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ASSESSING THE DEVELOPMENT OF BIOFUELS IN NIGERIA

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Abstract: Biofuels are a significant contributor to renewable energy, accounting for 70 % of the global renewable energy supply. This contribution is heavily influenced by the formulation and implementation of policies that favour the development and consumption of biofuels. This study adopts a systematic literature review of biofuel polices, production and utilisation in Nigeria. The study examines the influence of policies from 2007 to 2025 on Biofuel production in Nigeria. Some key challenges and opportunities for scaling up biofuel production in Nigeria were identified. Unfortunately, despite the numerous policies, over the past decades, they have not attracted sufficient attention to facilitate notable growth in the sector. The study shows that Nigeria possesses significant bioresource potential that could contribute substantially to meeting its growing energy demand, particularly through effective implementation of the 2007 Biofuel Policy. To be a self-sufficient energy-generating country, biofuel production should be sustainable through substantial investment in research to keep pace with global technological advances.

Keywords: Biofuels, Nigeria, Biomass, Renewable energy, fossil-derived fuels.

1. Introduction

The global energy system is undergoing a structural transition driven by climate change mitigation and energy security. In recent decades, biofuels, renewable fuels derived from biomass, have emerged as a crucial complement to electrification and transportation. As the transport sector remains one of the major emitters of greenhouse gases, greening this sector has been a major concern worldwide; liquid biofuels account for only about 3 % of the world's transport fuel needs. Nigeria remains heavily dependent on imported refined petroleum products despite being a crude oil producer, the increase in prices of premium motor spirit (PMS) and automotive gas oil (AGO) over recent decades, as presented in the National Bureau of Statistics (2024), indicates that the average cost of premium motor spirit (Petrol) per litre and automotive gas oil (diesel) per litre in Nigeria as at October 2024 was N1184.83 and N1441.28, respectively, this has escalated the cost of providing the required energy for transportation and electrification. However, biofuels derived from biomass can help address the rising energy costs to adequately meet Nigeria's growing population, reduce over-dependence on fuel imports, create job opportunities, and alleviate rural communities from poverty, as most of the biomaterials will be sourced from the rural areas. Nigeria is endowed with diverse biofuel feedstocks distributed across its agro-ecological zones. These include starch - and sugar-rich crops (cassava, sugarcane, sweet sorghum) suitable for bioethanol production; oil-bearing crops and wastes (oil palm, soybean, used cooking oil) for biodiesel; and abundant lignocellulosic residues (cassava peels, rice husk, etc.) that can serve as inputs for cellulosic ethanol or biogas. Approximately 62 Mtoe of energy can be generated from the Nigerian biomass resource, which exceeds 200 billion kg/yr and is sourced from agricultural, municipal solid, and human and animal wastes (Olanrewaju et al., 2019). If properly utilised, these wastes can serve as viable feedstock for the production of biofuels. With the effective implementation of biofuel policies and the availability of feedstock, Nigeria can meet the growing energy demands. Biofuel production has thrived in countries like the US and Brazil due to policies that favour its production and applications. The current paper is focused on providing a comprehensive review of Nigeria's available biomass resources. It provides a detailed discussion of biomass, biomass processing technologies, global trends in biofuel development, the current energy situation in Nigeria, the progress of biofuels in the country, the challenges facing the biofuel industry, and strategic suggestions for overcoming these challenges. Several studies have examined biofuel production in Nigeria. Previous studies on Biofuel development in Nigeria lack comprehensive data on available biomaterials for biofuel projections. This review will systematically identify the underlying roadblocks to biofuel development in Nigeria with strategic suggestions for resolving them.

2. Biomass

Biomass refers to the potential energy stored in biomaterials, which replenishes rapidly, making it a renewable energy source. In Nigeria, biomass distribution correlates with regional vegetation types; the highest proportion of woody biomass is predominant in the rainforests of the south, whereas a greater percentage of crop residues is common in the Guinea Savannah in the North Central region, in comparison to the Sudan and Sahel Savannahs in the North West and North East, respectively. Furthermore, densely populated urban areas are associated with higher municipal solid waste generation rates (Sambo, 2009). Establishing corresponding biorefineries in these regions will reduce the cost of transporting biomass to processing plants, thereby lowering the overall production cost of biofuels

2.1 Agricultural Crops and Residues

The arable land area in Nigeria is 34 million hectares, out of which 6.5 million hectares are designated for permanent crops, and 28.6 million hectares for meadows and pastures (Kamer, 2022). Several crops are widely cultivated in Nigeria in accordance with the vegetation of the regions, as shown in Figure 1. Crops like maize, cassava, sorghum, and sugarcane can be used to produce biofuels, such as bioethanol, because they are rich in carbohydrates. Oil-bearing crops such as oil palm, coconut, and soybean can be used to produce biodiesel due to their high lipid yields (Edeh & Okpo, 2023).

These agricultural crops are cultivated and produced in large quantities, with cassava as the most produced crop from 2020 to 2023, as shown in Table 1. Most studies have shown that cassava and maize dominate Nigeria's energy crop landscape, due to their high yields. Even though these crops show promising potential to be used as feedstocks for biofuel production, there has been an uneasy state regarding food-fuel competition and land-use, particularly for large-scale cultivation for biofuel production (Anyanwu et al., 2015). Despite several discussions on food-fuel competition, few Nigerian studies provide intensive assessments of land-use socio-economic impacts on the cultivation of energy crops primarily for biofuels production.

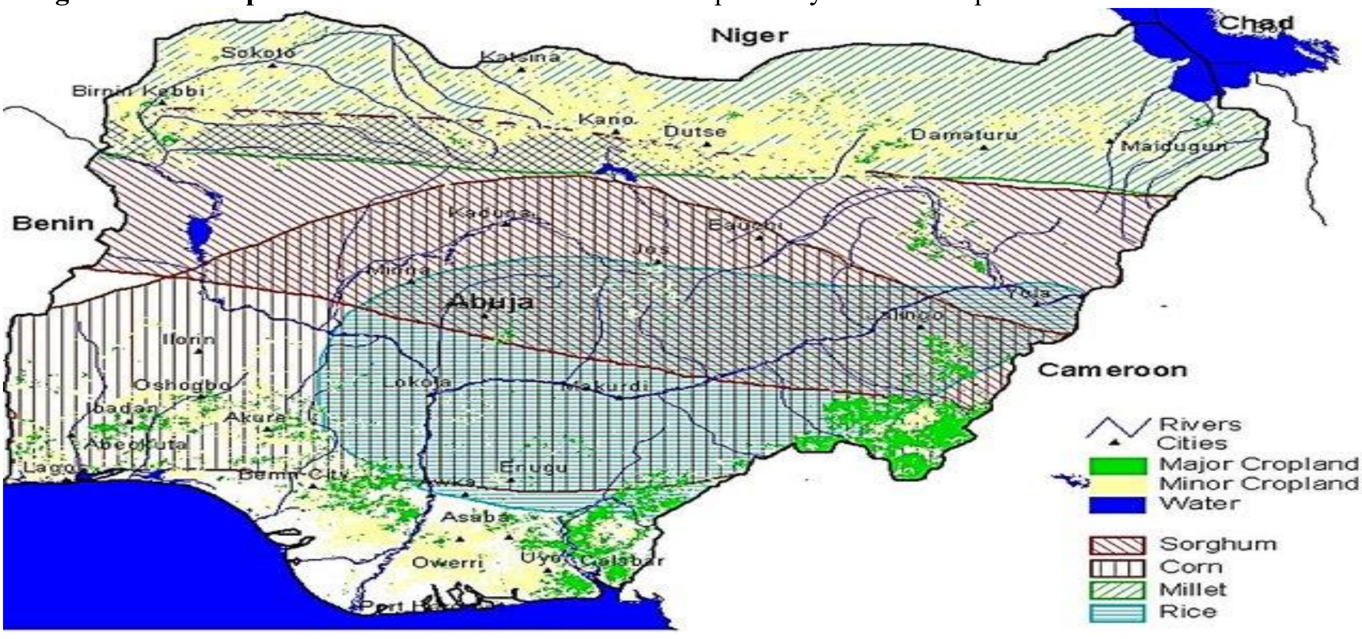

Figure 1: Major crop zones in Nigeria (Aliyu and Deba, 2016)

