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# Strengthening Nigeria Renewable Energy Practices and Policies for Sustainable Development in the 21st Century

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**Abstract:** Nigeria is an energy resource rich country, endowed with abundance of renewable energy (RE) resources. However, Nigeria is yet to exploit these huge available energy potentials with less environmental and climatic impacts. On the contrary, the National supply is at present almost entirely dependent on fossil fuels and firewood. The purpose of this presentation is to highlight the role of renewable energy for development in Nigeria. It examines the current level of the use of renewable energy systems and thereafter put forward necessary policy measures that are essential in order to promote the use of the technologies for the necessary economic advancement in the 21st century.

**Key words:** Nigeria, renewable energy, development

## 1. Introduction

Renewable energy sources involve the harnessing of natural energy flows (e.g., sunlight, wind, waves, falling water, ocean currents, and tides) or the tapping of natural stocks of energy whose rates of replenishment are comparable to or greater than the human use rates (such as ocean thermal gradients, biomass, and hydropower reservoirs) [1]. The World Commission on Environment and Development (WCED) called for renewable energy resources as the foundation of the global energy structure during the 21st century (WCED 1987). This call may be based on the theoretical potential estimates of renewable energy resources globally. For instance, the maximum technical and practical potentials of renewable energy resources globally have been estimated to be about $7.04\times10^4$ and $3.36\times104TWh_c$ per annum respectively by the year 2030 [2]. The contribution of the renewable energy resources to total world energy supply is getting more significant.

For instance, biomass provides currently about 40-55 Exajouile (EJ) per annum to the world's energy consumption [3, 4]. At the end of 1998, the installed wind power world wide was about 10,000 MegaWatts (MW) while added capacity was close to 2,600 MW the same year, and another 3,000 MW would have been installed at the end of 1999 (BTM Consult ApS 1999). However, the assessed global wind energy potential that may be realistically harvested is put at 640 EJ per annum [5]. Several studies have been carried out to assess the potential application of solar energy technologies to world energy consumption through electricity generation to be between 2-16 EJ [3, 6, 7]. While total amount of hydropower electricity production world wide reached 2,600,000 GigaWatt-hour (GWh) in 1997 [8], electricity generation by and direct use of geothermal energy were 43,756 and 38,178 GWh/annum respectively in 1997 [9].

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Nigeria is an energy rich nation with both fossil and renewable fuels. Its renewable energy potential base includes biomass (animal, agricultural and wood residues, fuelwood), solar, hydro, wind and geothermal. Only biomass and hydropower have been and are still being exploited. In recent times, the rate of exploitation of fuelwood is greater than its regeneration. If adequate intervening measures are not quickly implemented fuelwood may no loiigcr be thought of as renewable in the country. In Nigeria, the prejudice for fossil fuels to the neglect of the abundant renewable energy resources is often acknowledged as improper. ShehuShagari, the former President of the Federal Republic of Nigeria put this clarion call more succinctly in his message to the 'U.N. Nairobi Conference on New and Renewable Sources of Energy' in 1981 when he said: '...For us developing countries which are moving from energy patterns dominated by wood fuels to more commercial energy forms, we now have an opportunity to take action before stumbling into a fossil fuel trap. We ought now to investigate the possibilities in at least three directions (U.N. 1981):

- We need to reinvestigate the use of crop and wood plantations as basis of renewable energy supplies. Fortunately, much of the developing countries lie in equatorial and tropical zones where such development is eminently feasible.
- Solar energy seems an appropriate form given the very size of that resource. Here, considerations of technology are of course paramount.
- In an energy scarce period, we cannot afford to leave unutilized the potential for hydro-electric power schemes. Opportunities that remain in this field are in developing countries'.

## 2. Renewable Energy Resources and Technologies in Nigeria

Many national policy decisions taken today could well affect future climate change prospects significantly. Hence an effective and practical climate change strategy that is more convincing to decision makers, as well as integrate and reconcile the development, equity, and sustainability (DES) aspects within a holistic and balanced sustainable development framework, has to be developed [10]. This paper presents suggestions to a practical climate change and sustainable development strategy by putting the renewable energy resources and technologies in perspective in Nigeria.

