petroleum Gas (LPG), kerosene and smokeless coal briquettes to replace the use of fuel wood, (Sambo, 2005).

Kerosene is the predominant energy source used in the rural areas for lighting. There is strong evidence of the use of small quantities of kerosene to assist the quick commencement of fuel wood. This is in addition to its use in the urban centers as a cooking fuel. The predominant type of lantern used is the wick-type which does not produce a good level of luminosity. The third energy type in terms of significance in the household sector is electricity which is mostly limited to state and local government headquarters and some big towns. Most of the electricity in the rural areas is provided by the State Rural Electricity Boards, (Sambo, 2005).

Mains electricity from NEPA (now PHCN) dominates the energy supply for industrial sector. This is supplemented by electricity generating sets that are fueled by automotive gas oil (diesel). High and low fuel oils are used in textile, cement and brick manufacturing plants. The foregoing is for large industries which are mostly located in

the big cities and towns. For the small towns and villages, the bulk of the small-scale industries are operated on diesel generators for bakeries, small-scale steel works, small – scale ceramic/pottery works etc. In these localities other small – scale activities like handicraft, weaving etc are based on human power, (Sambo, 2005)

In the transport sector, prime motor spirit (petrol) is the major fuel for saloon cars and the small buses. For lorries, trucks and rail transport the predominant fuel is automotive kerosene. It has been estimated that 74% of the petroleum products demand of Nigeria is for the transport sector with only 19% for the industrial sector. Of the amount of fuel consumed in the transport sector, 50% is absorbed by passenger transport by air, (Sambo, 2005).

In remote rural areas, human power is used for water lifting from wells while in the big villages and many towns, diesel powered pumping systems are relied upon to lift water from boreholes. Hospitals and health centers in rural areas rely on both Rural Electricity Board (REB) – generated electricity and diesel generators for lighting, sterilizing of appliances as well as for storage of drugs and vaccines. Use is made of fuel wood and to a lesser extent LPG, for cooking. The situation in the health centers is very much the same in boarding schools, barracks and prison houses, (Sambo, 2005).

AVAILABILITY OF RENEWABLE ENERGY RESOURCES

The renewable energy sources considered in this paper include; Hydropower, Solar, Biomass and Wind energy.

Hydropower

Essentially, hydropower systems rely on the potential energy difference between the levels of water in reservoirs, dams or lakes and their discharge tail water levels downstream. The water turbines which convert the potential energy of water to shaft rotation are coupled to suitable generators. The hydropower potential of Nigeria (Sambo, 2001) is very high and hydropower currently accounts for about 29% of the total electrical power supply. The first hydropower station in Nigeria is at Kainji on the river Niger where the installed capacity is 836MW with provisions for expansion to 1156MW. A second hydropower station on the Niger is at Jebba with an installed capacity of 540MW. An estimate (Aliyu and Elegba, 1990) for rivers Kaduna, Benue and Cross River (at Shiroro, Makurdi and Ikom respectively) indicates their total capacity to stand at about 4,650MW. The overall hydropower resources potentially exploitable in Nigeria are in the Excess of 11,000MW.

In effect, small hydropower systems can be set up in all parts of the country so that the potential energy in the large network of rivers can be tapped and converted to electrical

energy. In this way the nation's rural electrification projects can be greatly enhanced, (Sambo, 2001).

Solar Energy

Solar energy technologies are divided into two broad groups namely Solar – Thermal (ST) and Solar – Photovoltaic (PV). In solar thermal applications, solar energy, as electromagnetic waves is first converted into heat energy. The heat energy may then be used either directly as heat, or converted into cold, or even into electrical or mechanical energy forms. Typical of such applications are in drying, cooking, heating, distillation, cooling and refrigeration as well as electricity generation in thermal power plants. In solar photovoltaic applications, the solar radiation is converted directly into electricity. The most common method of doing this is through the use of silicon cells, (Sambo, 2001).

Solar energy is the most promising of the renewable energy sources in view of its apparent limitless potential. The sun radiates its energy at the rate of about 3.8×10^{23} kW per second. Most of this energy is transmitted radially as electromagnetic radiation, which comes to about 1.5 kW/m^2 at the boundary of the atmosphere. After traversing the atmosphere, a square meter of the earth's surface can receive as much as 1kW of solar power, averaging to about 0.5 over all hours of daylight. Studies relevant to the availability of the solar energy resources in Nigeria (Sambo, 2001) have fully indicated its viability for practical use. Although solar radiation intensity appears rather dilute when compared with the volumetric concentration of energy in fossil fuels, it has been confirmed that Nigeria receives 5.08×10^{12} kWh of energy per day from the sun and if solar energy appliances with just 5% efficiency are used to cover only 1% of the country's surface area, then 2.54×10^6 MWh of electrical energy can be obtained from solar energy. This amount of electrical energy is equivalent to 4.66 million barrels of oil per day.

