# Renewable Energy as an Alternative Power Source in the Sustainability of Agriculture and Food Production in Nigeria

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***Abstract-*** In recent times, agricultural practices have transformed to a level that only well-articulated programs, mechanized equipment and clean energy input can ensure its sustainability. This research work is aimed at highlighting the potentials of clean, renewable and environmentally friendly sources of energy in the sustainability of agriculture and food production in Nigeria. The consequences of using non-renewable forms of energy in the farm have been a source of concern because of its attending environmental pollution and contamination of edible agricultural products due to its hazardous gas emissions. Nature on the other hand has provided in-exhaustible and available alternative energy source that could guarantee the continual existence of mechanized agriculture globally. These ranges from the harnessing of energy from the sun (solar), wind energy, hydro power and biogas forms of energy. These clean and environmentally friendly forms of energy can adequately replace fossil energy sources in all agricultural areas ranging from the tractor/ equipment fuel, drying of products, preservation of agricultural products, irrigation and electric power generation in the farm. Nigeria being one of the growing economies in the world, must embrace clean and sustainable sources of energy in the agricultural sector to pull herself out of impending economic crises that may result from the possible collapse of the non-renewable energy sources as being predicted by research findings conducted in major oil producing nations.

***Index Terms***- Renewable, Energy, Alternative, Mechanization, Sustainability, Production

## I. Introduction

Nigeria is the most populated black nation with estimated population of 182,202.000 located within an area of 923,768km$^2$ of which 38.97% of this area is an arable land [1]. The nation is endowed with both natural resources and human potentials. The oil sector accounts for about 11% of total production while the service sector growth slowed. Sole dependence on fossil fuel (oil) as key source of revenue has placed the nation at the "edge" of economic crises as other viable economic ventures are neglected. This economic decay has affected the public electricity power supply among other sectors resulting in alarming rate of power outage. The Council for Renewable Energy of Nigeria estimates that power outages brought about a loss of 126 billion naira (US$ 984.38 million) annually [2]. The Department for Petroleum Resources [3] reported an amount of petroleum of more than 78% of the total energy consumption in Nigeria. In the present predicament as a nation, it is obvious that depending mainly on fossil fuel (petroleum) is not enough to meet the energy needs of the country [4]. Mechanization of the agricultural sector requires a reliable and sustainable energy source which is currently lacking in Nigeria.

Currently, energy utilization in the agricultural sector has been on the decline, the problem of power has continued to be a major setback in the diversification of Nigerian economy. The nation's electricity demand is estimated to be 24.4GW while actual power generation from Hydro and Gas plant which are the major sources of energy to the Nation is put at 4.06GW as at July 2015[5]. The report from Nigeria Electricity Regulatory Commission reveal a gross shortage in the power distribution in 11 states where the electricity survey was carried out as shown in table below.

**Table 1. Depicts how electricity is sold to the 11 Power Distribution Companies (DISCOS) [2].**

| Company | Pop. Density | Notional Capacity MWh |
|---|---|---|
| Abuja | 83/km2 | 1400 |
| Benin | 229/km2 | 1800 |
| Eko | 2483/km2 | 1400 |
| Enugu | 566/km2 | 1900 |
| Ibadan | 172/km2 | 2000 |
| Ikeja | 2,483/km2 | 2000 |
| Jos | 107/km2 | 700 |
| Kaduna | 113/km2 | 12000 |
| Kano | 291/km2 | 800 |
| Port Harcourt | 283/km2 | 1200 |
| Yola | 56/km2 | 300 |

The projected energy demand for Nigeria up to 2050 as published by the Energy Commission in 2015 via the Nigeria Energy calculator 2050 is as presented below.

