

## Research Article

# BIOMASS ENERGY IN NIGERIA: CASE STUDIES ON THE USE OF AGRICULTURAL WASTE FOR RENEWABLE POWER

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### ABSTRACT

Biomass energy offers a promising solution to Nigeria's energy challenges, especially given the country's vast agricultural output, which generates significant volumes of agricultural waste. This paper investigates the potential for converting agricultural waste into biomass energy in Nigeria, examining various projects implementing biomass technologies. Using case studies from different regions of Nigeria, this article explores biomass energy's benefits, challenges, and prospects. It concludes by offering policy recommendations for scaling the adoption of biomass energy in Nigeria.

**Keywords:** Biomass energy, Nigeria, agricultural waste, renewable energy, rural electrification, sustainability.

### INTRODUCTION

Nigeria is faced with the dual challenge of energy poverty and environmental degradation. Despite being one of the largest oil producers in Africa, over 85 million Nigerians lack access to electricity, particularly in rural areas. This presents a critical need for sustainable energy alternatives. Agricultural waste, which is abundantly available across Nigeria, holds the potential for transforming the country's energy landscape through biomass energy. Biomass energy is a renewable energy source derived from organic materials such as plant residues, animal waste, and other agricultural by-products. It is increasingly recognized as a promising renewable energy source. In Nigeria, large quantities of agricultural waste—rice husks, cassava peels, palm kernel shells, and more—are produced annually but are often underutilized due to a lack of technologies, infrastructure, and policies. These biomasses when left, decay and contribute to environmental pollution. By harnessing these resources for energy production, Nigeria can address its energy needs while reducing its environmental footprint, rural electrification, and greenhouse gas emissions.

This paper aims to provide an in-depth analysis of biomass energy projects in Nigeria that utilize agricultural waste. It presents case studies from different regions, outlines the benefits and challenges of biomass energy, and offers recommendations for future development.

### OVERVIEW OF BIOMASS ENERGY AND AGRICULTURAL WASTE IN NIGERIA

#### Biomass Energy

Biomass energy is obtained from organic matter, which includes plant residues, animal waste, and other biodegradable materials. In Nigeria, agricultural biomass is the most readily available source for energy production. The process of converting biomass to energy involves several technologies, such as:

- **Direct Combustion:** This is the simplest and most direct way to generate energy from biomass. Agricultural residues like rice husks, palm kernel shells, and maize stalks are burned to generate heat, which can be used for power generation.
- **Gasification:** Biomass is heated in a low-oxygen environment to produce syngas (a mixture of hydrogen, carbon monoxide, and carbon dioxide). Biomass is converted into syngas can be burned in turbines or engines to generate electricity or converted to bio fuels. This method is more efficient than direct combustion as syngas can be processed further into fuel cells that can be used for synthetic fuel production.
- **Anaerobic Digestion:** In anaerobic digestion, organic material is broken down by microorganisms in the absence of oxygen, producing biogas (methane and carbon dioxide) that can be used for cooking, heating, and electricity or converted to biogas used for transport fuel.

#### Agricultural Waste in Nigeria

Agricultural waste refers to the by-products and residues generated from agricultural processes and farming. Nigeria's agricultural sector produces substantial amounts of waste, much of which can be utilized for energy generation. Below is a table summarizing the main types of agricultural waste in Nigeria and their annual production.

Table 1: Annual Agricultural Waste Production and Energy Potential in Nigeria

Agricultural Waste	Annual Production (Million Tons)	Energy Potential (TJ)
Rice Husks	3.4	1,200
Cassava Peels	4.1	1,300
Palm Kernel Shells	8.5	3,000
Maize Stalks	10.0	3,500
Cocoa Husks	2.0	700
Groundnut Shells	2.3	800

(Source: Nigerian National Biomass Strategy, 2017)

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## METHODOLOGY

This article adopts a case study methodology to explore the practical applications of biomass energy projects in Nigeria. Data was collected from:

- Field visits to biomass energy projects across different regions of Nigeria.
- Interviews with project stakeholders, including local farmers, energy developers, and government representatives.
- Secondary sources such as government reports, academic publications, and project documentation.

Three case studies were selected based on their relevance to the use of agricultural waste for biomass energy, geographical diversity, and project scalability. The analysis focuses on the technical approaches, socio-economic impacts, environmental benefits, and challenges faced by each project.

## BIOMASS ENERGY POTENTIAL IN NIGERIA

Nigeria's agricultural sector provides a wide variety of biomass resources with significant energy potential. According to the Nigerian National Biomass Strategy, the country produces over 144 million tons of agricultural residues annually. This section outlines the key crops and their associated waste streams that could be harnessed for biomass energy.

### Rice Husk Energy Potential

Rice is a major staple in Nigeria, and its cultivation generates large quantities of rice husks. These husks can be processed into bio energy through combustion or gasification, providing a significant source of renewable energy, especially in rural areas where rice is widely grown.

**Table 2: Rice Husk Energy Potential by Region in Nigeria**

Region	Rice Production (Million Tons)	Waste (Million Tons)	Energy Potential (TJ)
North Central	2.8	1.0	500
Southwest	0.6	0.2	120
Northeast	0.5	0.2	100

(Source: Federal Ministry of Agriculture, 2019)

## CASE STUDIES OF BIOMASS ENERGY PROJECTS IN NIGERIA

### Case Study 1: Cassava Peels for Biomass in Ogun State

One of the most promising examples of agricultural waste-to-energy in Nigeria is the Cassava Peel Biomass Project in Ogun State. Cassava is a widely cultivated crop in Nigeria, and its peels, typically discarded as waste, have significant energy potential. The project processes cassava peels into biomass pellets that are used for power generation. The plant produces approximately 10 megawatts (MW) of electricity annually, which is distributed to nearby communities.