Table 1: Some crop products produced in Nigeria 2020-2023(FAO, 2024)

Crop	Parameter	Year			
		2020	2021	2022	2023
Cassava	Area harvested (ha)	7290381	9085736	10144641.0	9878773.0
	Yield (hg/ha)	81015	69374	6014.5	6345.9
	Production (ton)	59063109.47	63031376.66	61015339.2	62690091.2
Coffee, green	Area harvested (ha)	1432	1398	1393.0	1416.0
	Yield (hg/ha)	12984	12984	1299.3	1302.1
	Production (ton)	1859.43	1815.14	1809.6	1844.1
Green corn (maize)	Area harvested (ha)	203145	204527	200977.0	201730.0
	Yield (hg/ha)	38056	37941	3918.8	3933.5
	Production (ton)	773095.75	775989.62	787587.6	793497.0
Maize (corn)	Area harvested (ha)	5500000	6000000	5800000.0	5700000.0
	Yield (hg/ha)	22545	21242	2232.6	1939.1
	Production (ton)	12400000	12745000	12948920.0	11053000.0
Oil palm fruit	Area harvested (ha)	3878183	3937865	4323296.0	4520090.0
	Yield (hg/ha)	25600	25554	2567.5	2565.8
	Production (ton)	9928000	10062917.05	11100000.0	11597872.4
Rice	Area harvested (ha)	4195100	4320100	4580000.0	4509800.0
	Yield (hg/ha)	19479	19310	1856.3	1974.0
	Production (ton)	8171800	8342000	8502000.0	8902200.0
Sorghum	Area harvested (ha)	5600000	5700000	5700000.0	5700000.0
	Yield (hg/ha)	11768	11798	1194.1	1123.2
	Production (ton)	6590000	6725000	6806370.0	6402000.0
Soya beans	Area harvested (ha)	972053	1057861	1150000.0	1200000.0
	Yield (hg/ha)	9259	9264	1147.8	1125.0
	Production (ton)	900000	980000	1320000.0	1350000.0
Sugar cane	Area harvested (ha)	85016	85214	86631.0	86707.0
	Yield (hg/ha)	178341	175796	17973.7	17798.9
	Production (ton)	1516175.49	1498023.25	1557084.3	1543289.4

2.2 Human and Animal Wastes

Several types of waste are generated from animal processing and human activities. Nigeria, being highly populated, produces a large volume of human waste daily, primarily in urban areas. Animal fat waste has been identified as a valuable fuel source because it produces low nitrogen oxides, which are major contributors to air pollution; it also has a high cetane number and good oxidative stability (Marques et al., 2016). Table 2 shows some of the animal products produced in Nigeria between 2020 and 2023.

Table 2. Some animal products produced in Nigeria 2020-2023 (FAO, 2024)

Animal	Parameter	Year			
		2020	2021	2022	2023
Cattle fat*	Production (tonnes)	9303.7	9224.0	9178.8	9074.1

Cattle**	Production (tonnes)	49176.6	48755.6	48516.4	47963.1
Goat**	Production (tonnes)	43814.9	43878.5	43911.4	43568.0
Pigs**	Production (tonnes)	14935.4	15657.7	16133.8	16216.6
Sheep**	Production (tonnes)	28045.9	28021.1	28123.8	28162.2
Sheep fat*	Production (tonnes)	4314.8	4310.0	4326.7	4332.7
Fat of pigs	Production (tonnes)	18669.2	19572.1	20167.2	20270.7
Game meat***	Production (tonnes)	177870.1	177123.9	175252.3	177149.3
Goat fat*	Production (tonnes)	6572.2	6581.8	6586.7	6535.2
Meat of cattle with the bone, fresh or chilled	Production (tonnes)	325628.5	322841.2	321257.5	317593.7
Hen eggs in shell, fresh	Production (tonnes)	706015.6	640000.0	662005.2	669340.3
Hen eggs in shell, fresh	Production (1000 No)	17650391.0	16000000.0	16550130.0	16733507.0
Meat of chickens, fresh or chilled	Production (tonnes)	318546.4	342332.9	355582.9	324136.0
Meat of goat, fresh or chilled	Production (tonnes)	273843.2	274240.7	274446.0	272300.1
Meat of pig with bone, fresh or chilled	Production (tonnes)	336046.1	352298.2	363009.9	364872.5
Meat of sheep, fresh or chilled	Production (tonnes)	154098.2	153962.1	154526.4	154737.4

* unrendered; ** edible offal of cattle, fresh, chilled or frozen; ***fresh, chilled or frozen

2.3 Forest Products and Residues

The use of forest products as a lignocellulosic biomass source for biofuels appears very promising. Nigeria is actively involved in the production and trade of forest products, as shown in Table 3 for 2023. Operations within the forestry sector, such as logging, cutting of forest tops and branches, sawing, and wood demolition, generate substantial quantities of residues.

Table 3: Forestry production and trade in Nigeria for 2023 (FAO, 2024)

Item	Unit	Value
Wood fuel, non-coniferous	m^3	67986750.0
Sawlogs and veneer logs, non-coniferous	m^3	7600000.0
Pulpwood, round and split, non-coniferous (production)	m^3	22000.0
Other industrial roundwood, non-coniferous (production)	m^3	2400000.0
Wood charcoal	tonnes	4988442.0
Sawnwood, coniferous	m^3	2000.0

Sawnwood, non-coniferous	m^3	2000000.0
Plywood and LVL	m^3	56000.0
Particle board	m^3	40000.0
Mechanical and semi-chemical wood pulp	tonnes	9000.0
Chemical wood pulp	tonnes	14000.0
Chemical wood pulp, sulphate, unbleached	tonnes	14000.0
Recovered paper	tonnes	20000.0
Wood fuel, non-coniferous	m^3	67986750.0
Sawlogs and veneer logs, non-coniferous	m^3	7600000.0

2.5 Municipal Solid Wastes [MSWs]

Municipal solid waste (MSW) in Nigeria consists primarily of household (domestic) waste, complemented by commercial waste generated within the municipality. These wastes occur in solid or semi-solid form and generally exclude industrial hazardous materials (Usman, 2012). MSW represents a significant feedstock for waste-to-energy conversion technologies, offering substantial potential for biofuel production and sustainable energy generation. As presented by Maiha & Yusuf (2025) in Table 4, Lagos generated the highest amount of 13,000 t/day of MSW, and the least quantity of 1,949 t/day was obtained from Taraba in 2023.

Table 4: MSW generated in most cities in Nigeria as at 2023 (Maiha & Yusuf, 2025)

S/N	States	Population	Per capita waste (kg/day)	Daily waste (tonnes)	Annual waste (tonnes)
1.	Kano	16,253,549	0.60	9,752.13	3,559,527.23
2.	Lagos	15,772,884	0.65	13,000.00	4,745,000.00
3.	Kastina	9,300,382	0.51	4,743.19	1,731,266.11
4.	Kaduna	8,324,285	0.58	4,828.09	1,762,251.13
5.	Bauchi	7,540,663	0.44	3,317.89	1,211,030.48
6.	Oyo	7,512,855	0.57	4,282.33	1,563,049.48
7.	Anambra	5,299,910	0.51	2,702.95	986,578.25
8.	Rivers	7,234,973	0.62	4,485.68	1,637,274.39
9.	Jigawa	6,979,080	0.44	3,070.80	1,120,840.25
10.	Niger	6,720,617	0.44	2,957.07	1,097,331.09
11.	Benue	6,687,706	0.5	3,343.85	1,220,506.35.
12.	Borno	6,651,590	0.43	2,860.18	1,043,967.05
13.	Ogun	6,445,275	0.54	3,480.45	1,270,430.85
14.	Sokoto	6,163,187	0.44	2,711.80	989,807.42
15.	Delta	6,107,543	0.55	3,358.15	1,225,424.75
16.	Imo	6,067,722	0.54	3,276.47	1,195,891.55
17.	Kebbi	6,001,610	0.43	2,580.69	941,938.85
18.	Ondo	5, 469,707	0.53	2,899.94	1,058,478.10
19	Akwa Ibom	5,780,581	0.53	3,063.91	1,118,333.77
20.	Zamfara	5,517,793	0.43	2,372.65	865,997.49
21.	Plateau	5,400,974	0.52	2,808.51	1,024,107.52
22.	Enugu	5,396,098	0.55	2,967.85	1,083,262.76
23.	Adamawa	5, 236,948	0.51	2,670.84	974,857.87