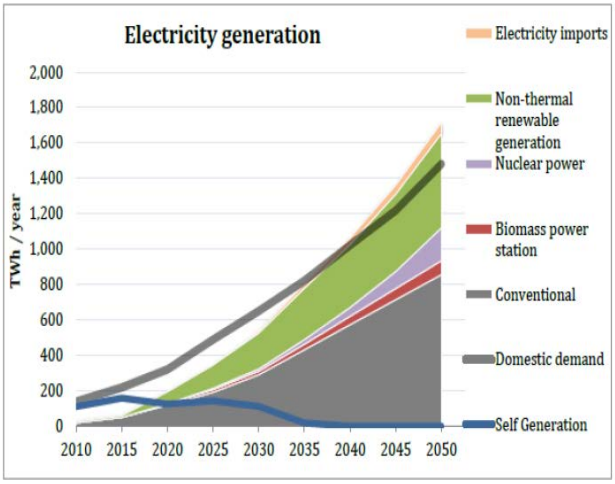


**Figure 1: Projected Electricity Generation in Nigeria [6]**

The average per capital energy consumption per year in Nigeria is put at about 1149KWh. Out of this; house hold electricity demand is allotted 570KWh per year. The agricultural and other industries are left to scramble for the balance of energy distribution, which is grossly inadequate for any meaningful economic impact. When compared to peer nations globally, Nigeria leaves much be desired In terms of feeding her agricultural and other industrial sectors with adequate electricity power supply as shown in figure 2.

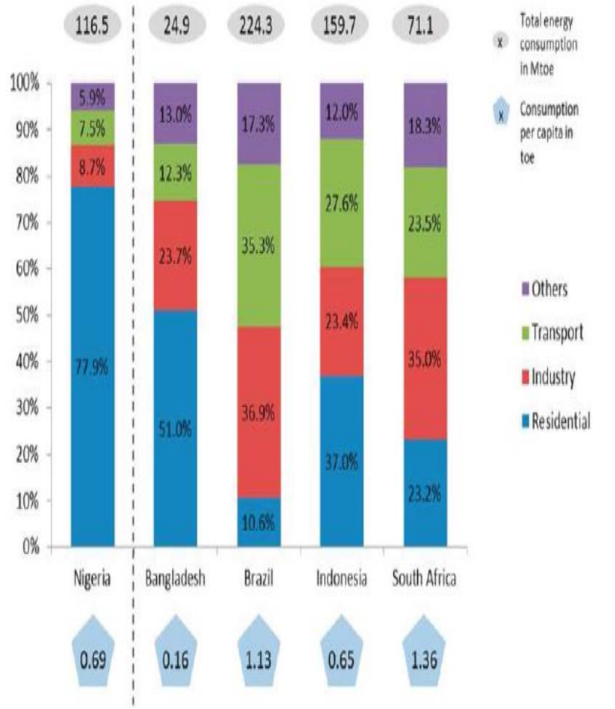


**Figure 2. Nigeria's Energy Consumption Compared to Peer Nations.[7]**

At a crude production average rate of 1.8-2.4 million barrels per day, the next 42 years will possibly see the end of estimated 37.14 billion barrels of crude oil reserve in Nigeria. Recently, Nigeria has witnessed key private and co-operative participation in the area of agricultural activities. Ota farm, cassava growers association, Songhai farm (replications), Agricultural Machinery and Equipment Manufacturers Association of Nigeria (AMEFAN), Divine Engineering Works (DEW), Farm Industries outlets, Raw Materials Research and Development council among others are few examples of agricultural based establishments in Nigeria. All these enterprises and related organization require adequate supply of power to function optimally. To meet the energy demand of the nation's industrial and agricultural sector, alternative and sustainable energy sources must be explored. Thus, the need for Nigeria to embrace renewable energy sources as an alternative power source in sustaining agriculture and food production.

**Potentials of Renewable Energy Source in the Sustainability of Agriculture and Food Production**

Nigeria is rich in conventional energy resources, which include oil, national gas, lignite, and coal. It is also well endowed with renewable energy sources such as, hydropower, solar, wind and biomass materials among others [8]

The way forward is for private organizations to harness these free gifts of nature in the area of power generation to meet the energy requirements in the farm sector. Closely located establishments can also move into partnership with the key aim of pulling resources together towards generating alternative and renewable power supply for their organizations.