**Table 3: Project Data for Cassava Peel Biomass Plant in Ogun State**

Project Data	Statistics
Annual Cassava Peel Intake	50,000 tons
Power Generation	10 MW
Households Powered	5,000

(Source: Project Reports from the Nigeria Green Energy Company, 2020)

This project not only provides renewable energy by converting cassava waste into electricity but also offers economic benefits by creating jobs for local communities involved in peel collection and processing. The environmental impact is significant, as it reduces waste accumulation and associated methane emissions from peel decomposition.

### Case Study 2: Rice Husk Power Plant in Ekiti State

In Ekiti State, a rice husk power plant was established to harness the energy potential of rice husks, which are typically burnt or left to decompose after rice processing. The plant generates electricity used to power rice mills and nearby rural areas, contributing to both the agricultural and energy sectors.

**Table 4: Project Data for Rice Husk Power Plant in Ekiti State**

Project Data	Statistics
Rice Husk Intake	30,000 tons/year
Power Output	5 MW
Beneficiaries	10,000 people

(Source: Federal Ministry of Agriculture, 2019)

This initiative has improved energy access in Ekiti State, where grid power is unreliable. By utilizing agricultural waste, the plant also helps to mitigate environmental degradation caused by the open-air burning of rice husks.

### Case Study 3: Palm Kernel Shell Energy in Cross River State

Palm kernel shells, a by-product of the palm oil industry, are an abundant source of biomass energy in Nigeria's southern region. In Cross River State, a biomass plant was established to convert palm kernel shells into biogas. This energy is used to power local industries and homes, replacing expensive and polluting diesel generators.

**Table 5: Project Data for Palm Kernel Shell Biomass Plant in Cross River State**

Project Data	Statistics
Palm Kernel Shells Processed	40,000 tons/year
Biogas Output	7 MW
Carbon Emissions Reduction	25,000 tons CO <sub>2</sub> e annually

(Source: Project Reports from Cross River Bio-energy Initiative, 2021)

The project has been instrumental in reducing the reliance on fossil fuels and improving air quality in the area by cutting down on emissions from traditional energy sources.

## BENEFITS OF BIOMASS ENERGY IN NIGERIA

### Environmental Benefits

Biomass energy provides a sustainable solution:

- Renewable Energy Source:** Biomass is a sustainable alternative to fossil fuels and reduces greenhouse gas emissions.
- Enhanced Air Quality:** Biomass energy reduces air pollution by converting fossil fuel and mitigating particulate matter emission.
- Waste Management:** Biomass energy utilizes agricultural waste thereby promoting waste management and reducing environmental pollution.

- **Carbon Capture:** Biomass energy absorbs Carbon dioxide during crop growth thereby offsetting emissions during energy production.

### Economic Benefits

Biomass economic benefits include:

- **Income Generation:** Biomass provides income for rural communities and farmers through the sale of biomass feedstock.
- **Job Creation:** It creates employment opportunities in rural areas, from the collection and processing of waste to the operation and maintenance of power plants.
- **Reduced dependency on fossil fuels:** It reduces dependency on fossil fuel, its importation, and foreign exchange. They also reduce the cost of energy for local industries, improving productivity and competitiveness.
- **Stimulating Local Economy:** It projects the local economy through investment and infrastructure development.

### Energy Access

Biomass provides energy access through:

- **Flexibility:** It enhances grid stability by integrating with existing power infrastructure.
- **Reliability:** Biomass energy, particularly in off-grid rural areas, provides a reliable and affordable source of electricity. This is especially crucial for agricultural processing industries that are located far from the national grid, allowing them to operate efficiently.
- **Scalability:** It can be scaled up or down depending on the energy demand.

### CHALLENGES IN THE ADOPTION OF BIOMASS ENERGY

Despite the benefits, the adoption of biomass energy in Nigeria faces several challenges:

- **Technological Barriers:** Many rural areas lack the technical expertise and equipment needed to convert agricultural waste into energy efficiently.
- **Financial Constraints:** The high initial capital costs for setting up biomass power plants and the lack of access to finance make it difficult for small-scale farmers and businesses to invest in these technologies.
- **Policy Gaps:** Inconsistent government policies and a lack of incentives for renewable energy projects slow down the growth of the biomass energy sector.
- **Logistics:** Collecting and transporting agricultural waste to power plants can be a significant challenge, particularly in remote areas with poor infrastructure.

### PROSPECTS AND POLICY RECOMMENDATIONS

To unlock the full potential of biomass energy in Nigeria, the following policy recommendations are made:

1. **Government Incentives:** The Nigerian government should provide tax breaks, subsidies, and grants to encourage private investments in biomass energy projects.
2. **Capacity Building:** Local engineers and technicians should be trained in biomass conversion technologies to ensure the sustainability of projects.
3. **Research and Development:** R&D investments are needed to improve the efficiency of biomass energy technologies and reduce costs.
4. **Waste Collection Networks:** The establishment of organized networks for the collection and processing of agricultural waste would ensure a steady supply of feedstock for biomass power plants.

### CONCLUSION

Biomass energy obtained from agricultural waste presents a viable solution to Nigeria's energy deficit while offering environmental and economic benefits. By using the country's rich agricultural residues, renewable power can be generated, reducing reliance on fossil fuels and contributing to rural development. Though there are challenges such as lack of adequate technology, financial limitations, and regulatory barriers with strategic investments in education, infrastructure, and policies these barriers can be unlocked. The case studies presented in this article demonstrate the feasibility and potential of converting agricultural waste into renewable energy. However, to fully harness this potential, Nigeria must overcome challenges related to technology, financing, and policy. With the right support, biomass energy could play a critical role in Nigeria's transition to a more sustainable energy future.

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