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Application of Renewable Energy to Power Generation in the Nigerian Environment.

Joseph, E.A
Department of Electrical & Electronics Engineering,
The Federal Polytechnic
Ilaro, Ogun State. Nigeria.
adelekejoe12@yahoo.co.uk

Alausa, D.W.S, Olaiya, O.O. & Olasina, J.R.
Department of Computer Engineering,
The Federal Polytechnic Ilaro
Ogun State. Nigeria.
alausa2008@gmail.com, yinkakol@gmail.com, jamiuolasina@gmail.com

ABSTRACT

Electricity demand in Nigeria greatly overshadows the supply which is epileptic in nature. This epileptic electricity supply hampers development, notwithstanding the availability of vast natural resources in the country. Nigeria is endowed with abundant renewable energy resources, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. The current state of exploitation and utilization of the renewable energy resources in the country is very low due to absence of market and the lack of appropriate policy, regulatory and institutional framework to stimulate demand and attract investors, which is largely of high initial upfront cost. Decentralized Energy (DE) is the production of electricity at or near the point of use, irrespective of size, fuel or technology. The adoption of renewable energy technologies in a decentralized energy form will improved electricity supply and enhance the overall economic development in the country. Therefore, in this paper, the use of renewable energy in power generation in Nigeria is considered.

Keywords: Renewable energy, biomass, wind, Hydropower, electricity.

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1. INRODUCTION

Electricity generation grows from few kilowatts used to serve the colonial masters in Lagos when the first generating plant was installed in 1898. In the late 19th century the Electricity Corporation of Nigeria (ECN) was established by Act of Parliament in 1951, a decade later 1962, Niger Dams Authority (NDA) was set up to develop hydroelectricity which was merged with ECN to form National Electric Power Authority (NEPA) in 1972. However, there was a decline in electricity generation capacity despite an increase in population, with no visible plan to commensurately increase generating capacity. This caused electric power demand to increasingly overshoot available supply. Electricity plays a very important role in the socio-economic and technological development of every nation. The electricity demand in Nigeria far outstrips the supply and the supply is epileptic in nature.

The country is faced with acute electricity problems, which is hindering its development notwithstanding the availability of vast natural resources in the country. It is widely accepted that there is a strong correlation between socio-economic development and the availability of electricity. For over twenty years prior to 1999, the power sector did not witness substantial investment in infrastructural development. During that period, new plants were not constructed and the existing ones were not properly maintained, bringing the power sector to a deplorable state. By year 2000, the problem had sent Nigeria into electricity supply crisis. In 2001, generation went down from the installed capacity of about 5,600MW to an average of about 1,750MW, as compared to a load demand of 6,000MW (Fodeke, 2009). Nigeria has become, quite naturally, heavily dependent on fossil fuels. But while thermal plants supply about 60 percent of its stationary energy grid and petroleum products help meet its transportation needs, it must continue to find ways to reduce the dependence on fossil fuels and make its consumption less harmful to the environment. Replacing fossil fuels with renewable energy is the ultimate goal, though, the volume of renewable is increasing at an enormous rate, it is still being outstripped by rising energy demand (Sambo, 2008). There are abundant renewable energy resources in the country, the significant ones being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies.

Aside the large scale hydropower which serves as a major source of electricity, the current state of exploitation and utilization of the renewable energy resources in the country is very low, mostly used for small projects, such as street lighting, rural bore-hole project and some other smaller projects. The main constraints in the rapid development and diffusion of technologies for the exploitation and utilization of renewable energy resources in the country are the absence of market and the lack of appropriate policy, regulatory and institutional framework to stimulate demand and attract investors. The comparative low quality of the systems developed and the high initial upfront cost also constitute barriers to the development of markets.

2. RENEWABLE ENERGY ANALYSIS

The abundances of renewable energy and its improving technologies day to day cannot be over-emphasized. There are many ways to use renewable energy. Most of us already use renewable energy in our daily lives. Some renewable energy in use are discussed in the sections that follows.

