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Energy development in Nigeria: Forward to the sustainable development

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Abstract

Access to clean, modern energy is a major challenge in Africa, with 60% to 70% of Nigeria's population lacking electricity. The ongoing power crisis in Nigeria will continue unless the government diversifies energy sources across domestic, commercial, and industrial sectors and adopts new technologies to reduce waste and cut costs. This paper explores energy policy interventions that could significantly enhance Nigeria's sustainable economic, environmental, and social development. Improving energy efficiency can lower energy bills for poor households, while meeting renewable energy targets may incur costs that can be mitigated by selling carbon credits, as per the Clean Development Mechanism. Targeted interventions could reduce local air pollution, tackle greenhouse gas emissions, and advance sustainable energy through the promotion of renewable resources, energy efficiency, and conservation measures across various sectors.

Keywords: Energy, sustainable development, Nigeria

1. Introduction

Access to clean, modern energy services is a significant challenge across the African continent, as energy is crucial for socioeconomic development and the eradication of poverty. In Nigeria, this challenge is particularly pronounced, with an estimated 60% to 70% of the population lacking access to electricity. This energy deficit has far-reaching implications, hindering economic growth, limiting educational opportunities, and affecting overall quality of life. The current energy crisis in Nigeria is unlikely to improve unless there are substantial changes in the country's energy strategy. The Nigerian government needs to diversify its energy sources, expanding beyond traditional fossil fuels to include renewable options such as solar, wind, and hydroelectric power. Additionally, adopting new technologies to enhance energy efficiency and reduce wastage is crucial. These steps would not only help in addressing the electricity shortage but also in reducing costs and ensuring a more sustainable energy future. By investing in a more diverse and efficient energy infrastructure, Nigeria can pave the way for sustainable development, improve the standard of living, and move closer to achieving its economic and social goals. Nigeria stands to gain significantly from targeted interventions aimed at reducing local air pollution and combating greenhouse gas emissions. This article explores the various factors that must be carefully considered and addressed to transition to a sustainable energy future. Key among these are the full exploitation and promotion of renewable energy resources, which could include solar, wind, and hydroelectric power. Implementing energy efficiency practices is equally vital, as it can greatly reduce the energy demand in both residential and commercial sectors. Additionally, the application of energy conservation measures across various sectors is crucial, particularly in the construction of industrial, residential, and office buildings, as well as in transportation. By focusing on these areas, Nigeria can create a more sustainable and resilient energy landscape, improving environmental quality and supporting economic growth. The shift towards renewable energy and greater energy efficiency not only supports environmental goals but also offers economic benefits by reducing energy costs and creating new jobs in the green energy sector. These strategic actions will be essential for Nigeria as it navigates the complexities of developing a sustainable energy future.

This paper explores various energy policy interventions that could significantly contribute to Nigeria's sustainable economic, environmental, and social development. Enhancing energy efficiency can bring substantial social benefits, such as lowering energy costs for low-income households. Economically, achieving Nigeria's renewable energy targets will incur considerable expenses.

However, these costs can be partially mitigated by selling carbon credits under the 'Clean Development Mechanism,' established about a decade ago. This approach not only supports environmental goals but also provides indirect health benefits, creating a comprehensive strategy for sustainable development in Africa's most populous country.

2. Literature review

Energy is crucial for a nation's economic growth, progress, development, poverty eradication, and overall security. Ensuring an uninterrupted energy supply is a critical priority for all countries. Future economic growth depends heavily on the long-term availability of energy that is affordable, accessible, and environmentally sustainable. The interconnectedness of energy with security, climate change, and public health highlights the need for reliable and clean energy sources. As nations strive for development, managing energy resources wisely becomes essential to achieving sustainable economic and social outcomes (Midilli *et al.*, 2006) [4]. Energy is a key element across all sectors of a country's economy, directly impacting its overall development. The standard of living in any nation is closely linked to its per capita energy consumption. The recent global energy crisis stems from two main factors: rapid population growth and rising living standards worldwide. Per capita energy consumption serves as an indicator of both income and a nation's prosperity. As societies advance and demand more energy, managing energy resources effectively becomes crucial for sustainable economic growth and maintaining high living standards (Singh *et al.*, 2016) [5].