24.	Edo	5,161,137	0.53	2,734.40	998,056.10
25.	Kogi	5,053,734	0.50	2,526.87	922,304.85
26.	Abia	4,841,943	0.50	2,420.97	883,654.60
27.	FCT	4,802,443	0.63	3,025.54	1,104,321.77
28.	Gombe	4,623,462	0.44	2,034.32	742,528.00
29.	Yobe	4,350,401	0.45	1,957.68	714,553.63
30.	Taraba	4,331,885	0.45	1,949.35	711,512.11

Previous studies on Nigerian biofuel development have demonstrated that much emphasis has been placed on a few crops (maize, sorghum, and cassava) as major feedstocks for biofuel production. These crops are foods to human, so the food-fuel competition keeps increasing. This review explored the potential of using other feedstocks that do not compete with crops used for human consumption. Nigeria has these biomass streams, including forest products and residues, a source of lignocellulosic feedstock, a new driver for biofuel production, and a feasible, economically viable biomass due to its availability and its non-competition with food crops. Also sustainable biomass stream is Municipal Solid Waste (MSW). When utilised as a feedstock, it helps to control

3. Biomass Processing Technologies

There are many process routes, which are determined by the type of biofuel desired and the biomass used. The processing technologies include thermochemical, biochemical and chemical routes. The biochemical process involves enzymatic or acid hydrolysis of cellulosic biomass to produce ethanol (bioethanol). The chemical processing pathway can be esterification or transesterification, a suitable route for producing biodiesel from oil. Transesterification involves the exchange of the organic group of an existing ester (fatty acid- triglyceride) with that of an alcohol to produce an ester (biodiesel) and glycerol (Simonyan and Fasina, 2013). The thermochemical pathway involves pyrolysis or gasification of biomass to generate syngas, which can then be processed via the Fischer-Tropsch (FT) method to produce various liquid biofuels, such as FT diesel, methanol, methane, and hydrogen fuel. All discussed routes are simplified in Figure 2. While thermochemical, biochemical, and chemical conversion pathways offer a feasible route to biofuel production, their implementation within Nigeria's energy infrastructure varies significantly depending on scalability, capital requirements, feedstock availability, and environmental considerations. The comparative assessment of biomass conversion pathways in Nigeria is presented in Table 5.

Table 5: Comparative Assessment of Biomass Conversion pathways in Nigeria

Pathway	Scalability	Capital needed	Feedstock availability
Biochemical (Bioethanol)	High enzyme costs, pretreatment complexity, and limited local biorefinery infrastructure may constrain large-scale deployment.	The process is relatively cheap, as it requires low energy.	This process is well-suited to Nigeria due to the availability of agricultural residues such as cassava peels, sugar cane, maize and other lignocellulosic wastes
Chemical (Biodiesel)	It is easily scalable, as infrastructures that favours it commercial production are available	The capital investment required for small- to medium-scale biodiesel plants is comparatively low.	Oil-bearing feedstocks such as palm oil, soybean and waste coking oil. These are readily available. Feedstocks in competition with food resources
Thermochemical	Highly scalable as it utilises a wide range of biomass types.	It is capital-intensive and requires advanced	Municipal wastes and agricultural waste. its ready available

		operational expertise and stable infrastructure	

Biochemical and chemical conversion pathways appear more feasible for Nigeria's current technological and economic landscape, particularly at small- to medium-scale levels. The thermochemical pathway, though promising for biofuel production, requires significant infrastructure investment.

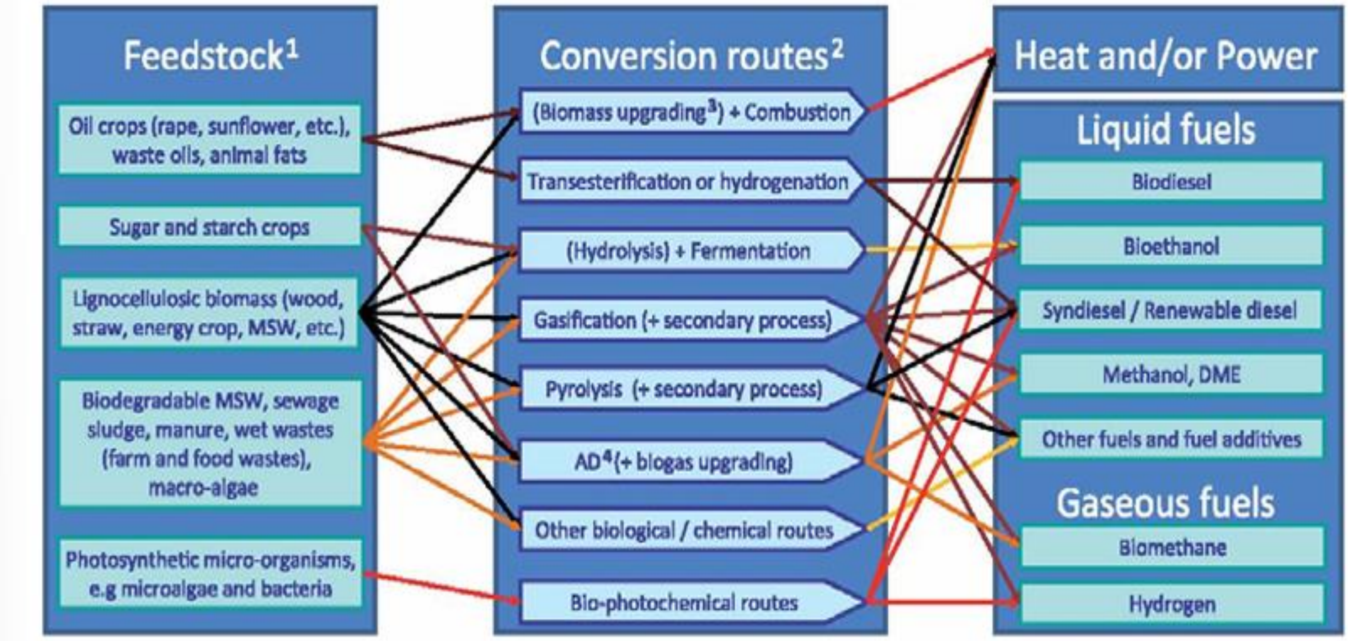

Figure 2: Synthetic view of the wide variety of bioenergy routes (Matthew and Ralph, 2018)

Notes: [1]Parts of each feedstock, e.g., crop residues, could also be used in other routes.
[2]Each route also gives co-products.
[3]Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.).
[4]AD – anaerobic digestion.

4. Global Trends and Policy Benchmarks

Biofuels production, driven by the potential to contribute to energy security, climate change mitigation and rural development, has gained increasing attention. Biofuel has experienced rapid growth in many countries in recent years due to the formulation and implementation of policies, such as blending mandates. Currently, most countries' primary source of economic growth is fossil fuels, which negatively affect the environment. Developing the potential of biomass for energy is a promising way to reduce human influence on the environment. The transport sector is a major emitter of greenhouse gases, and greening this industry is becoming increasingly important worldwide. Given current technological developments in transport, liquid biofuels are seen as the most promising way to accelerate decarbonisation. The economic feasibility of liquid biofuel production directly depends on the choice of raw materials. Crop choice is influenced by limited land and climate (Morone et al., 2016).