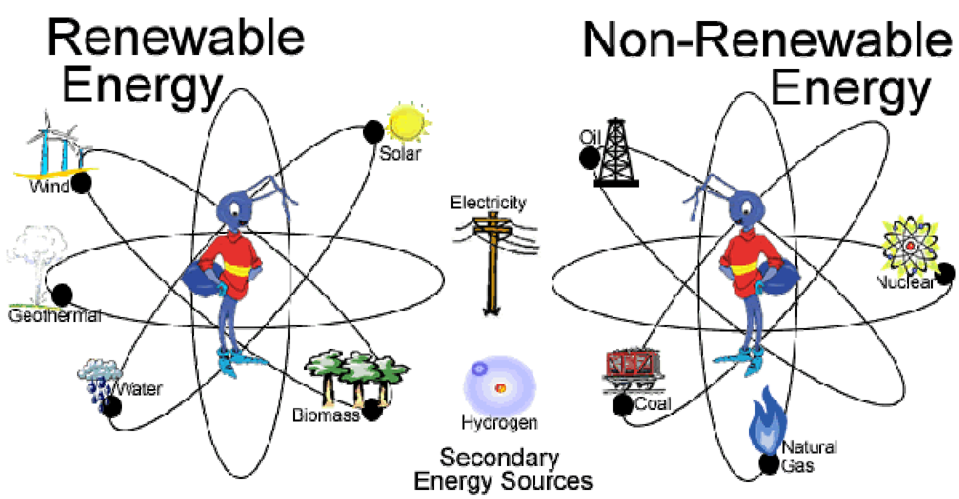

Fig 1: Renewable and Non-renewable Energy Resources
Source https://harmonscience6.wikispaces.com/Renewable+and+Nonrenewable+Resources

2.1 Hydropower

This a plant that convert the kinetic energy in water into electrical energy known as electricity. The most common form of hydropower uses a dam on a river to retain a large reservoir of water. Water is released through turbines to generate power. "Run of the river" systems, however, divert water from the river and direct it through a pipeline to a turbine. Hydropower is the most mature and largest source of renewable power, producing about 10 percent of the nation's electricity. Existing hydropower capacity is about 77,000 megawatts (MW). Hydropower plants produce no air emissions but can affect water quality and wildlife habitats. Therefore, hydropower plants are now being designed and operated to minimize impacts on the river.

2.2 Bioenergy

Bioenergy is the energy derived from bio- mass (organic matter), such as plants. If you've ever burned wood in a fireplace or campfire, you've used bioenergy. But we don't get all of our biomass resources directly from trees or other plants. Many industries, such as those involved in construction or the processing of agricultural products, can create large quantities of unused or residual biomass, which can serve as a bioenergy source.

2.3 Biopower

Biopower After hydropower, biomass is this country's second-leading resource of renewable energy, accounting for more than 7,000 MW of installed capacity. Some utilities and power generating companies with coal power plants have found that replacing some coal with biomass is a low-cost option to reduce undesirable emissions. As much as 15 percent of the coal may be replaced with biomass. Biomass has less sulfur than coal. Therefore, less sulfur dioxide, which contributes to acid rain, is released into the air. Additionally, using biomass in these boilers reduces nitrous oxide emissions. A process called gasification—the conversion of biomass into gas, which is burned in a gas turbine—is another way to generate electricity. The decay of biomass in landfills also produces gas, mostly methane, which can be burned in a boiler to produce steam for electricity generation or industrial processes. Biomass can also be heated in the absence of oxygen to chemically convert it into a type of fuel oil, called pyrolysis oil. Pyrolysis oil can be used for power generation and as a feed- stock for fuels and chemical production. Biofuels Biomass can be converted directly into liquid fuels, called biofuels.

Since biofuels are easy to transport and possess high energy density, they are favored to fuel vehicles and sometimes stationary power generation. The most common biofuel is ethanol, an alcohol made from the fermentation of biomass high in carbohydrates. The current largest source of ethanol is corn. Some cities use ethanol as a gasoline additive to help meet air quality standards for ozone. Flex-fuel vehicles are also now on the market, which can use a mixture of gasoline and ethanol, such as E85—a mixture of 85 percent ethanol and 15 per- cent gasoline. Another biofuel is biodiesel, which can be made from vegetable and animal fats. Biodiesel can be used to fuel a vehicle or as a fuel additive to reduce emissions. Corn ethanol and biodiesel provide about 0.4 percent of the total liquid fuels market. To increase our available supply of biofuels, researchers are testing crop residues— such as cornstalks and leaves—wood chips, food waste, grass, and even trash as potential biofuel sources. Biobased Products Biomass—corn, wheat, soybeans, wood, and residues—can also be used to produce chemicals and materials that we normally obtain from petroleum. Industry has already begun to use cornstarch to pro- duce commodity plastics, such as shrinkwrap, plastic eating utensils, and even car bumpers. Commercial development is underway to make thermoset plastics, like electrical switch plate covers, from wood residues.

2.4 Geothermal Energy

The Earth's core, 4,000 miles below the surface, can reach temperatures of 9000° F. This heat—geothermal energy—flows out- ward from the core, heating the surrounding area, which can form underground reservoirs of hot water and steam. These reservoirs can be tapped for a variety of uses, such as to generate electricity or heat buildings. By using geothermal heat pumps (GHPs), we can even take advantage of the shallow ground's stable temperature for heating and cooling buildings.