Energy is fundamental to meeting basic human needs and plays a critical role in ensuring a decent quality of life. It is essential for cooking food, maintaining a comfortable indoor temperature, providing lighting, and operating various household appliances (Al-Mulali *et al.*, 2016) [1]. Access to energy also enables crucial services such as clean water supply, effective sewage systems, and essential healthcare services, including refrigerated vaccines, emergency, and intensive care. Furthermore, energy facilitates educational tools and communication technologies like radios, televisions, email, and the internet, all of which are integral to modern life. Beyond these basic needs, energy is the backbone of productive economic activities, driving sectors such as agriculture, commerce, manufacturing, industry, and mining. These activities are vital for creating jobs, fostering innovation, and contributing to the overall economic growth of a country (Than *et al.*, 2022) [6]. On the other hand, a lack of access to reliable energy sources can lead to poverty and deprivation, stifling economic development and causing widespread social and economic decline. The relationship between energy access and poverty reduction is deeply intertwined with broader socioeconomic development. Without energy, productivity in various sectors diminishes, leading to reduced income growth and limited opportunities for education and health improvements. Access to affordable and sustainable energy is, therefore, crucial for enabling economic activities that drive development, improve living standards, and support overall well-being. In this way, energy not only empowers individuals and communities by lifting them out of poverty but also acts as a catalyst for sustained economic growth, enhanced education, and better health outcomes, ultimately fostering a more equitable and prosperous society.

Nigeria has faced a severe energy crisis for nearly two decades, significantly impacting its economy and contributing to widespread poverty. This crisis has crippled industrial and commercial activities, exacerbating economic hardship across the country. The Council for Renewable Energy of Nigeria reports that power outages have resulted in an estimated annual loss of 126 billion naira (approximately US\$ 984.38 million) (Ighodaro, 2010) [3]. This substantial financial loss highlights the urgent need for reliable energy solutions to restore economic stability and growth in Nigeria. Without addressing these energy challenges, the country's path to sustainable development remains uncertain. In addition to the significant financial losses, Nigeria's energy crisis has led to severe health risks due to carbon emissions from the widespread use of household and business generators. These generators are often relied upon due to frequent power outages, contribute to air pollution, and pose health hazards. The crisis has also increased unemployment and raised the cost of living, further deteriorating living conditions for many Nigerians (Gbadebo & Okonkwo, 2009) [9]. As a result, the overall quality of life has declined, highlighting the urgent need for sustainable energy solutions to improve both economic and public health outcomes. Addressing these issues is essential for reversing the negative impacts on Nigeria's society and environment.

3. Findings

3.1. The situation of energy in Nigeria

Nigeria is known as Africa's energy giant, being the continent's leading oil producer and, alongside Libya, holding two-thirds of Africa's crude oil reserves. In terms of natural gas, Nigeria ranks second only to Algeria, showcasing its significant role in the continent's energy landscape. The country also possesses most of Africa's bitumen and lignite reserves, further emphasizing its vast energy resources. With such a diverse and abundant mix of conventional energy reserves, Nigeria stands unparalleled by any other African nation.

Energy exports have become the cornerstone of Nigeria's economy, reflecting the country's vast reserves and production capabilities. The prominence of these energy resources has not only driven economic growth but also positioned Nigeria as a key player in global energy markets. Additionally, the abundance of primary energy resources plays a critical role in supplying the nation's industrial raw materials, underscoring the importance of energy in Nigeria's economic structure. Given this substantial endowment, it's clear why energy remains central to the country's economic strategy and development goals. By continuing to harness and develop its energy sector, Nigeria has the potential to sustain its economic growth and further solidify its position as a leading energy powerhouse in Africa.

Nigeria is rich in a variety of energy resources, with substantial reserves of crude oil, natural gas, coal, lignite, and tar sands. It holds the world's sixth-largest crude oil reserve, with an estimated 36.2 billion barrels. The country is also a significant gas province, boasting nearly 5,000 billion cubic meters of proven gas reserves. These oil and gas reserves are primarily located in the Niger Delta, Gulf of Guinea, and Bight of Bonny, with most exploration activities concentrated in deep and ultra-deep offshore regions, and future plans targeting the Chad Basin in the northeast.