4.1 Current Production and the medium-to-long-term outlook

Recently, the liquid biofuel sector has shown a high growth rate. Currently, many countries declare strategic goals for developing the biofuel sector. However, despite increased energy efficiency, a rise in the number of electric vehicles, and a steady increase in biofuel consumption, transport remains the industry with the lowest share of renewable energy sources (IEA 2024). As shown in Figure 3 described by REN21 (2025), liquid biofuels provide only about 3.6 % of the world's fuel needs in the transport sector, with 31 % of the Total Final

Energy Consumption (TFEC). The transport sector is one of the major emitters of greenhouse gases, behind the heat sector, with 46 % (TFEC), of which renewable heat accounts for 10.6 % of the world's heat. The world is far from achieving its goal of decarbonising heat and transport, which still rely heavily on fossil fuels (IEA, 2025).

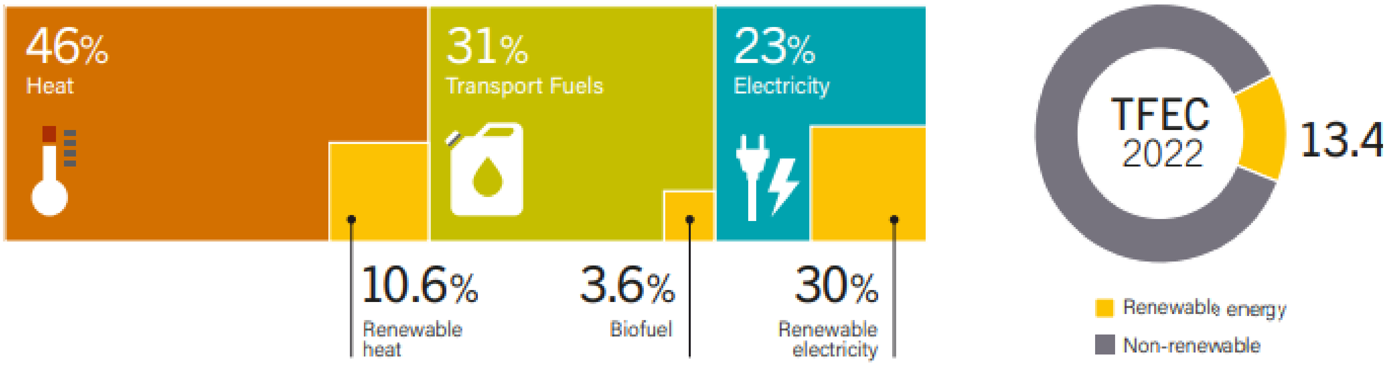

Figure 3: The share of renewable energy in the total final energy consumption 2022 (REN21, 2025).

The production and the use of biofuels such as bioethanol and biodiesel are more dominantly spread in the liquid biofuels market, with bioethanol accounting for approximately 65 % of the world's production, and almost 35 % - biodiesel (REN 21, 2020). The world market for liquid biofuels has an annual growth rate of 3 % (54 thousand barrels of oil equivalent per day), while over the last decade it was twice as high (Global status report, REN 21, 2020).

According to the (REN21, 2025) report, the production of biofuel rose to 7 % in 2023, reaching a new mark of 175.2 billion litres, led by Brazil, India, Indonesia and the United States, with bioethanol accounting for approximately 57 %, Biodiesel 28 % and renewable diesel 14 % of the production, as shown in Figure 4.

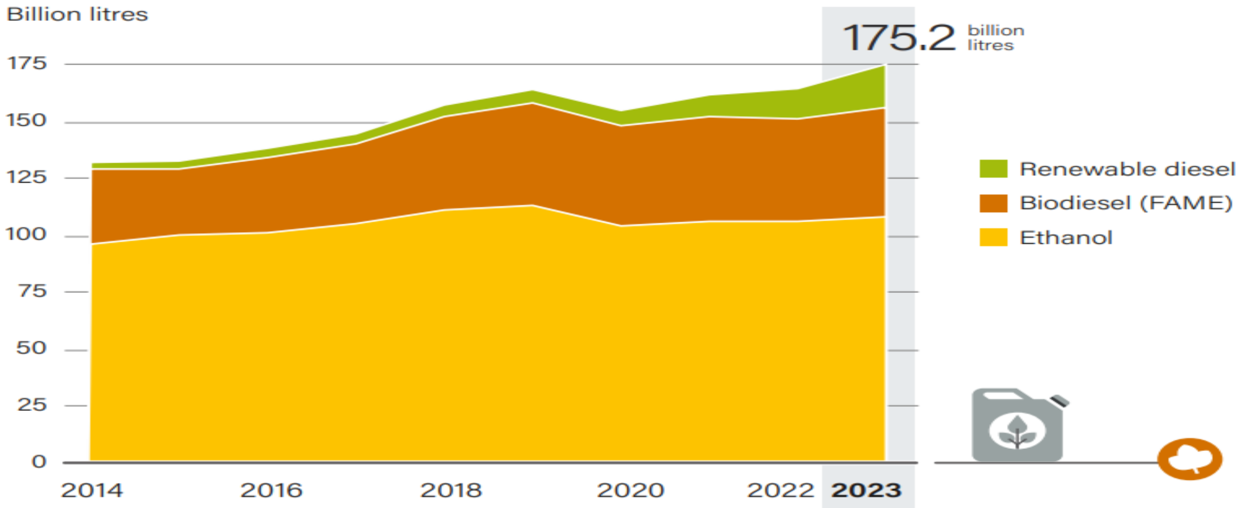

Figure 4. Biofuels production (2014-2023) (Global status report, REN 21, 2025).

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4.2 Energy policies to promote the development of liquid biofuels

Recently, developed countries, recognising the importance of energy security and environmental sustainability, have implemented effective strategies and policies to develop industries at the national level to positively affect the liquid biofuel sector, as shown in Figure 6. Besides, policies to promote renewable energy in the transport sector continue to focus mainly on road transport, which accounts for the vast majority of energy use, while ignoring aviation and shipping. Policies enacted for biofuels production include: blending mandates, public procurement, financial incentives, and infrastructure support for refuelling and blending. According to the Global Status Report by REN 21 (2020) described in Figure 5, the mandates for blending biofuels are the most widely accepted type of policy to increase renewable fuels in the transport sector, by most countries. Nigeria's biofuel is still in its infancy, with little to no implementation of the 2007 biofuel policy. As shown, the EU's blending mandate has been yielding the expected results, and, as seen as the most adaptable, Nigeria adopting and implementing this policy will help boost biofuel production.