Biomass

Biomass energy refers to the energy of biological systems such as wood and wastes. Biomass energy is an indirect form of solar energy because it arises due to photosynthesis. The biomass resources of Nigeria (Sambo, 2001) can be identified as wood biomass forage grasses and shrubs, residues and wastes (forestry, agricultural, municipal and industrial) as well as aquatic biomass.

Wood, apart from being a major source of energy in the form of fuel wood is also used for commercial purposes in various forms as plywood, paper products and electric poles. For energy purposes, Nigeria is using 80 million cubic meters (43.4×10^9 kg) of fuel wood annually for cooking and other domestic purposes. The energy content of fuel wood that is being used is 6.0×10^9 MJ, out of which only between 5-12% the fraction

that is gainfully utilized for cooking and other domestic uses. Although the biomass availability as at 1973 was put at 9.1012 MJ, it is expected that the overall biomass resource availability at present is lower than the 1973 figure. This is largely due to the demand of wood also for construction and furniture industries in addition to its use as an energy source. As for forage grasses and shrub, estimates show that 200 million tones of dry biomass can be obtained from them and this comes up to 2.28×10^6 MJ of energy, (Sambo, 2001).

For crop residues and wastes, estimates of the 6.1 million tones of dry biomass that are produced annually leave residues whose energy content approximate to 5.3×10^{11} MJ. Estimates made in 1985 gave the number of cattle, sheep, goats, horses and pig as well as poultry birds as 166 million. These produce 227,500 tones of animal wastes daily which come to 2.2×10^9 MJ taking the calorific value of animal dung to be 9.800 MJ/tones. Animal residue can be converted to biogas and estimates show that this is of the order of 5.36×10^9 MJ which has an energy content amounting to 2.93×10^9 kWh, (Sambo, 2005).

Wind Energy

Wind is a natural phenomenon related to the movement of air masses caused primarily by the differential solar heating of the earth's surface. Seasonal variations in the energy received from the sun affect the strength and direction of the wind. The ease with which aero turbines transform energy in moving air to rotary mechanical energy suggests the use of electrical devices to convert wind energy to electricity. Wind energy has also been utilized for decades, for water pumping as well as for milling of grains, (Sambo, 2005).

A study on the wind energy potential for a number of Nigerian cities shows that the annual wind speed ranges from 2.32 m/s for Port Harcourt to 3.89 m/s for Sokoto. The maximum extractable power per unit area, for the two sites was estimated at 4.51 and 21.97 Watt per square meters of blade area respectively. When the duration of wind speeds greater than 3 m/s is considered then, the energy per unit area work out at 168.63 and 1,556.35 kWh per meters of blade area, again for Port Harcourt and Sokoto, (Sambo, 2005).

Although the use of wind energy for water supply has been known and used for hundreds of year, in recent times effort have been directed largely towards the use of wind power for the generation of electricity and in the past twenty years or so rapid changes in technology have occurred and major wind powered generating plants have been installed, especially in the rural areas of the developed countries (Sambo, 2005).

APPLICATIONS OF RENEWABLE ENERGY TECHNOLOGIES IN NIGERIA

In Nigeria, as a result of research and development activities that have been undertaken in

our universities and polytechnics a large number of renewable energy systems and devices have been developed and a good number are indeed ready for adoption into the economy. A report compiled by the Sokoto Energy Research Centre in 1991 (Sambo, 2001) provides details of the technologies that were developed at the centre and which were ready for adoption into the economy.

Solar Energy

There are many solar thermal systems especially solar water heaters and solar dryers in use in many parts of the country. Solar cookers, solar stills, solar chicken brooders and solar thermal refrigerators developed by research centers and confirmed to be of practical applications,

Solar Photovoltaic applications have wider current installation in the country and these include solar photovoltaic water pumping systems, solar-powered vaccine refrigerators as well as telecommunication repeater stations. There are also solar photovoltaic power plants that are providing electricity to entire villages and also others that are powering on standalone basis, specific projects such as rural health centers and television viewing centers (Sambo, 2001).

Biomass

Many versions of efficient wood-burning and charcoal stoves have been developed and are being used in many parts of country with the overall objectives of curtailing the amount of trees perennially cut to provide fuel wood and charcoal. Biogas digesters, which are capable of producing biogas that could be used for domestic and industrial uses have been developed in many parts of the country (Sambo, 2001).

Wind Energy

Wind energy use to be relied upon in the 1950's and 1960's for provision of water in many northern parts of the country. However, this was largely abandoned when the development of the petroleum products reached advanced stages. The development of Poldow wind pump in Bauchi, using locally available materials is surely a move in the right direction. It should be mentioned that, there are few modern wind pumps in some parts of the country. There is also one wind electricity generator currently supplying energy from wind at Sayya in Sokoto state, (Sambo, 2001).

PROMOTION OF RENEWABLE ENERGY TECHNOLOGIES

Sambo (2005) described the following strategies for the promotion of renewable energy technologies in Nigeria.

Adopting Renewable Energy Technologies

With the availability of renewable energy resources in all parts of the country and the existing level of development of systems and devices in the nation, there is the urgent need to adopt practical measures that will systematically introduce various renewable technologies into the economy, (Sambo, 2005).