## II. HYDRO POWER

Nigeria can boost of large hydro powers at Kainji (760MW), Shiroro (600MW), Jebba (570MW) and some smaller hydropower units (30-60MW) in different parts of the country [2]. The emphasis here is for the farm sector to adapt small or medium scale hydro power to run their equipment and other facilities. Akinbami [9] in his work reported that the total hydroelectric power potential of the country was estimated to be about 8,824 MW with an annual electricity generation potential in excess of 36,000 GW h. This consists of 8,000 MW of large hydropower technology, while the remaining 824 MW is still small-scale hydropower technology as shown in plate 1. Presently, 24% and 4% of both large and small hydropower potentials, respectively, in the country have been exploited. The agricultural sector need to benefit from this huge gift of nature for the sustenance of food production in Nigeria.

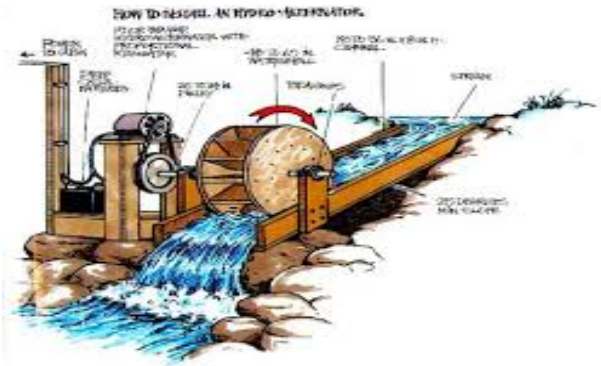

**Plate 1, Images of small scale Hydro Power plant [10]**

## III. SOLAR ENERGY

In recent times, the uses of photovoltaic cells to harness solar energy from the sun have found so many areas of applications in the farm. Garden tractors, farm irrigation systems, grain dryers, electric power generation among others have being successfully powered with photovoltaic cells as shown in plates: 2, 3 and 4.

Solar powered tractor

Plate2. Image of solar powered tractor[11]

**Solar powered irrigation systems**.

Plate 3, Image of solar operated irrigation systems.

Solar Dryer.

Plate 4, Image of Solar Dryer [12].

Onyebuchi [13] estimated the technical potential of solar energy in Nigeria with a 5% device conversion efficiency put at 15.0×1014 kJ of useful energy annually. This equates to about 258.62 million barrels of oil equivalent annually, which corresponds to the current national annual fossil fuel production in the country. This will also amount to about 4.2×105GW/h of electricity production annually, which is about 26 times the recent annual electricity production of 16,000 GW/h in the country. In their work, Chineke and Igwiro [14] show that Nigeria receives abundant solar energy that can be usefully harnessed with an annual average daily solar radiation of about 5.25 kWh/m$^2$/day. This varies between 3.5 kW h/m$^2$/day at the coastal areas and 7 kW h/m$^2$/day at the northern boundary. The average amount of sunshine hours all over the country is estimated to be about 6.5 h. This gives an average annual solar energy intensity of 1,934.5 kW h/m$^2$/year; thus, over the course of a year, an average of 6,372,613 PJ/year (approximately 1,770TW h/year) of solar energy falls on the entire land area of Nigeria. This is about 120,000times the total annual average electrical energy generated by the Power Holding Company of Nigeria (PHCN). With a 10% conservative conversion efficiency, the available solar energy resource is about 23 times the Energy Commission of Nigeria's (ECN) projection of the total final energy demand for Nigeria in the year 2030 [15]. To enhance the developmental trend in the country, there is every need to support the existing unreliable energy sector with a sustainable source of power supply through solar energy.

## IV. WIND ENERGY

Indigenous researchers have explored the availability of wind energy sources in Nigeria with a view of deploying it in the agricultural and other sectors of the economy. Adekoya and Adewale [16] analyzed the wind speed data of 30 stations in Nigeria, determining the annual mean wind speeds and power flux densities, which vary from 1.5 to 4.1 m/s to 5.7 to 22.5 W/m$^2$ respectively. Wind energy can be harnessed and adapted to run farm equipment, power irrigation pumps or used for electricity generation through the use of wind turbines as shown in plate 5. Nigeria has about 2-4m/s at 10m height of wind velocity. This has the capacity of generating above 100MW of electricity[2]**.** The era of wind energy technology has introduced another type of 'farming' known as – Wind Mill Farm. This type

of farming involves the installation of multiples of wind turbines in a cleared expanse of land to generate electricity for industrial and domestic purposes. Fagbenle and Karayiannis [17] carried out a 10-year wind data analysis from 1979 to 1988, considering the surface and upper winds as well as the maximum gusts, A cost benefit analysis was also performed using the wind energy conversion systems for electric power generation and supply in some states in Nigeria [18]. The various research works established a common fact that the nation is endowed with a vast opportunity for harvesting wind for electricity production. All that is required is to look at ways of harnessing resources towards establishing wind farms in various agricultural ventures for the harvesting of wind energy.