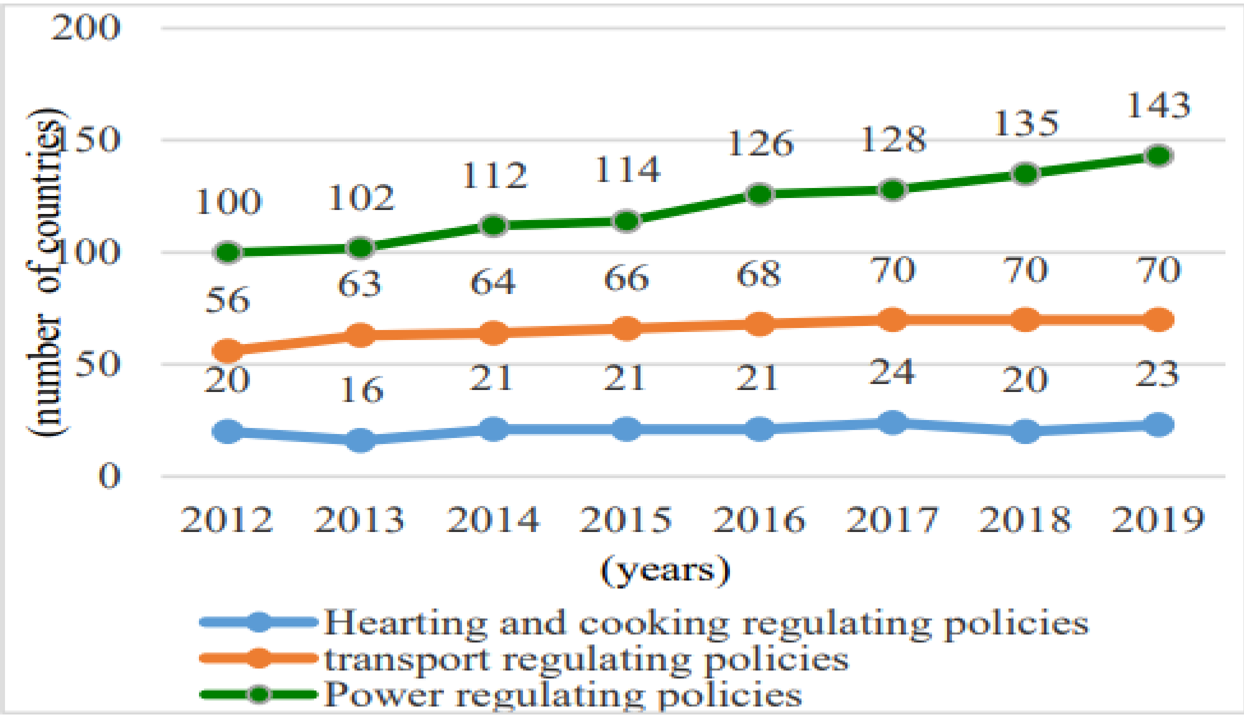

Figure 5: Number of countries implementing Renewable Energy Policies (2012–2019) (Global status report, REN 21)

Table 6 shows the frontiers of global liquid biofuel production. The assessment of the structure of national policies on mandate for blending has clearly reflected the industry trend and the prospects for further change. The USA leads in the production of ethanol with a production capacity of 16,219 million gallons (US Energy Information Administration, 2024) as at 2024, owing to the credit facilities program designed to support new innovative bioenergy infrastructure. At the federal level, several programs have been created to encourage and facilitate increased biofuel production.

Table 6: Annual world Fuel Ethanol Production in (Million Gallon) (RFA analysis of public and Private data sources, 2024)

Region	2020	2021	2022	2023	2024	% of World Production
United States	13,941	15,016	15,361	15,580	16,219	52
Brazil	8,100	7,320	7,400	8,470	8,780	28
India	530	950	1,200	1,510	1,630	5
European Union	1,310	1,380	1,420	1,390	1,400	5
China	940	900	960	1,070	1,200	4
Canada	429	434	446	454	464	1
Thailand	390	350	380	340	360	1
Argentina	210	270	310	310	310	1
Rest of World	630	690	722	806	807	3
Total	**26,480**	**27,310**	**28,220**	**29,930**	**31,210**	

These favourable conditions have earned the USA the top spot, accounting for 52 % of the world's ethanol production (RAF, 2024). The Brazilian government implemented the tax benefits for producers and users of liquid biofuels. With an impressive duty-free quota of 600 million litres per year for the importation of ethanol. Providing subsidies for producers of raw materials used in the process of biofuel production. Brazil provides 28 % of the world's production of ethanol (RAF, 2024).

5. Nigeria's Energy Situation and Biofuel Status

With most of Nigeria's population residing in rural areas, where biomass such as wood fuel is a major source of energy for cooking and heating, as described in Table 7. The country's current energy capacity cannot meet the growing energy needs of a population of over 200 million, which is increasing at a rate of 2.53 % (Edeh & Okpo, 2023). The total energy supplied, including both non-renewable and renewable energy, in 2014 was 6127948 TJ and that in 2019 was 6591012 TJ (IRENA, 2022).

Table 7: Energy consumption by different sectors in Nigeria

Sector	Oil products Mtoe (EJ)	%	Coal Mtoe(EJ)	%	Natural gas Mtoe(EJ)	%	Biofuels/Waste Mtoe(EJ)	%	Electricity Mtoe(EJ)	%
Industry	0.40(0.02)	5.26	0.00(0.00)	0.00	2.60(0.11)	34.21	4.20(0.18)	55.60	0.400(0.02)	5.26
Transport	8.40(0.35)	100	0.00(0.00)	0.00	0.00(0.00)	0.00	0.00(0.00)	0.00	0.00(0.00)	0.00
Household/ others	2.70(0.11)	2.62	0.00(0.00)	0.00	0.00(0.00)	0.00	98.70(4.14)	95.64	1.80(0.08)	1.74
Non-energy use	0.00(0.00)	0.00	0.00(0.00)	0.00	1.40(0.06)	100.00	0.00(0.00)	0.00	0.00(0.00)	0.00

Despite being endowed with vast fossil fuel (crude oil and natural gas) and renewable energy resources, especially hydroelectric and solar, and a vibrant private sector, giving Nigeria a unique opportunity to redefine energy access for millions, as of 2022, 61% of Nigeria's population had access to electricity, leaving more than 90 million people without access (African Progress Report, 2015). Even Nigerians connected to the grid face frequent outages and do not receive adequate or reliable power supply, despite several electricity infrastructure spanning the nation, as shown in Figure 6. The situation is worse for cooking. Over 160 million people lacked access to clean cooking fuels and technologies in 2022 (African Progress Report, 2015), creating a deficit in energy supply to the industrial and transport sectors.

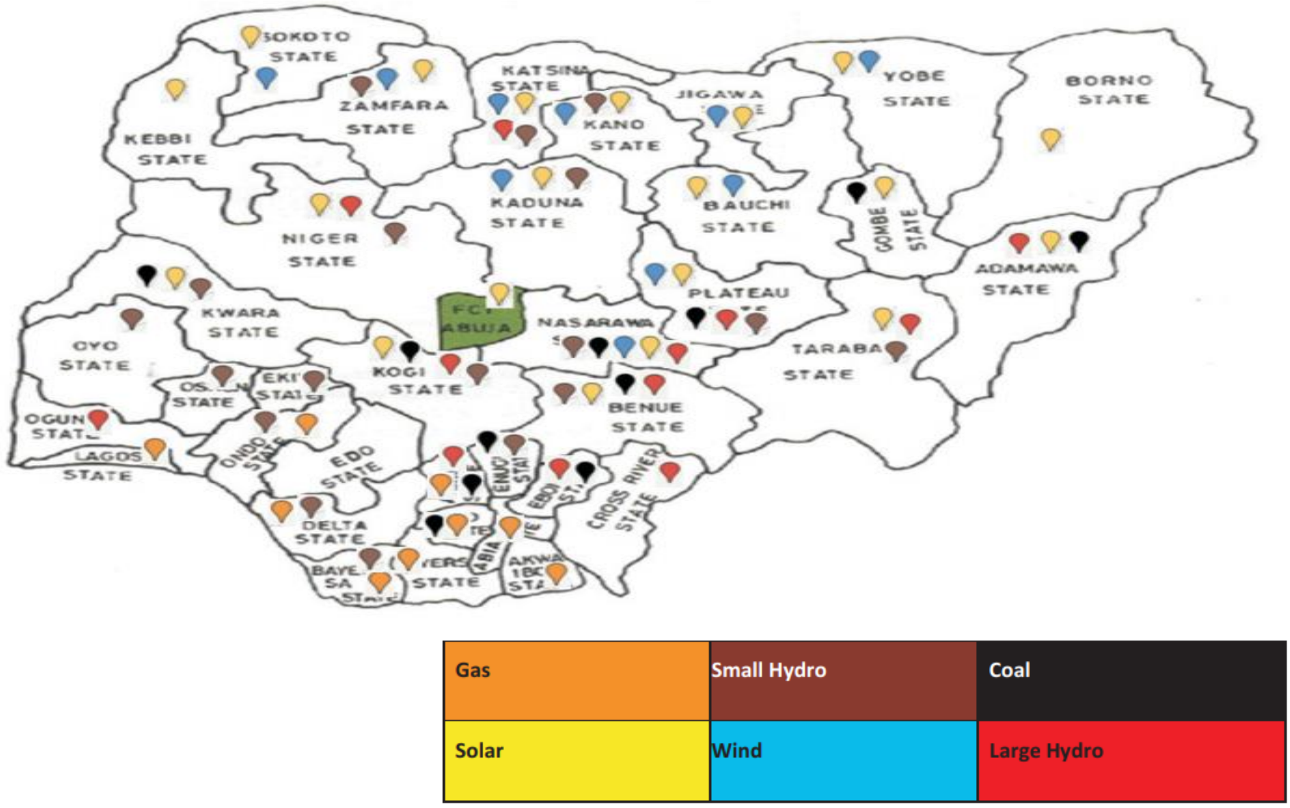

Figure 6: Nigeria energy resources distribution map (Federal Ministry of Power, Works & Housing, 2016)

The country is still heavily dependent on fossil fuel energy production, as shown in Figure 7. Crude oil accounted for 47.9% of domestic energy production in Nigeria in 2022, as reported by the International Energy Agency (IEA, 2023), while biofuels and waste generated 1,352,837.0 TJ of energy, approximately 25.3% of the energy mix in 2022.