Apart from the policy measures that will promote the introduction of technologies based on individual energy sources, there is also the need to adopt an integrated approach to sustainable energy development. This is in recognition of the fact that conventional energy sources will continue to serve the transport and industrial sector of the economy, (Sambo, 2005).

Policy Measures for the Various Renewable Energy Technologies

a). Solar Energy

The thrust of the policy here should be the incorporation of solar energy devices into many spheres of the economy as possible. The strategies for this include:

- Continuous active support of research and development activities to cater for site specificity of designs for all parts of the country.
- Support of demonstration and pilot projects to ensure that the general public become aware of the potentials of solar energy technologies which will as well assist in creation of markets for solar energy systems.
- The provision of financial incentives to encourage the use of solar energy systems particularly in rural areas where the greatest potential exist.
- The introduction of regulatory measures to encourage and protect local capabilities.

b). Biomass

The policy outlined above for solar energy also applies here. However, it should be emphasized that fuel wood consumption rate should be significantly reduced. Strategies for this include:

- The adoption of efficient wood burning stoves
- Systematic cultivation of fast growing trees needed to facilitate the regeneration of forests.
- The active introduction of biogas digesters to cater for cooking energy needs of especially large house holds and institutions like boarding schools, hospitals, barracks, prison houses, etc.
- The development of alternative technologies to supplement wood both as a domestic energy source and also as a building/furniture material.

c). Wind Energy

The policy and strategies for solar energy are also applicable here. Additionally, the policy should emphasize the exploitation of wind energy for rural water supply and also for electricity generation. That is to say the additional strategies are:

- Aggressive drive to optimize the components of wind water pumping and electricity generation, and
- To de-emphasize diesel-powered water pumps where ever the wind speed will allow wind water pumping.

d). Hydropower

The policy here is for the nation to manage its water resources for the development of its hydroelectric potentials as well as focus on micro-hydro plants. The additional strategy includes the initiating and updating of data on the potentials of small-scale hydro plants and the preparation of inventories for their locations.

Provision of Energy Security for Rural Dwellers

One of the major needs of rural dwellers is the energy they consume for subsistence and because they lack access to commercial fuels like petroleum products and electricity they depend largely on traditional fuels mainly fuel wood, charcoal and agricultural residues. In order to provide the energy needs of rural dwellers, especially in the Sahelian zone of the country, the following measures are necessary.

- Continued afforestation programmes
- Setting up of community based wood lot programmes
- Accelerated rural electricity scheme, and
- Promotion of energy-efficiency practices.

Strengthening Technical Capabilities in the Energy Sectors

Two major steps are required here. First, the offering of specialized training and development of sound technical education in the educational system and secondly, to ensure that the available pool of human resources are given the opportunities to ‘learn-by-doing’. Another requirement for strengthening technical capabilities is developing more activities in the energy sector and provision of adequate funding for energy research, development and demonstration activities.

CONCLUSION

Nigeria is blessed with abundant renewable energy resources; solar, wind biomass hydro, etc, however, the adoption of these resources especially in the rural house hold sectors and service sectors will surely led to reduced consumption of petroleum products. The major advantage of the renewable energy technologies include the simplicity of the technologies, ease of maintenance as well as their enhanced environmental friendliness over fossil fuel system.

For the nation to move forward in the areas of coming up with an optimum energy mix, there is urgent need for more support of research, development, demonstration and diffusion activities for renewable energy technologies in the existing research centers as

identified groups in other institutions.

In view of the apparent reluctance of local entrepreneurs to adopt the mature and proven renewable energy system for mass production and subsequent commercialization, there is also need to actively promote the training of local craftsmen on the design, construction, operation and maintenance of these energy systems.

All the policy measures and the strategies for the promotions and use of sustainable energy systems and practices can only be realized with strengthened energy institution. In this regard, there is the need to identify organizations or offices at states and local government levels that will be charged with the responsibilities of ensuring the full implementation of projects and programmes of the Energy Commission of Nigeria at the grass root levels.

REFERENCE

Aliyu, U. O. and Elegba, S. B. (1990) "Prospect of Small Hydropower Development for Rural Applications in Nigeria" *Nigeria Journal of Renewable Energy*, Vol. I pp 74-86.

Babakano, A. (2000) "Energy Uses and Utilization" B. Eng. Lecture Notes, Federal University of Technology, Yola, Adamawa State, Nigeria.

Sambo, A. S. (1991) "Documentation of Solar Energy Systems: Developed and Ready for Mass Production" *Sokoto Energy Research Centre, Usman Danfodio University, Sokoto, Nigeria*.

Sambo, A. S. (2001) "Renewable Energy Technologies for National Development: Status, Prospects and Policy Directions" *The Nigerian Engineers*, Vol. 39, No. 1.

Sambo, A. S. (2005) "Renewable Energy for Rural Development: The Nigerian Perspective" *ISESCO, Science and Technology Vision* Vol. 1, (12-22)