The geothermal energy potential in the uppermost 6 miles of the Earth's crust amounts to 50,000 times the energy of all oil and gas resources in the world. In the United States, most geothermal reservoirs are located in the western states, Alaska, and Hawaii. GHPs, however, can be used almost anywhere. Geothermal Electricity Production Geothermal power plants access the under- ground steam or hot water from wells drilled a mile or more into the earth. The steam or hot water is piped up from the well to drive a conventional steam turbine, which powers an electric generator. Typically, the water is then returned to the ground to recharge the reservoir and complete the renewable energy cycle. There are three types of geothermal power plants: dry steam, flash steam, and binary cycle. Dry steam plants draw from reservoirs of steam, while both flash steam and binary cycle plants draw from reservoirs of hot water. Flash steam plants typically use water at temperatures greater than 360°F. Unlike both steam and flash plants, binary-cycle plants transfer heat from the water to what's called a working fluid. Therefore binary cycle plants can operate using water at lower temperatures of about 225° to 360°F.

All of the U.S. geothermal power plants are in California, Nevada, Utah, and Hawaii. Altogether about 2800 MW of geothermal electric capacity is produced annually in this country. Geothermal Direct Use If you've ever soaked in a natural hot spring, you're one of millions of people around the world who has enjoyed the direct use of geothermal energy. Direct-use applications require geothermal temperatures between about 70° to 302°F—lower than those required for electricity generation. The United States already has about 1,300 geothermal direct-use systems in operation. In a direct-use system, a well is drilled into a geothermal reservoir, which pro- vides a steady stream of hot water. Some systems use the water directly, but most pump the water through what's called a heat exchanger. The heat exchanger keeps the water separate from a working fluid (usually water or a mixture of water and antifreeze), which is heated by the geothermal water. The working fluid then flows through piping, distributing the heat directly for its intended use. The heated water or fluid can be used in a building to replace the traditional heat source—often natural gas—of a boiler, furnace, and hot water heater. Some cities and towns actually have large direct-use heating systems—called district heating— that provide many buildings with heat. Geothermal direct use is also used in agriculture—such as for fish farms and to heat greenhouses—and for industrial food processing (vegetable dehydration).

Geothermal Heat Pumps While air temperatures can vary widely through the seasons, the temperatures of the shallow ground only range from 50° to 70°F depending on latitude. GHPs draw on this relatively stable temperature as a source for heating buildings in the winter and keeping them cool in the summer.
Through underground piping, a GHP dis- charges heat from inside a building into the ground in the summer, much like a refrigerator uses electricity to keep its interior cool while releasing heat into your kitchen. In the winter, this process is reversed; the GHP extracts heat from the ground and releases it into a building. Because GHPs actually move heat between homes and the earth, instead of burning fuels, they operate very cleanly and efficiently. In fact, GHPs are at least three times more efficient than even the most energy- efficient furnaces on the market today.

2.5 Solar Energy
Solar technologies tap directly into the infinite power of the sun and use that energy to produce heat, light, and power. Passive Solar Lighting and Heating People have used the sun to heat and light their homes for centuries. Ancient Native Americans built their dwellings directly into south-facing cliff walls because they knew the sun travels low across the southern sky in the Northern Hemisphere during the winter. They also knew the massive rock of the cliff would absorb heat in winter and protect against wind and snow. At the same time, the cliff- dwelling design blocked sunlight during the summer, when the sun is higher in the sky, keeping their dwellings cool.

3. RENEWABLE ENERGY POTENTIAL OF NIGERIA

Nigeria is endowed with sufficient renewable energy resources to meet its present and future development requirements. However, hydropower is the only sustainable resource currently exploited and connected to the grid.18 Interest in renewable energy development and dissemination in Nigeria is driven by, among other things, the recent increase in oil prices, and the unavailability of electricity to majority of the population and the high cost and energy losses associated with grid extension. The government has made efforts through several power reform programmes and policies to attract private participation, thus encouraging renewable energy RE development. However, there are hindrances, mainly due to technical and financial barriers, that need to be overcome for this to be a reality. Renewable energy sources have contributed to Nigeria's energy mix for centuries now, albeit in a largely primitive way. Fuel wood, what is commonly referred to as woody biomass, is the primary energy source for rural Nigeria, and indeed, for much of the African continent. Large hydropower has also featured substantially as an energy source, providing about 19 percent of Nigeria's national electric grid supply.

3.1 Industrial and economic development

There is a historically positive relationship in Nigeria between power availability and industrial and economic development, shown in the decline or stagnation of the manufacturing sector in Nigeria after the late 1980s. A faster pace of industrial development is expected when IPP begins producing and supplying additional cheap power. Normally 40% of power generated goes to industrial development. In rural areas, agro-based SME are most likely to develop. Nearly 200,000 employees get direct employment and the same number get indirect employment. Similarly converting the SHP sites for tourism development and fish farming can create employment opportunity, allowing more people to benefit from these projects.