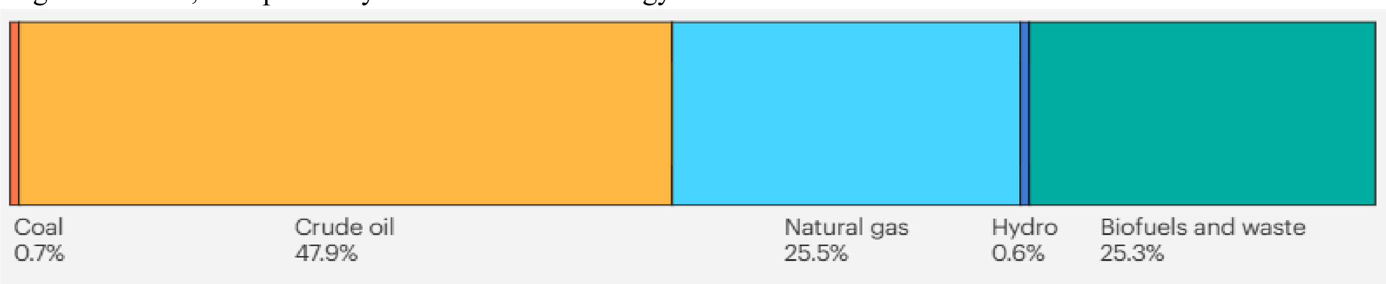

Figure 7: Domestic energy production, Nigeria, 2022 (IEA, 2023)

5.1 Energy Supply

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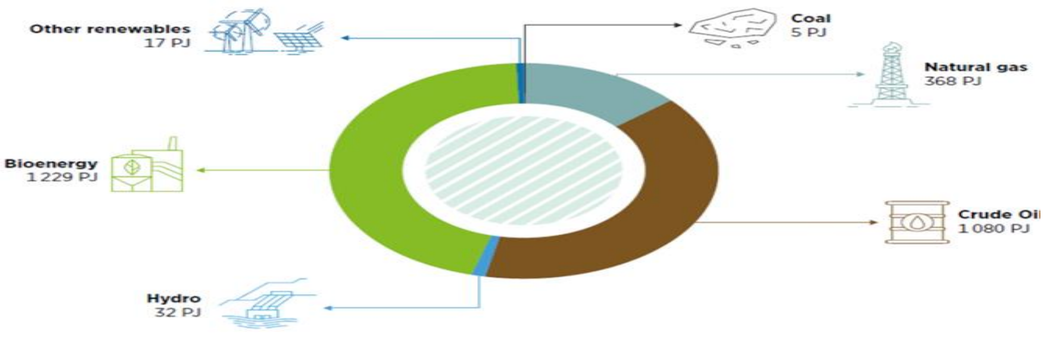
Nigeria is greatly rich in agricultural resources, such as wood, energy crops and agricultural residues, which significantly account for the nation's primary energy supply, with renewable accounting for about 47 % of the total energy supply in 2022. Biomass is the dominant source, accounting for 43 % of the total energy supply mix, as shown in Figure 8(b). This is primarily due to the direct combustion of biomass (firewood) for cooking and heating. Transiting from traditional biomass consumption to other technologies would greatly enhance air quality. Nigeria depends heavily on imported petroleum products, which account for 80 % of the total energy supply (Statista, 2023). Nigeria would benefit significantly from shifting to renewable energy rather than relying on imported fossil fuels.

(a)



(b)

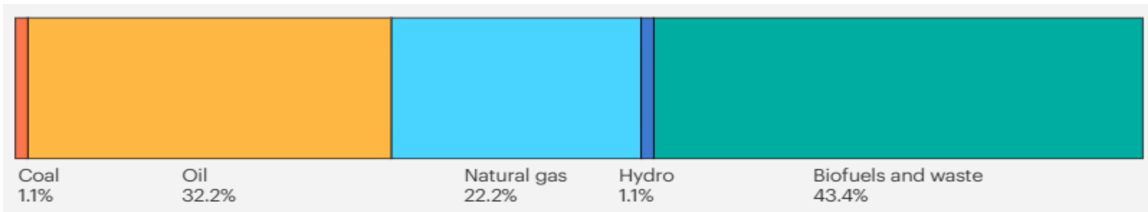


Figure 8: (a) primary energy sources in 2022 (IRENA, 2023) in PJ, (b) shows the percentage of total energy supply, Nigeria, 2022 (IEA, 2023)

5.2 Energy demand sectors in Nigeria

As shown in Figure 9, there are 4 major energy-demanding sectors: the residential sector is the largest in final energy consumption in Nigeria in 2022, accounting for 42 % of total final energy consumption; the transport sector accounts for 35 %; the Commercial sector consumes 6 %; and the industry consumes 14 %.

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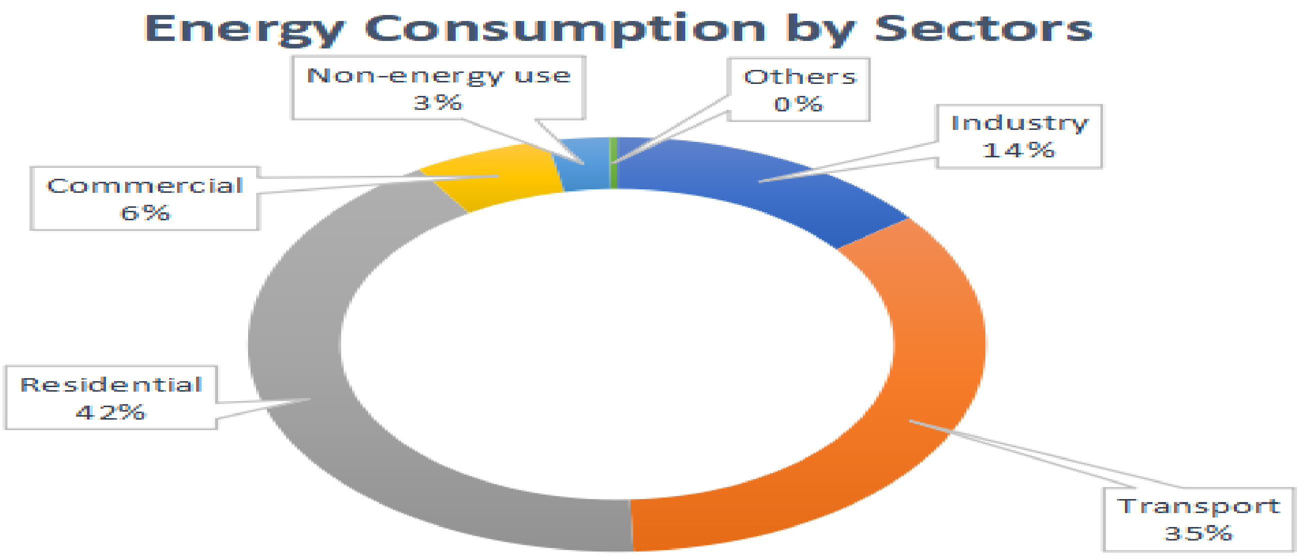

Figure 9: Total final energy consumption by sectors in Nigeria, 2022 (IEA, 2023).