## 3. Estimates of Potential Renewable Energy Resources

A modest estimate of the technical potential of solar energy in Nigeria with 5% device conversion efficiency is put at $15.0\times10^{14}$ KJ of useful energy annually [11]. This is about 258.62 million barrels of oil equivalent annually which compares with current national annual fossil fuel production in the country. This will also amount to about $4.2\times10^{5}$ GWh of electricity production annually, which is about 26 times the recent annual electricity production of 16,000 GWh in the country. In 1990, energy content of total national biomass potential stood at approximately 1.2 PetaJoule (PJ) (Table 1). Currently, total hydro electric power potential is estimated to be about 8,824 MW with an annual electricity generation potential in excess of 36,000 GWh. This consists of 8,000 MW of large hydro power technology while the remaining 824 MW is small-scale hydro power technology. Presently, 24% and 4% of both large and small hydro power potentials, respectively, in the country have been exploited. Various studies including Lovejoy (1984), Ojosu and Salawu (1990) reveal that the potential for wind energy abound in northern Nigeria [12, 13]. The potential estimates of geothermal energy are yet to be carried out. There are considerable potentials for ocean thermal energy conversion (OTEC) and biogas production in Nigeria.

## 4. Current Status of Renewable Energy Use

Table 2 shows that there has been a steady increase in the consumption patterns of both hydro and biomass

**Table 1 Bioenergy potential of Nigeria (1990)[14].**

| Biomass Resource | Animal Residue | Agricultural Residue | Wood residue (Industrial Wood, Fuelwood, Charcoal) | Total |
|---|---|---|---|---|
| Potential (GJ) | 47,718 | 325,822 | 805,580 | 1,179,120 |

**Table 2 Distribution of energy consumption in Nigeria (Calculated from FOS, 1980, 1985, 1990, 1995).**

| | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|
| Coal (PJ) | 2.75 | 3.86 | 2.14 | 0.57 |
| Natural gas (PJ) | 2.20 | 45.73 | 32.78 | 44.99 |
| Hydro (P3) | 9.91 | 10.83 | 10.09 | 26,35 |
| Fuelwood-charcoal+other biomass (PJ) | 340.77 | 385.21 | 412.29 | *464.85* |
| Petroleum products (PJ) | 297.94 | 388.83 | 414.28 | 355.95 |
| Electricity (PJ) | 18.50 | 26.44 | 28.33 | 35.35 |
| Total energy consumption (PJ) | 653.57 | 834.46 | 871.58 | 901.71 |
| Total commercial energy (PJ) | 312.80 | 449.25 | 459.29 | 436.86 |
| Fuelwood + charcoal + other biomass + hydro (PJ) | 350.68 | 396.04 | 422.38 | 491.20 |
| Share of electricity in total commercial energy (%) | 5.91 | 5.89 | 6.17 | 8.09 |
| Share of electricity in total energy (%) | 2.83 | 3.17 | 3.25 | 3.92 |
| Share of petroleum products in total commercial energy (%) | 95.25 | *86.55* | 90.20 | 81.48 |
| Share of petroleum products in total energy (%) | 45.59 | 46.60 | 47.53 | 39.47 |
| Share of hydro in commercial energy (%) | 3.17 | 2.41 | 2.20 | 6.03 |
| Share of hydro in total energy (%) | 1.52 | 1.30 | 1.16 | 2.92 |
| Share of total biomass in total energy (%) | 52.14 | 46.16 | 47.30 | 51.55 |
| Share of biomass + hydro in total energy (%) | 53.66 | 47.46 | 48.46 | 54.47 |