3.2 Clean power development

Nigeria will suffer if its sustainable hydropower potential (SHP) is not tapped, since hydropower is its only easily harnessed indigenous power source. It is also one of the very few competitive advantages for the country, since land, labor and other inputs to industrial development are costlier in Nigeria compared to other countries. The development of SHP projects reduces the usage of diesel and kerosene for generating electricity in off-grid areas for the high-income group. This will also reduce transportation costs of transporting fuel from cities to rural areas. Another aspect to be noted is the destruction of trees from forested areas for lighting and cooking. The SHP projects can be developed as multipurpose projects, being used for flood control, drinking water purpose, irrigation, fish farming and for tourism development.

3.3 Improved availability and quality of the power supply

Reliable and adequate electric power will reduce the costs and losses currently suffered as a result of inadequate power by increasing productivity, effectiveness and the quality of outputs while reducing hardships, inconveniences and disrupted services due to power interruptions, as well as the expenditures made by businesses and households to compensate for inadequate power. Since Nigeria faces a power shortage during the peak hours, this additional capacity will help in improving the voltage in the distribution network.

3.4 Economic growth and employment

Poverty is clearly related to unemployment. The lack of electricity is an important constraint that works against employment, contributing to the under-utilization of human and natural resources, resulting in widespread unemployment and poverty. Although the poor generally do not qualify for new jobs in the industrial and manufacturing sectors, they can benefit from the effects of economic growth, such as new construction and increased expenditure in the informal sector. These types of unskilled jobs, however, tend to be low-paid, temporary and/or insecure. This has been demonstrated from experience, where income from the Gulf countries facilitated the increase of wage rates, not only in the construction sector, but also in agriculture because of linkages in the labor market.

The availability of power would also enhance public services and infrastructure facilities such as communications, which are necessary for the growth of industries and activities in the service sector.

3.5 Public services

Continuous power is a necessary condition for the full operation of a range of public services, from health and medical services and facilities, street lighting, schools and communications to water systems. All these services have major impacts on the quality of life through health, sanitation, education, safety and security, information and recreation. They provide essential services to those with limited incomes, who cannot afford the alternatives like the affluent in the country.

3.6 Accessibility

More than sixty percent of total households in Nigeria do not have access to electricity. Availability of electricity is critical for household work. Sufficient power throughout the day and evening will allow women to complete their domestic tasks more easily, quickly and effectively, and to become involved in other income generating additional activities. If we are adding 732.0MW from SHP, a major portion nearly 39 MW will go to domestic consumers, thereby providing electricity for additional 3,700 new consumers.

4.0 CHALLENGES AND RESPONSES ON THE COSTS OF RENEWABLE ENERGY IN NIGERIA

CHALLENGES	RESPONSES
High initial capital cost of installing renewable energy—whether wind, solar, hydro, or solar thermal.	The upfront capital investment cost has some advantages in Nigeria— there are no questions about the ongoing financial and stability issues of fuel and pipelines.
Solar and wind power are clearly better suited to specific parts of Nigeria for the most competitive solutions.	The areas with overwhelming solar potential (northern Nigeria) are very poorly served at present, and seem likely to face very high transmission costs from growing power generation areas in the Niger Delta.
Renewable energy installations have tended to be relatively small compared to conventional grid generation.	Smaller installations near to target communities should mean faster deployment and much lower transmission losses than distant gas- powered options
Grid-level renewable energy is not an ‘always on’ generation solution. Both solar and wind require complementary generation.	Nigeria’s power shortages are so acute that this may be an acceptable shortcoming initially. As the grid improves, Nigeria has a wide range of sources that should complement renewable sources well.
The feed-in tariffs used as a tool in other countries could prove expensive at a time when Nigeria has difficulties funding infrastructure.	If structured correctly, a green feed-in tariff could prove attractive to agencies such as the World Bank, with a good potential match in the longer term between affordable interest rates and economically sensible green outcomes. The existing cost of power to the private consumer is extremely high, making even the more expensive renewable options competitive.

5. CONCLUSION

Experience has shown that most renewable energy technologies (especially those that can be locally manufactured) require subsidies only in the initial stages, and can become financially sustainable in the short- to medium-term after a certain level of technology dissemination has been attained. Nigeria now has a published energy policy which emphasizes the development renewable energy. However, an integrated policy and vigorous implementation strategy are needed to facilitate rapid diffusion of renewable energy in the nation's energy mix. Activities such as entrepreneurship and managerial skills development training programs and technical courses in renewable energy technologies with a view of developing energy service companies for providing services to rural areas need to be introduced. The existing research and development centers and technology development institutions should be adequately strengthened to support the shift towards increased renewable energy utilization.

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