5.2.1 Residential sector

In Nigeria, heating and cooling account for the largest share of residential energy consumption. Although appliances, lights, and air conditioners mainly use electricity, households still rely heavily on combustible fuels such as natural gas, oil, and coal. The effective use of waste generated in this sector can green it, helping mitigate the energy deficit.

5.2.2 Transport sector

In most developed countries, integrating blending mandates and other incentives into the transportation industry has notably increased the utilisation of biofuels. The transportation sector is predominantly fueled by oil. The widespread adoption of biofuels in this vital sector, whose energy demand continues to rise, would constitute a highly strategic measure to mitigate CO_2 emissions.

5.2.3 Industry sector

The industry's demand for energy primarily drives the manufacturing of finished or semi-finished products. This sector accounts for 14 % of the total energy consumption. Nigeria can rely on biofuels to further drive its industrialisation.

6. Biofuel Development in Nigeria

In recent years, Nigeria has lost its position as Africa's largest crude oil producer, now ranking fourth behind Angola, Algeria, and Libya (Edeh & Okpo, 2023). Nigeria currently cannot provide the energy needed for its growing population. Biofuels are recognised as liquid fuels derived from enhanced biomass resources and serve as substitutes for fossil-fuel-based transportation fuels such as diesel and aviation fuels. Nigeria, just like other developing countries, is now investing in biofuels.
As contained in the official gazette copy of the Nigerian Biofuel Policy of 2007, biofuel was defined as ethanol, biodiesel and other fuels derived from biomass. Under the Biofuel Policy and Incentives, the recognised feedstocks for biofuel production in Nigeria include: cassava, sugarcane, oil palm, jatropha, cellulose-based materials, and any other crop approved by the commission. Nigeria's definition of biofuel, which includes food crops as one of the major feedstocks, is one of the policy's loose ends, as there are no measures to address the use of food crops as biofuel feedstock, which can cause serious food security issues in the country.

6.1 Present Status of Biofuel

The nation's biofuel development does not progress in a linear manner, unlike global trends. Currently, Nigeria's bioenergy consumption remains primarily reliant on traditional biomass sources, such as wood, charcoal, and waste, for household cooking. Concurrently, modern biofuels constitute a minor fraction of transport fuel sources (IEA, 2023). Additionally, over 60 % of Nigeria's population depends on fuelwood for cooking and other domestic applications (Energy Commission of Nigeria, 2022).

The outlook for biofuels in Nigeria is hopeful but depends heavily on effective policies, investments, and sustainability efforts. The 2025 National Update reports major investments, including a $300 million biofuel refinery in Ogun State, which aims to boost biofuels' contribution to renewable energy and support the agricultural sector. Additionally, new initiatives like cassava-based ethanol plants in Ekiti State are emerging to enhance domestic bio-energy production (VON News, 2025).

6.2 The Current Available Biofuel Resources in Nigeria include:

6.2.1 Biodiesel

Biodiesel is a fuel derived from vegetable oils, animal fats or waste oils through chemical, biochemical or physical processes. Nigeria possesses abundant biodiesel feedstocks. The current production capacity remains insignificant relative to the available resources. Presently, most biodiesel plants' capacity is insufficient to replace fossil-based fuels. Fortafric Biodiesel, located in Ilorin, Kwara, is one of Nigeria's leading biodiesel producers, manufacturing 400 litres per day (LPD) from jatropha seeds sourced from farmers in Kogi and multiple northern states. The North Central region is more feasible for siting a biodiesel biorefinery due to its proximity to feedstocks and existing infrastructure. Table 8 summarises biodiesel plants and investment into the sector.

6.2.2 Ethanol

Ethanol is an alcohol produced by fermenting crops such as sorghum and cassava. Bioethanol is gaining global attention as it is used in the blending of Premium Motor Spirit (PMS) to E10 and E20 (Kwiatkowski et al., 2006). The acceptance and commercial production of biofuel in Nigeria are at an early stage, and the rate of development appears slow in some areas of the country where it is produced (Edeh & Okpo, 2023). Bioethanol companies are producing, with cassava as the major feedstock for most of them, owing to its abundance. Nigeria is the biggest producer of cassava, recording 60.8M tonnes in 2022 (World Population Review, 2025). The south-west region is a major cassava-producing region in Nigeria, and its infrastructure makes bioethanol production more feasible. Table 9 shows selected bioethanol plants in Nigeria.

Table 8: Some biodiesel plants and proposed plants in Nigeria

Company/ Plant	Location	Capacity/Note	Year Installed	Operational Status	Source
Avandith Energy/ Avandith Renewable Energy Ltd (B-60 pilot)	Lagos	Pilot scale (~4 batches/day)	2014	Unavailable	Florida Biodiesel / Biodiesel Magazine
FortAfric/ Fortafric	Ilorin, Kwara State	400 L/day (pilot), 20,000 L/day planned	2018	Operating (pilot scale)	FortAfric
Cresnior Energy International (IncBio contract)	Nigeria (Project)	80,000 tonnes/year	2023 (contract announced)	Under development	IncBio project
Oguta Lake/ Amishi Ventures (collaboration)	Imo State	Not stated ($50M project)	2024 (announcement)	Under development	BioEnergy Times

Green Energy BioFuels (Bio-refinery project)	Lagos (bio-refinery project)	22 million L/year (ethanol), biodiesel component planned	2021 (AFDB financing)	Project stage	AFDB SEFA project summary

Table 9: Selected bioethanol plants in Nigeria

Name / Project	Location	Year installed	Feedstock(s)	Capacity / Notes	Status
Pure Biotech Co. Ltd	Benue State	2020	Cassava	76million litres ethanol/year	Operating / Growing
Allied Atlantic Distilleries Ltd	Igbesa, Ogun State	1999	Cassava	10.9 million litres/year	Operating
Asanita Agricultural Processing Company Ltd	Edo State	2018	Cassava	50,000 litres/day	In operation / developing
Global Biofuels Ltd	Ondo / Ekiti States	2007	Sweet sorghum, safflower, soybeans, etc.	Proposed complex; 200,000 litres/day capacities envisioned.	Under development/planned
Micro Distillery - Green Social / Project Gaia	Ogbomosho, Oyo State	2005	Cassava and cashew waste	1,000 litres/day (pilot scale) for cooking fuel.	Pilot/small scale
Cassava-Based Ethanol Plant (Ekiti State MoU)	Ekiti State	2024	Cassava	50,000 litres ethanol/day.	Flagged off / planned
NNPC + Kogi State Progressive Project	Kogi State	2025	Sugarcane / others	Planned 84 million litre bioethanol plant + 64 MW power cogeneration.	MoU stage

6.2.3 Biogas

Biogas is a biofuel primarily composed of methane and carbon dioxide. It is generated through the biological decomposition of organic matter via anaerobic digestion. In recent years, several pilot biogas plants have been established, mainly by the private sector, which produce biogas from sources such as cow dung, poultry waste, wastewater, and sewage. Notably, the biogas plant at Ikorodu Mini Abattoir in Lagos State, established in 2019, which employs four 5,000 L digester tanks fed with digestible organic waste and concentrated wastewater from the abattoir (Guardian Newspaper, 2019). As shown in Table 9, most biogas plants in Nigeria are pilot plants, insufficient to meet the country's energy requirements and to compete effectively with fossil-derived cooking fuels. The government has not committed to developing biogas.

Table 9: Some of the Biogas Plants in Nigeria

Name / Project	Location	Reported Capacity / Size	Year Installed / Announced	Operational Status (public)	Source / Reference
University of Africa Toru-Orua (UAT)	Bayelsa State	Not specified	2025	Research/ demonstration stage	Premium Times
University of Ibadan Dairy Farm pilot digester	Ibadan, Oyo State	4 m³ pilot Digester	2021–2025 (research project)	Pilot / operational in research use	Aralu et al., 2021
Usmanu Danfodiyo University (Sokoto Energy Research Centre)	Sokoto State	10–20 m³ digesters	2000s–2010s (research installations)	Non-Operational pilot plants	BioResources
Ikorodu Mini Abattoir Biogas Plant	Ikorodu, Lagos State	Four (4) × 5,000L digesters	2019	Operational	Guardian News, 2019
Ajima Farms 20 kW Biogas Mini-Grid	Rije, Abuja	20 kW system	2016–2021	Failed / not sustained	Prime Progress

6.1 Biomass Sources for Biofuels in Nigeria

Before the era of crude oil exploration and exploitation, agriculture was the largest contributor to the nation's GDP and a major source of foreign exchange, accounting for 50 % of GDP and 75 % of export earnings (Galadima et al., 2011). Nigeria is one of the top producers of energy crops (CBN, 2007). Nigeria's abundance of arable land and water resources enables the production of energy crops in large quantities, which can serve as feedstock for biofuel production. Table 10 summarises the production capacity of these crops and the biofuel that can be derived from them.

