RESEARCH AND DEVELOPMENT EFFORTS IN RENEWABLE ENERGY TECHNOLOGIES IN NIGERIA

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ABSTRACT

Despite Nigeria's position as an oil exporting country, there is an important role for renewable energy in the present and future. Nigeria has enormous renewable energy resources. These could adequately supplement conventional energy. But this will require the development of efficient and economical indigenous technological. Renewable energy activities in Nigeria over the last 15-20 years are reviewed. This rather slow (compared to many other African countries) development of renewable energy technologies is attributed to the lack of a comprehensive energy policy in the past.

INTRODUCTION

At present Nigeria is mainly dependent on conventional energy sources (coal, oil, gas, and hydropower) except for firewood which has been the major source of energy in rural areas for a long time. The role of renewable energy sources in Nigeria can be defined as supplementary for the present with great potential for meeting a much more substantial part of the future energy needs of the country.

The renewable energy technologies are at various stages of development in many countries of the world. This paper reports on the research and development efforts made in Nigeria in various renewable energy technologies. Information given here has been obtained through various Nigerian and international publications on renewable energy technologies and related areas, and personal communications of the authors with other researchers in the country.

RESEARCH AND DEVELOPMENT EFFORTS IN RENEWABLE ENERGY TECHNOLOGIES

Renewable energy research and development activities have been going on for the last 15-20 years. Participation of private sector in renewable energy research and development has been negligible. There are only a few multinational companies in this field, and they have only been interested in commercialising some imported renewable energy systems. Most research emanates from research institutes, universities, polytechnics and colleges of technology.

Activities in renewable energy technologies

Solar radiation and wind data

A considerable amount of effort has been directed to the collection of solar radiation and wind data for various locations in the country. The International Institute for Tropical Research, Ibadan has collected such data for Ibadan for the last 15 years or so. Similarly, the Road and Building Research Institute, Lagos has installed a number of recording units at various locations in the federation, recently. Many research institutes and univerisites have also tried to collect the data for their geographical areas.

Various empirical relations and models have been worked out. Sun tables and charts are being evolved. The effect of the period of harmattan when the atmosphere is filled with suspended dust particles has been assessed. Such a period last for about 3-4 months in the northern part of the country.

Some attempts to find the optimum angle of tilt for various locations have been made. Elementary approaches towards the construction of radiation measuring instruments and sunfinders have also been explored. A preliminary attempt to plot a solar map of Nigeria has been made (Figure 1).

Solar Thermal Systems

A number of systems have been designed and constructed in various institutions.

Flat plate collectors A number of flat plate collectors have been made, designed and constructed, usually from locally available materials. However, there has been little follow-up to improve their performances. Imported flat plate collectors have been used in solar water heaters, dryers and refrigeration systems and their performance evaluated. Locally constructed spiral-type collectors have also been tested.

Concentrating collectors Various concentrating techniques have been tried at a number of places using mainly parabolic, cylindrical, conical and fresnel type collectors.

Selective coatings University of Nigeria, Nsukka and University of Sokoto have reported some efforts towards the development of selective coatings. Studies on spectral emissivity of layered systems have been conducted.

Tracking systems Because of the abundance of solar radiation in Nigeria, little importance has been attached to developing tracking systems. Studies on tracking versus non-tracking have been undertaken at a few locations. A photovoltaic powered tracker has been developed at the University of Lagos.

Solar water heaters A number of low cost solar water heaters have been designed and evaluated. Solar water heaters have considerable potential in both the domestic and industrial sectors, but only a few are actually in use in the country.

Solar cookers and ovens Solar cookers and ovens have attracted a lot of interest in Nigeria particularly by researchers at Bida, Sokoto and Enuga. Various types - parabolic, box-type with or without boosters, and fresnel-type solar cookers and ovens - have been fabricated. Temperatures up to 200°C have been achieved. Several types of local food items have been cooked in reasonable times in these solar cookers and ovens. Figure 2 shows a locally fabricated box-type solar oven with two boosters. Indoor solar kitchens with a roof that directs solar radiation onto the cooking area are being designed. Studies on the possible assistance of solar energy in baking and other purposes have also been reported.

Solar dryers Hot box and separate collector solar dryers have been fabricated for drying grain, fruit, fish and vegetables. Studies of performance and economics aspects have been undertaken. Researchers at Nsukka, Ife, Lagos, Ibadan, Kano, Bida and Zaria for example, have made considerable efforts to develop dryers to minimise the spoilage of agricultural produce. Recently, the Institute of Oceanography and Marine Research, Lagos has developed a commercially feasible solar dryer for fish.