resources in Nigeria. However, the share of hydro in the commercial and total energy consumption is very low annually. While the share of hydro in commercial energy consumption ranged between 3-6%, its share in total energy consumption was in the range 1-3% during 1980-1995. On the other hand, the share of biomass in total energy consumption averaged about 50%in the same period and the share of both biomass and hydro together in the total energy consumption followed the same trend. Commercial renewable energy is presently of immense benefit to electricity generation in the country. In the period 1970-1990, the generation mix was dominated by hydro and natural gas thermal plants. Between 1973 and 1978, hydro electric power took the largest share, about 46% of the total installed capacity [15]. From the early 1980s, the balance has shifted in favour of gas thermal plants as depicted by the share of fuel use for electricity generation in Table 3. The 1995 distribution of energy consumption, typifies the current energy supply mix in the country. This pie chart shows that of the total energy consumption, the share of natural gas was 5.22%, hydroelectricity took 3.05%, fuelwood had the lion share of 50.45% and petroleum products had 41.28% share. This further confirms the fact that presently, renewable-energy use in the country is split essentially between hydroelectricity and traditional fuelwood. Therefore, commercial renewable energy resources contribute only a small share of total commercial electricity supply in the current national energy supply system.

## 5. Policy Measures for the Various 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 for all of us to adopt practical measures that will systematically introduce various renewable energy technologies into the economy. Apart from the policy measures that will promote the introduction of technologies based on individual renewable 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 sectors of the economy.

**Table 3 Share of fuel use for electricity generation (%) (Calculated from FOS, 1980, 1985, 1990, 1995).**

| Year | Natural gas | Coal | Diesel | Fuel oil | Hydro | Total fossil fuel | Total renewable energy |
|---|---|---|---|---|---|---|---|
| 1980 | 77.54 | 1.07 | 2.99 | 1.14. | 17.26 | 82.74 | 17.26 |
| 1985 | 82.89 | 0.15 | 5.31 | 0.77 | 10.88 | 89.12 | 10.88 |
| 1990 | 88.15 | 0.14 | 0.25 | 0.67 | 10.79 | 89.21 | 10.79 |
| 1995 | 73.51 | 0.00 | 0.02 | 0.64 | 25.83 | 74.17 | 25.83 |

*5.1 Solar Energy*

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

- 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

*5.2 Biomass*

The policy outlined above for solar energy also applies here. Further it should be emphasized that fuelwood consumption rate should be significantly reduced. Strategies for this are:

- 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 the cooking energy needs of especially large households 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.

*5.3 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 wherever the wind speed will allow wind water pumping.

*5.4 Hydropower*

The policy here is for the nation to manage its water sources for the development of its hydro - electric potentials and for other uses. The policy should focus more 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.

## 6. Integrated Approach to Sustainable Energy Development

While the foregoing is aimed at policies to enable the adoption of renewable energy technologies, this section will focus on what is necessary in order to address the general energy issues raised. The agenda for solving these general energy problems include the promotion of rational and efficient energy use, to guarantee energy security for the rural populace, to create an enabling environment to attract investments in the energy sector, the integration of environmental considerations into energy development plans and the strengthening of technical capacities in the energy sector.

*6.1 Promotion of Rational and Efficient Energy Use*

To achieve a more rational and efficient energy utilization we must ensure that wastages in energy use are reduced, energy efficiencies of major energy supply systems are improved considerably and a more energy efficient development path is pursued. For these to be realized the following strategies are required:

- creation of awareness for the benefits of energy savings in all sectors of the economy.
- encouraging households to shift to more energy efficient fuels such as LPG to kerosine in place of fuelwood.
- promoting the use of improved cooking stoves.

- providing incentives for energy intensive industries to invest in industrial energy efficiency measures and human resources development in the area of energy Conservation.

*6.2 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 fuelwood, 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 programme,
- setting up of community based woodlot programmes,
- accelerated rural electrification schemes,
- promotion of energy efficiency practices.