**Plate 5,. Images of Wind farm [19]**


**Plate 6. Images of Wind mill.[19]**

Sometime in the past, Nigeria government has tried without encouraging results to established wind farms in some parts of the country as presented on table 2.

**Table 2**, Wind Power Systems under Development in Nigeria [1]

| S/N | WIND ENERGY PROJECTS | CAPACITY (MW) | PROPONENT |
|---|---|---|---|
| 1 | WIND POWER PROJECT AT VWEI KURU, JOS PLATEAU STATE. | 100 | JBS WIND POWER LTD |
| 2 | WIND IN COASTAL AREA PROJECT IN LEKKI TOWN, LAGOS STATE | | PRICEWATER HOUSE COOPERS LTD |
| 3 | WIND FARM POWER PLANT AT LAMBA, RIMI LGA, KATSINA STATE | 10 | FED. MIN. OF POWER |
| 4 | WIND FARM PROJECT AT ADO EKITI | 8.5 | ENERSYS NIG LTD |
| 5 | KATSINA WIND FARM | 10 | FED. MINISTRY OF POWER |
| 6 | CGC NIG. LIMITED LOCATED AT PLOT 674 CAD ZONE, ALONG LUGBE EXPRESSWAY , FCT ABUJA | | CGC NIGERIA |

The impacts of these projects are yet to be felt in our economy. Individuals and cooperate bodies are advised to key into this programme to overcome their enterprise power challenges.

## V. BIOLOGICAL ENERGY SOURCE

Biological based waste accounts for about 82% of total discarded item in most cities [20]. These wastes attract rodents, insects and harbor some parasites and fungi which are both harmful to man, farm animals and the environments. Burning these wastes can be cancerous in addition to contaminating the surface waters and causing imbalance in the ecosystem[21]. Waste like poultry droppings (plate 7), cow dung (plate 8), pig excreta (plate 9), human faeces, and vegetable wastes among others when properly managed can be useful substrates in the biological process of generating methane, carbon-dioxide and biological fertilizer[2]. Converting these organic wastes into more useful products may be achieved through the dry process (non-biological method) or wet process (biological method). The dry process involves burning of waste materials in excess air (near complete combustion), can be used to generate steam or for electricity generation [22]. On the Other hand, heating of organic matter at high temperature in the absence of oxygen which is known as – Pyrolysis is used to achieve waste drying to produce oil, gas and charcoal. The soot free charcoal produced from this process is in turn used as fuel for product drying and other purposes in the farm. A cutting edge technological approach in re-using biological wastes is known as –"composting". These selected organic matters are allowed to decompose in the absence of oxygen to serve as substrates in a biogas reactor to produce methane and carbon dioxide gases as shown in fig 3 and 4. The residue of this reaction is also used as manure for crops. The

entire process is simple and straight as illustrated in the flow chart on fig 3.

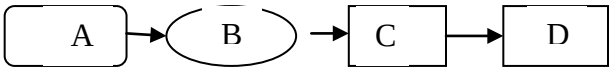


**Fig 3, Flow Chart of Biogas Production.**

Where,
A = Feed stock
B = Hydrolytic Stage
C = Acid Forming Stage
D = Gas Production Stage