Solar stills Proto-type solar stills have been constructed at Lagos, Bida, Kaduna and Sokoto. Predicted and actual performance studies, and mass-energy balance studies of some of the solar stills have been undertaken. Large-scale solar distillation plants for rural areas where the water supplies are unhygenic have been suggested. Distillation rates of the order of $0.8kg/m^2$ to $1.2kg/m^2$ have been obtained in places with average sunshine.

Solar refrigeration and air conditioning Solar refrigeration and air conditioning has enormous potential in rural Nigeria particularly for storage of food, and drugs. Unfortunately, there have been few break-throughs. Attempts have been made to fabricate aqua-ammonia refrigerating systems powered with solar energy at Zaria, Nsukka, Lagos, Bida, Ife and Port Harcourt. Studies on solar-driven organic jet ejectors have also been reported. The possibility of distributing centrally-generated chilled fluid for solar cooling systems has been considered.

Solar thermal powered engines Only some theoretical studies have been reported in this area. No practical development has taken place so far.

Integration of solar thermal systems into agro and other industrial setups Apart from the studies on solar thermal energy applications in agricultural and industrials processes mentioned above, only a few theoretical studies on other aspects such as seed germinaters, incubators, large-scale distillation units, process heat units, and solar ponds have been carried out. No practical results have so far emerged.

Solar Photovoltaic Systems

Very little effort has been made to develop indigenous photovoltaic technology. This may be due to the capital intensive nature of the technology.

Solar cells Photovoltaic studies in organic dyes and $(pbI_2)_{1-x}$ $(KI)_x$ alloys have been undertaken and attempts made recently to fabricate wide band solar cells. There are plans at various universities including the Sokoto Energy Research Centre to construct various types of solar cells.

Characterisation of solar cells and modules Attempts have been made to characterise solar cells and modules manufacturered overseas. Studies on I-V curves at various insolation levels, effect of temperature on power output, matching of load with modules, effect of environmental conditions on the output, efficiency, spectral sensitivity and optimum angle of tilt of modules have been carried out. Most cells and modules being studied are mono-crystal silicon solar cells. Theoretical studies have been carried out on the possible performance of other types of solar cells in local climatic conditions. Some theoretical studies on the application of microprocessors for automatic control of modules have been carried out at Sokoto.

Photovoltaic pumps A demonstration project at Tungar Buzu, Sokoto State for the supply of drinking water to a small rural community has been set up. In addition, photovoltaic pumps have been installed in some individuals' houses. Much has been written about the potential of photovoltaic pumps for micro-irrigation and rural water supplies. Plans are underway to install imported pumps in rural and remote locations and study the feasibility of their use in local conditions. A number of multinational companies have attempted to commercialise photovoltaic pumps in Nigeria. Success has been limited due to

their inability to recognise the need to evaluate their technologies under local conditions.

Photovoltaic powered televisions There is an important role for photovoltaic powered televisions for education and enlightenment in rural and remote areas not connected to the national electricity grid. A community TV viewing centre at Zauro, Sokoto State has been set up and studies have been reported on matching a household television with photovoltaic modules.

Photovoltaic powered communication systems There is much potential for using photovoltaic power especially in remote places. These include railway signalling, transmitting and booster stations and road traffic control. The Sokoto Energy Research Centre has initiated a project to power its intercom systems with photovoltaic modules.

Photovoltaic powered cathodic protection systems Nigeria has long oil pipe lines and there is scope for introducing photovoltaic powered cathodic protection systems. No practical projects or studies have as yet been proposed.

Remote home power systems At Birnin-Kebbi, a proto-type house has been powered with photovoltaic modules for all its electricity requirements and the results have been encouraging.

Passive solar systems

Although passive solar technology has tremendous scope, particularly for keeping buildings cool, in Nigeria, little research has been directed to the field.

Solar passive architectural buildings Studies on energy consumption in residential buildings, thermal performances and thermal comfort levels in traditional and modern buildings etc. have been reported. Proto-type solar passive houses have been constructed at Ife and Birnin-Kebbi. A number of passive and integrated energy houses are being conceived at a number of locations. The integration of such architecture in the national and states housing programmes is being recommended.

Passive cooling systems Two passive coolers have been developed at Sokoto and Maiduguri. Concepts of evaporative cooling, roof ponds etc. are being considered. Such passive coolers when fully developed might reduce the electricity demands in urban areas by substituting for air conditioners. They will also be very useful in rural areas where there are no cooling systems.

