# BIOMASS RESOURCES AND BIOENERGY POTENTIALS IN NIGERIA: A REVIEW

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## Abstract
*The need for clean and sustainable energy sources as alternatives to fossil fuels is a subject of research concern, with several studies in the literature. This is as a result of the dire environmental impacts posed by the use of fossil-based fuels, such as climate change due to greenhouse gases emissions, environmental degradation from oil spills, and air pollution from the release of particulates and toxic gases. Nigeria is a country with an abundance of biomass resources. These biomass resources can be converted into biofuels and bioenergy for the production of valuable chemicals and the generation of electricity. The latter will no doubt considerably help to improve the perennial electricity problems bedevilling the country. This paper highlights the various biomass resources in the country and their potential energy contributions.*

***Keywords:*** *Biomass resources, bioenergy, biofuels, agricultural residues, Nigeria*

## Introduction
Besides the huge petroleum and gas deposits in Nigeria, albeit poorly harnessed, there abound huge biomass resources in Nigeria that is still largely untapped and highly underutilized. Biomass resources have the potential to meet the energy needs of the nation, address rising environmental concerns in addition to value-addition and value creation. Traditional biomass (wood and charcoal) accounted for 85% of total energy consumption in Nigeria in 2014, with wood fuel making up about 94% of traditional biomass utilized for household cooking and heating (Sambo, 2006). Nigeria's bioresource is estimated at 200 million tonnes/year with the potential to generate about 62 Mtoe (2.58 billion GJ or 2.58

EJ) of energy annually (Olanrewaju et. al., 2019). This is more than half of the nation's energy consumption in 2015 (121 Mtoe) and more than four times the equivalent of the nation's electricity consumption in 2015 (Olanrewaju et. al., 2019). Biomass is generally comprised of organic materials derived from plants and animals. This includes agricultural crop residues, forest residues, dedicated energy crops, municipal solid wastes, animal and human wastes. Agricultural crop residue is the largest biomass resource in Nigeria accounting for more than 76% of the nation's biomass resources with an estimated value of 153.76 million tonnes/year (Olanrewaju et. al., 2019). However, these are mostly burnt in the fields. The efficient utilization of these bioresources will help prevent the devaluation of biomass residues through the common practice of burning, address environmental pollution arising from the indiscriminate disposal of agricultural wastes residues, and invariably improve the economy of the country.

**Benefits of biomass and bioenergy resources**

The potential benefits accruable from the efficient utilization of the bioresources in Nigeria include but are not limited to the following:

- Clean, sustainable, and renewable energy sources.
- Reduction in fossil fuel consumption leading to lower carbon footprints.
- Reduction in greenhouse gases emissions.
- Conformity and compliance with world climate change commitments.
- Advancement in bioenergy and biorefining technologies for the production of biofuels and valuable chemicals.
- Improved food security through renewed interest in agriculture.
- Improved economy through job availability and market opportunities.
- Poverty reduction and development of rural infrastructures.

Biomass resources in Nigeria and their energy potentials

Biomass resources comprise of forest residues, agricultural crop residues, dedicated energy crops, municipal solid waste, algae, animal, and human wastes. Below is a list of selected bioresources and their estimated energy potentials in Nigeria.

## Forest residues

Forest residues are by-products of forest products. The study by Olanrewaju et. al. (2019) puts the estimated forest residues in Nigeria to be around 19 million tonnes with an estimated energy potential of about 8.68 Mtoe (363 PJ). Forest and wood processing residues comprise of logging residues (tops, stumps, branches, leaves, offcuts, defect logs), sawmilling and wood processing residues (offcuts, slab, bark, edgings, trimmings, sawdust, veneer log cores and rejects), particle board production, and demolition wood from construction sites (Koopmans and Koppejan, 1997). Residues from the sawmill can vary between 15-20% of the total biomass (full tree) and 30-40% of the actual biomass (logs) delivered to the sawmill (Simonyan and Fasina, 2013).

## Agricultural and crop residues

Agricultural crop residue is the largest biomass resource in Nigeria accounting for more than 76% of the nation's biomass resources with an estimated value of 153.76 million tonnes/year (Olanrewaju et. al., 2019). These residues can be used to provide around 0.60 EJ, which is equivalent to 34% of the energy consumption in Nigeria (Simonyan and Fasina, 2013). Agricultural and crop residues are by-products of agricultural resources derived from the harvesting and processing of crops such as cassava, maize, wheat, rice, sugarcane, sorghum, millet, soybean, groundnut, oil palm, cotton seeds, cocoa, coffee, tobacco, etc. These residues consist of stalks, leaves, peels, cobs, pods, husks, straws, stubbles, shells, empty bunches, stems, bagasse, etc. Agricultural and crop residues do not interfere with food production and are readily available in large quantities.