**Plate 7, Vegetable Wastes**

**Plate 8. Cow Dung**

**Plate 9, Pig Dung**

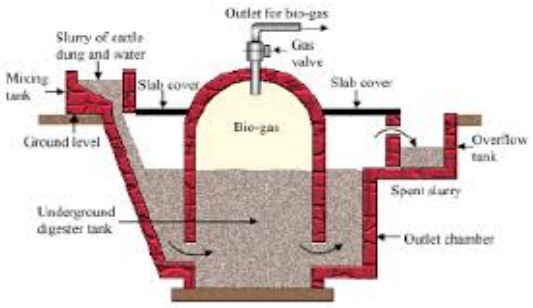


**Fig 4, Underground Bio gas Reactor.**

**Plate 10, Methane Operated Engine[23].**

The entire system can be continuous or batch process. The extracted methane gas is used directly as fuel in most gas powered electric generating set (see plate 10) to power basic farm equipment and houses. Akinbami et al.'s assessment [23] indicated that the identified feedstock substrate for an economically feasible biogas program in Nigeria includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid waste, agricultural residues, and sewage. The authors' views include the following: Nigeria produces about 227,500 tonnes of fresh animal wastes daily. Since 1 kg of fresh animal wastes produces about 0.03 $m^3$ gas, then Nigeria could produce about 6.8 million $m^3$ of biogas every day. This volume of gas will be sufficient to run well established farm settlement anywhere in Nigeria.

## VI. CONCLUSION

Technically speaking, most biological materials considered as waste “yesterday” are “today” identified as vital raw materials in our farms and related industries. Much may have been said about solar panels, wind turbines, hydro powers and nuclear energy but, the emerging technology of biodiesel and biogas production and utilization is awaiting the efforts of engineers and related fields to practically introduce them to the Nigeria farm sector. Farm establishments in neighbouring Benin republic (Songhai farm Port Novo) among others are currently enjoying the services of biogas electricity generation powered with biological waste from their farm. Nigerian farmers can as well operate above dependence on public power supply in the management of their farms. Nigeria with her vast green vegetation is capable of producing healthy animals and excess waste material as shown in fig 5.

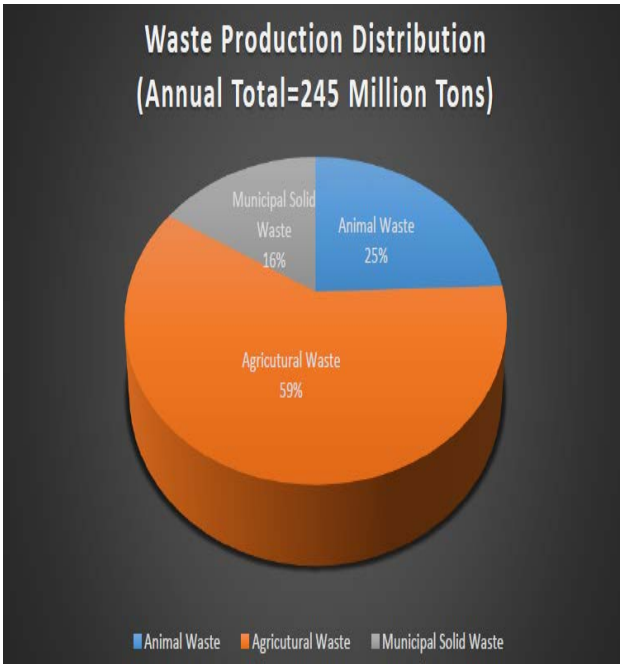


**Fig 5. Combined Annual Waste (Animal, Agricultural & Municipal) Production in Nigeria [1]**

Research by **Centre** for Renewable Energy Technology[1] has shown that a ton of waste can produce an average of 550-750 kWh of electricity. Nigeria generates above 245 million tons of waste annual and this can yield about 160 Billion kWh of electricity per annum. This quantity of electricity will take care of most power requirements in the nation's farms.

## VII. 4.0. RECOMMENDATIONS

Developed nations are investing more in alternative and renewable forms of energy than buying crude oil. Coal and renewable energy resources are grossly underutilized in our nation despite their availability in commercial quantities [25]. A former Vice President of this nation once said "it is crude thinking to continue to talk and base development projection on crude oil" [26]. To ensure sustainable agricultural development and food production in Nigeria, the key players must embrace the use of alternative and renewable energy sources as the benefits are enormous and affordable given that they are free gift of nature.

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