Wind Energy Systems A number of windmills have been installed for pumping water. Some were installed more than two decades ago and the majority are now broken and abandoned. Studies on the potential of windpower for different locations have been carried out. The Sokoto Energy Research Centre is presently involved in reactivating some of these old windmills.

Biomass Biomass has not been given enough attention and it is only recently that the potentials of biomass in Nigeria has started to be appreciated.

Biogas systems The biogas potential in Nigeria has been estimated. Prototype biogas digesters (continuous and batch feeding types) have been fabricated at Ife, Zaria, Birnin Kebbi and Sokoto. Production of biogas from different animal manures, Eupatorium odaratum, algae and other agricultural wastes has been

studied. Analytical studies of biogas produced and its end-use systems are at developmental stages. Figure 4 shows a locally fabricated prototype biogas plant.

Fuelwood This area requires immediate attention. Shortage of fuelwood, draught and desertification are major problems in Nigeria. Patterns of supply and consumption of fuelwood have been studied and various exotic and indigenous tree species have been identified for fuelwood production. Community woodlots, shelterbelts, agroforestry etc. are the major focus of research. Studies on combustion-related characteristics of various plant species concerning their suitability as domestic fuel have been carried out at Ibadan. The Federal Department of Forestry has been involved in this area for a long time. Various State Governments and the Federal Government have planned tree-plantation programmes. The Sokoto Energy Research Centre in conjunction with the Faculty of Agriculture of the University of Sokoto is planning a long-term research programme on fuelwood for the sudan savanna region of Nigeria.

Woodstoves Most of rural population in this country uses fuelwood for cooking and water heating. The traditional three-stone type of stove is very wasteful of energy. The Sokoto Energy Research Centre is developing more efficient woodstoves. Three types of such stoves to suit different sizes of families have been fabricated (Figure 3) and are presently being tested for further improvements and popularisation.

Other biomass utilisation technologies Other potential technologies include combustible gases and liquid fuels, pyrolysis, aerobic fermentation etc. No practical applications have been reported so far.

Energy Storage Systems Thermal energy storage systems studies on thermochemical storage have been carried out at Sokoto and Zaria and are being considered at various other places.

Electrical energy storage systems Commonly available lead-acid batteries have been used for storing electrical energy in most of the photovoltaic installations. There is a need for developing suitable electrical energy storage systems. Such developments will broaden the scope of photovoltaics, particularly where electricity is required for night-use such as street and home lights etc.

Energy conservation

Interest in energy conservation is growing. The potential for conserving conventional energy in different sectors of the economy and the possibility of integrating them with renewable energy systems have been considered. Some energy conservation monitoring devices have been reported.

Integrated and rural energy systems

Integrated and rural energy projects are underway at Ife, Ibadan and Sokoto. The energy supply and consumption patterns of some rural communities are being studied and the possibilities of incorporating renewable energy systems to improve the living conditions are being explored.

Training and manpower development programmes

The availability of suitable manpower is essential to the success of any programme. Plans are underway to start high level training programmes in renewable energy technologies at the Sokoto Energy Research Centre of the University of Sokoto, Solar Energy Research Centre of the University of Nigeria, Nsukka, and the Yola Campus of the University of Maiduguri. Training programmes for middle-level manpower are being set up at the Federal Polytechnic, Bida and the Sokoto State Polytechnic, Birnin-Kebbi. A proposal for an integrated approach to training and manpower development in renewable energy technologies has been put forward by the authors of this paper at a recent national conference.

CONCLUSIONS AND FUTURE PROSPECTS

a) Nigeria has an enormous potential of renewable energy sources. Conventional energy sources are finite and are likely to be exhaustible in the not too distant future.

b) To harness these renewable energy sources particularly in rural areas, considerable research and development efforts are necessary.

c) Research and development activities have been in progress for some time. But in most cases with no defined goals and the "development" aspect of renewable energy technology has not been considered. Private sector involvement in these activities has been negligible.

d) The Federal Government has started supporting these activities recently. It has established two energy research centres at Sokoto and Nsukka for training, research and development in solar and other renewable energy technologies.

e) There is a need for a more collaborative and cooperative approach among the organisations involved in renewable energy technologies development. A comprehensive national renewable energy programme has to be evolved to coordinate and streamline these activities.

f) We believe that with the present backing of various governments and with the active participation of the private sector, the future will see the mass adaptation of renewable energy systems in various sectors of Nigerian economy.

* A bibliography of published papers on renewable energy research in Nigeria is available from the authors.

FIGURE 1: Preliminary solar radiation map of Nigeria.