Table 10: Usage of Plants for Biofuels Feedstock (National Productivity, 2024)

Agricultural Resource	Production capacity (thousand metric tons)	Derivable biofuel type
Cassava	64,361,224.58	Bioethanol
Yam	54,577,973.19	Bioethanol
Millet	1,546,293.37	Bioethanol
Maize	11,216,837.37	Bioethanol
Sorghum	6,416,975.27	Bioethanol
Rice	9,129,907.68	Bioethanol
Cowpea	4,093,945.27	Biodiesel
Groundnut	5,084,548.59	Biodiesel
Soyabean	947,952.08	Biodiesel
Cocoyam	3,213,281.95	Bioethanol
Cotton	304,177.80	Biodiesel
Plantain	3,366,735.66	Biodiesel

6.3 Biofuel Policies in Nigeria

Biofuel production serves as a significant catalyst for socio-economic advancement, particularly in rural communities (Domac et al., 2005). However, this potential remains largely untapped by the Nigerian government. Fundamentally, the Nigerian biofuel policy, gazetted as Nigerian Biofuel Policy and Incentive dated June 20, 2007, aimed to reduce the country's reliance on imported fuels, mitigate environmental degradation, and generate long-term employment opportunities (Oniemola & Sanusi, 2007).

The NNPC is responsible for connecting energy crops to the petroleum downstream to enhance the nation's energy security. To facilitate the implementation of the Nigerian Biofuel Policy, the Federal government established the Biofuels Energy Commission (BEC). The program was designed to integrate biofuels directly into the national fuel mix, specifically through blends such as E10 and B20, while also initiating the development of biofuel feedstock plantations and the construction of biofuel processing plants. The primary goal was to achieve full domestic production of all biofuels consumed in the country by the year 2020 (Anyaoku, 2007). Unfortunately, as at 2026, appreciable progress seemingly has not be made. The policy has faced many bottlenecks. According to (Oshewolo, 2012), the policy has been widely criticised, stemming from the fact that the project was prepared by the Nigerian National Petroleum Corporation (NNPC) without public participation. The government has always embarked on reforms without the political will to push them through in different circumstances, and without engaging the reform instruments necessary to achieve the desired outcome. Nigerian Biofuel Policy will not survive the current global definition of biofuels, as most of the feedstocks stated are in direct competition with food; as such, the policy may have been designed to fail (Oshewolo, 2012). Recently, to enforce the 2007 Biofuel policy, according to an article published by The Nation Newspaper (April 17, 2024), the Federal Government declared its intention to reinstate the 2007 Biofuel Policy and Incentives as a strategic and progressive measure to address the nation's energy crisis.

7. Challenges Facing Biofuel Production in Nigeria

For biofuel production to truly thrive, many factors have to be put in place, ranging from economic to technological, political, and ecological. The presence of advanced technology, government-enacted laws and policies, and infrastructure is needed to fully utilise the available bioresources (Licht, 2005). These prevailing challenges are discussed below.

7.1 Competition for Viable Lands

Nigeria has arable lands suitable for the cultivation of biofuel feedstock. If biofuel is to be produced at a commercial level, large quality lands would be targeted for production to achieve high yields, leaving low-nutrient lands for food cultivation, as this may result in food insecurity in the nation. This is a major issue that would pose a challenge to the development of biofuel production in Nigeria and which is not properly captured in the 2007 Biofuel Policy (Mashapa et al., 2019)

7.2 Effect on the Environment

Recently, lignocellulosic biomass has been a promising feedstock for biofuel production, largely sourced from forestry. Despite the government's effort and numerous afforestation programmes going on in Nigeria, the nation is yet to achieve the 25 % forest recovery stipulated by the international standard. Exploiting this resource would contribute to desertification, which is one of the major problems hindering the development of biofuel in Nigeria.

7.3 Food Insecurity

A significant portion of biomass utilised for biofuel production, as contained in the 2007 Biofuel policy, also serves as food for humans. The continuous use of edible biomass for biofuel production could lead to a food shortage, as non-edible feedstocks are not cultivated in sufficient quantities to meet production demands relative to food requirements.

7.4 Uneven Distribution of Biomass Resources

Nigeria possesses abundant biomaterial. These resources are predominantly found in rural communities where agricultural activities are more prevalent, far from urban centres, where the demand is primarily concentrated. This uneven distribution has led to increased production costs for biofuels, particularly in transportation expenses associated with moving raw materials to processing facilities and distributing biofuels to end-users. Consequently, this challenge has deterred both government initiatives and private investment in biofuel development (Mashapa et al., 2018).

7.5 Insufficient Funding

The acquisition of land, cultivation, and production of energy crops for biofuel are capital-intensive for a local rural farmer and, as such, require a loan to produce these energy crops (Ozoegwu et al., 2017). Inaccessibility to financial aid to facilitate the cultivation of energy crops and the establishment of a biorefinery is a major challenge facing the biorefining sector.

8. Strategic Suggestions in Overcoming Obstacles Facing the Biofuel Industry in Nigeria

Feasible analysis contained in the research carried out by (Ozoegwu et al., 2017), concluded that variations in feedstock for biofuel production would have a significant impact on the cost of production. However, if incentives and other relevant policies, such as tax duty waivers, are fully implemented, it will encourage investors to commit their resources to biofuel production. These strategies are outlined below.

8.1 Strengthening Policy Implementation and Financial Support

To make a significant change in biofuel production, priority must be given to the full implementation of the existing 2007 Nigerian Biofuel Policy. The policy is not without bottlenecks that must be addressed before implementation to ensure Nigeria's biofuel reforms align with those of leading global producers. Additionally, government-backed credit facilities and financial aid should be provided to farmers cultivating these energy crops, and proper storage facilities should be established. This is a critical step that should be addressed to ensure a smooth transition into a biofuel-producing country.

8.2 Expanding Research Capacity and Feedstock Development

Sustained research efforts are crucial to prevent stagnation once biofuel production becomes fully operational. Emphasis should be placed on strengthening research and development capacity to improve feedstock yields and processing efficiency. Educational and research institutions should be equipped and funded to conduct research that drives the technological advancement needed to propel the sector. This will increase private sector participation.

8.3 Regular Policy Review

For long-term sustainability, the Nigerian government must subject the policy to periodic review, including research into improving and developing new feedstocks to enhance biofuel productivity. Without long-term institutional support, emerging challenges could undermine earlier progress. Establishing a robust framework would therefore address governance and sustainability concerns identified in this study and support Nigeria's long-term transition to cleaner energy sources.

9. Conclusion

This study assesses Nigeria's biofuel potential by examining biomass availability, conversion pathways, and the challenges of policy implementation. The findings confirm that Nigeria possesses abundant biomass resources capable of supporting domestic biofuel production with associated socio-economic benefits, including rural employment, reduced fuel imports, and agricultural value-chain development.

Despite this potential, biofuel deployment in Nigeria remains limited, primarily due to weak policy implementation and institutional inefficiencies. The Nigerian Biofuel Policy of 2007 has not translated into meaningful large-scale production, indicating that governance and execution, rather than resource availability, are the major constraints.

This review highlights the need for region-specific techno-economic assessments, environmental life-cycle analyses, and performance data from existing pilot projects. To advance the sector, priority actions include enforcing existing biofuel policies, expanding the framework to include second- and third-generation feedstocks, and strengthening research funding and investment mechanisms.

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