*6.3 Creation of Enabling Environment to Attract Investment in the Energy Sector*

Investment requirements for the conventional energy sector is large and it is clear government will not be able to solely finance the sector as has been the case in the past. Hence private sector participation is necessary. Therefore, there will be need to attract foreign investment in the sector. The needed attractions include the serious improvement in the financial performance of the conventional energy supply companies as well as the existence of conducive investment environment. On the whole, attention of private sector investment will call for:

- reviewing existing energy pricing to allow for good returns on investments;
- easing the difficulties in the procurement of foreign exchange;
- promoting energy conservation and efficiency measures in all sectors of the economy;
- maximising the operating performance of existing energy supply infrastructure.

*6.4 Integration of Environmental Consideration into Energy Development Plan*

Because of the strong energy — environment linkage it is important to integrate the policies affecting the two sectors for sustainable development. This can be done by incorporating environmental considerations during the planning and execution stages of large conventional energy projects. The requirements for this include:

- improving forestry management by strengthening the institution charged with monitoring forestry resources;
- incorporating environmental impact assessment for all major energy projects;
- internalizing the external cost in pricing energy products
- designing and enforcing guidelines for monitoring the environment.

*6.5 Strengthening Technical Capacities in the Energy Sector*

Two major steps are required here. These are firstly, 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 the strengthening of research, development and demonstration activities in the energy sector. Of course the acquisition of technology developed elsewhere and adapting them for use in Nigeria is a key element here. We can therefore list the strategies for strengthening technical capacities as follows:

- provision of technical support services needed for the effective training of personnel
- subsidizing the cost of technical education
- mobilizing local expertise and involving them in the planning, designing and construction of energy projects so they can "learn-by-doing".

- provision of adequate funding for energy research, development and demonstration activities.

*6.6 Institutional Support and Strengthening*

The development, application and diffusion of renewable energy systems especially for decentralized electricity generation and supply into the Nigerian economy require adequate institutional support and strengthening. Presently, there are two national energy research centres devoted to the science and technology of solar energy. The Energy Commission of Nigeria, a supervising clearing house, may be insufficient for effective implementation of programmes for the development, application and diffusion of renewable energy systems. The establishment of a national agency for renewable energy systems may be needed. The Agency objectives should include:

- quantitative assessment of all renewable energy resources in the country;
- quantitative assessment of locally available manpower on various renewable energy systems;
- capacity building through training at various levels on the science and technology of renewable energy systems;
- development, acquisition and dissemination of appropriate renewable energy technologies;
- development of a programme of research, development and demonstration for renewable energy systems;
- financial support for the development, application and diffusion of renewable energy systems;
- outreach programmes to raise the level of awareness of the potentials and benefits of renewable energy systems to both the decision makers and the general public.

## 7. Conclusion

Nigeria is blessed with abundant resources of fossil fuels as well as renewable energy resources. There is the urgent need to encourage the evolvement of an energy mix that will emphasize the conservation of petroleum resources in such a manner that will lead to their continued exportation for foreign exchange earnings for as many years to come as possible. The adoption of renewable energy technologies especially for rural development will surely lead to reduced internal consumption of petroleum products.

The major advantages of the renewable energy technologies include the simplicity of the technologies, ease of maintenance as well as their enhanced environmental friendliness over fossil fuel systems. There is clear evidence of the use of renewable energy technologies at the moment. However there is the necessity to increase the use of the system especially for rural development. In this regard there is the urgent need for more support of research, development, demonstration and diffusion activities in the existing research centres as well as identified groups in other institutions. Indeed energy extension outfits will have to be established. While the existing research centres should be supported adequately to carry out quality research and development activities, the energy extension centres should be mandated to carry out demonstration and diffusion activities. In view of the apparent reluctance of local entrepreneurs to adopt the mature and proven renewable energy systems for mass production and subsequent commercialization there is need to actively promote the training of local craftsmen on the design, construction, operation and maintenance of appropriate energy end use devices. After such training programmes soft loans could be made available to the craftsmen so they can commence the production and subsequent sale of the devices.

All the aforementioned policy measures' and implementation strategies to promote the use of the sustainable energy systems and practices can only be realised with strengthened energy institutions. In this regard there is the need to identify organisations or offices at state 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 grassroots levels.

Of course the much awaited National Energy Policy for the country should be approved and released by the Federal Government.

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