(Year averages for the ration of measured solar radiation on a horizontal surface on ground in a day, H, and extra-terrestrial irradiation in the day, Ho)

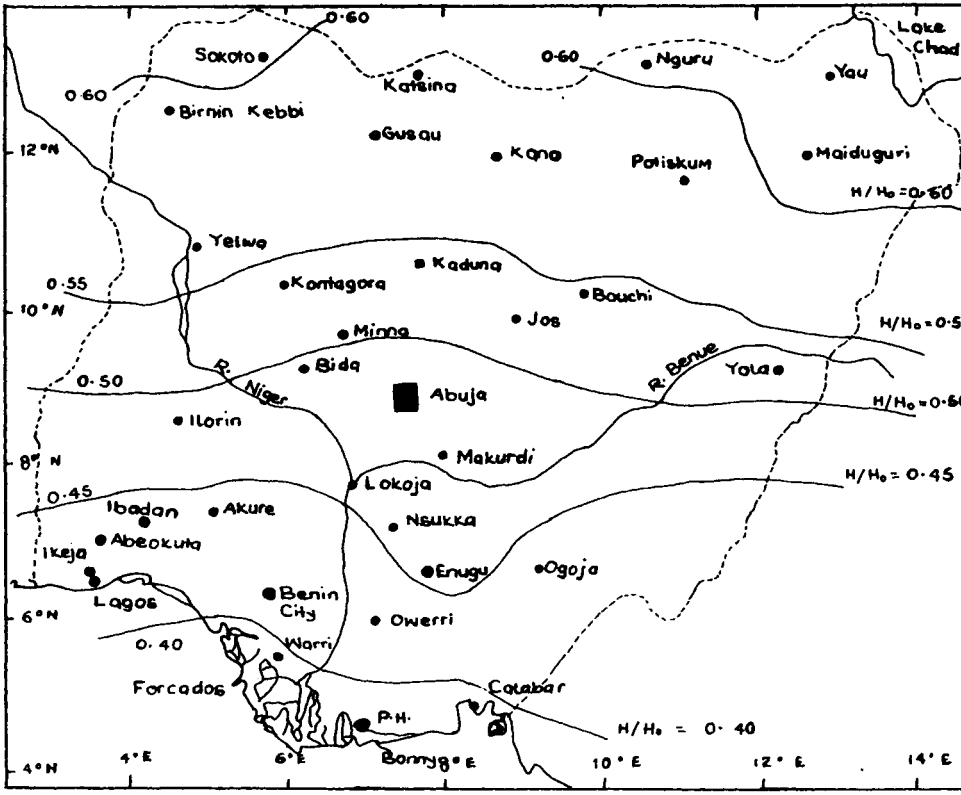

FIGURE 2: A locally fabricated solar oven

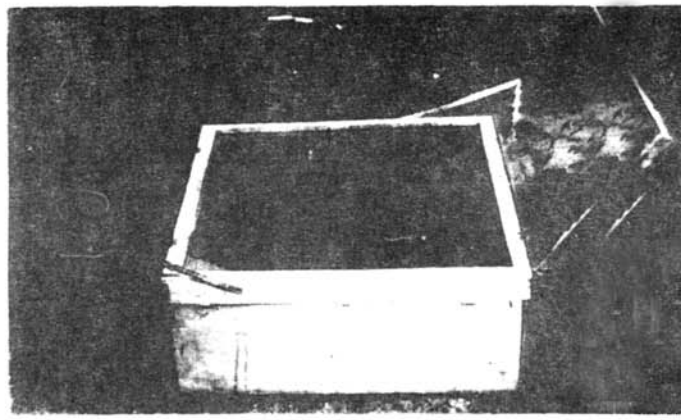

FIGURE 3: Woodstoves under testing

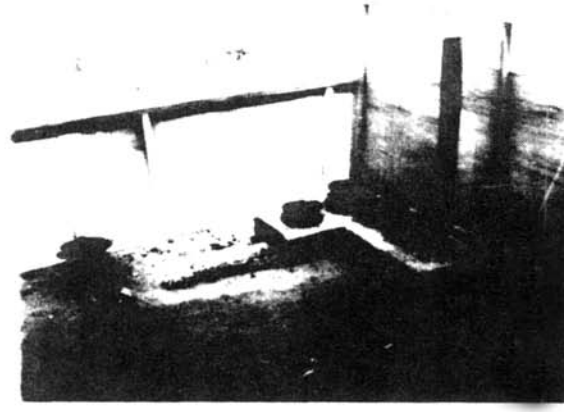

FIGURE 4: A prototype biogas plant