## Animal wastes

Like agricultural crops and forest residues, animal wastes are a by-product of animal husbandry. These animal wastes from livestock such as cattle, chickens, goats, pigs, and sheep have great potentials for biofuel generation and are most suitable for biogas production via anaerobic digestion. The total estimated animal wastes generation in Nigeria as of 2010 was 15.76 million tonnes of dry matter per year with a biogas potential of about 4.19 billion $m^3$/year (29.25 GJ) (Simonyan and Fasina, 2013). Olanrewaju et. al. (2019) put the estimated values for animal wastes in 2013 at 17.69 million tonnes of dry matter/year with a

potential biogas yield of 4.76 billion $m^3$/year, equivalent to 2.54 Mtoe (106.39 PJ).

**Human wastes**

Nigeria with its bulging population is a great source of human waste that can be converted into valuable products. Given the populated nature of Nigeria, the country generates a large quantity of human wastes, with an estimated dry matter of 2.59 million tonnes per year as of 2010 (Simonyan and Fasina, 2013). This translates to a potential biogas yield of about 1.17 billion $m^3$/year (8.13 GJ) (Simonyan and Fasina, 2013) based on biogas yield estimates of 0.45 $m^3$/kg dry matter (Jain, 1993). The study by Olanrewaju et. al. (2019) puts the estimated annual dry matter at 2.87 million tonnes in 2015 with a potential annual biogas yield of 1.29 billion $m^3$/year (28.83 PJ), representing a 9.3% increase compared to the estimate by Simonyan and Fasina (2013). The results from these studies were calculated based on urban population dry matter estimates by Jossy (1994) of 0.09 kg dry matter per head per day.

**Municipal solid waste (MSW)**

Municipal solid wastes consist of food wastes, household and industrial wastes, animal wastes, and can be broadly grouped into two categories: biogenic and non-biogenic wastes components. The biogenic waste comprises of biodegradable organic materials that can be converted via anaerobic digestion to produce methane biogas. The non-biogenic wastes on the other hand consist of nonbiodegradable inorganic materials such as plastics and metals (Ben-Iwo et al., 2016). Nigeria's municipal solid waste generation is estimated to be 36.5 million tonnes/year, with a theoretical energy potential of 0.44 EJ and a technical energy potential of 0.11 EJ (Jekayinfa et al., 2020).

Table 1: Summary of biomass estimates and bioenergy potentials in Nigeria

| | **Simonyan and Fasina (2013)** | | **Olanrewaju et. al. (2019)** | |
|---|---|---|---|---|
| Biomass Resource | Biomass Weight | Energy Potential (GJ) | Biomass Weight | Energy Potential (PJ/year) |

| | (billion kg) | | (billion kg) | |
|---|---|---|---|---|
| Agricultural crops | 145.62 | 1,958.94 x $10^6$ | 153.76 | 2,033.85 |
| Perennial crop residues | 4.47 | 54.60 x $10^6$ | 2.35 | 28.88 |
| Forest residues | - | 0.02 | 19 | 362.95 |
| Municipal solid waste | 3.17 | 186.33 | 4.51 | 21.36 |
| Animal waste | 15.76 | 29.25 | 17.69 | 106.39 |
| Human waste | 2.59 | 8.13 | 2.87 | 28.83 |
| Total: | 171.61 | 2,013.54 x $10^6$ (48.06 Mtoe) | 200.18 | 2,582.26 (61.67 Mtoe) |

*1 PJ = 1 million GJ

## Conclusion

Considering the vast biomass resources available in Nigeria and the potentials for energy generation, concerted efforts need to be put in place to better harness these abundant resources through efficient conversion into bioenergy and biofuels, rather than the usual practice of burning them or littering of the environment as means of disposal. The efficient utilization of these bioresources will help prevent the devaluation of biomass resources and wastage of energy through the common practice of burning, reduce the cost of transportation and cooking fuels and ensure their availability through conversion into biofuels, address environmental pollution arising from indiscriminate disposal of biomass wastes residues, and invariably improve the economy of the country.

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