Table 1: Nigeria's energy reserves/capacity as in December 2005

Resource type	Reserves	Reserves (BTOE) ^c	Reserves ($\times 10^7$) TJ
Crude oil	36.2 billion barrels	4.896	20.499
Natural gas	166 trillion SCF ^a	4.465	18.694
Coal and lignite	2.7 billion tonnes	1.882	7.879
Tar sands	31 billion barrels of oil equivalent	4.216	17.652
Subtotal Fossil		15.459	64.724
Hydropower, large Scale	11,000 MW		0.0341/year
Hydropower, small Scale	3,250 MW		0.0101/year
Fuel wood	13,071,464 ha ^b		
Animal waste	61 million tonnes/year		
Crop residue	83 million tonnes/year		
Solar radiation	3.5 to 7.0 kW h/m ² /day		
Wind	2 to 4 m/s (annual average) at 10 m in height		

Source: U.S. Energy Information Administration, International Energy Statistics database

In addition to its oil and gas resources, Nigeria has substantial coal and lignite reserves estimated at 2.7 billion tons. The country also possesses tar sands reserves equivalent to 31 billion barrels of oil. Nigeria's hydroelectric potential is notable, with identified sites having an estimated capacity of about 14,250 megawatts. Furthermore, Nigeria has significant biomass resources that can support both traditional and modern energy applications, including electricity generation.

Despite these abundant resources, Nigeria faces a significant

supply and demand gap due to inadequate development and inefficient management of its energy sector. The supply of electricity, which is the country's most critical energy resource, has been inconsistent and unreliable. This erratic supply has contributed to challenges in meeting the energy needs of the population and has impeded the overall economic development. Addressing these issues requires substantial improvements in developing and managing Nigeria's energy resources to bridge the supply and demand gap and ensure a more stable and efficient energy supply.

Table 2: Nigeria's energy overview in 2021

	Crude oil and other petroleum liquids	Natural Gas	Coal	Nuclear	Hydro	Renewables and other	Total
Primary energy consumption (quad Btu)	1.0	0.8	0.0	0.0		0.1	1.9
Primary energy consumption (percentage)	52%	44%	0%	0%		4%	100%
Primary energy production (quad Btu)	3.4	1.6	0.0	0.0		0.1	5.2
Primary energy production (percentage)	67%	32%	0%	0%		1%	100%
Electricity generation (TWh)		23.4		0.0	8.0	0.1	31.5
Electricity generation (percentage)		74%		0%	25%	0%	100%

Source: U.S. Energy Information Administration, International Energy Statistics database

Rural areas in Nigeria, often difficult to access due to inadequate road networks, face significant challenges in accessing conventional energy sources like electricity and petroleum products. In these areas, petroleum products such as kerosene and gasoline are sold at prices 150% higher than their official pump rates. As a result, the primary source of heat energy for rural communities is fuel wood, which is largely obtained from uncontrolled sales within the unorganized private sector.

The sale of essential energy resources like kerosene, electricity, and cooking gas is regulated by federal authorities. The Nigerian National Petroleum Corporation (NNPC) oversees the distribution of kerosene and cooking gas, while the Power Holding Company of Nigeria (PHCN) manages electricity supply. Historically, the Federal Government has subsidized the prices of locally consumed petroleum products and electricity to make them more affordable.

However, in an effort to improve the efficiency of the petroleum downstream sector and address issues of over-consumption, the government has gradually reduced and removed subsidies on various energy resources. These policy changes have often led to increased prices for energy products, impacting the affordability of energy for the general populace. Despite these efforts, the rural areas continue to struggle with high energy costs and limited access to reliable

energy sources, highlighting the need for more effective and equitable energy policies.

Electricity is essential for providing basic developmental services, including piped water, healthcare, telecommunications, and quality education. Successful poverty eradication and Universal Basic Education programs also rely on a stable energy supply. The lack of reliable electricity has resulted in social stagnation and untapped economic potential in rural areas. However, Nigeria is fortunate to have abundant renewable energy resources, including solar, wind, biomass, and small hydropower. To address these challenges and enhance energy access, increasing the integration of renewable energy sources into the national energy mix is a logical and promising solution. By harnessing these renewable resources, Nigeria can improve energy reliability, support development goals, and unlock the economic potential of underserved areas.

3.2. Energy consumption pattern in Nigeria

Global energy consumption patterns reveal that Nigeria, along with other African countries, has some of the lowest rates of energy consumption. Despite this, Nigeria faces a significant challenge of inadequate energy supply, exacerbated by rapidly increasing demand typical of a developing economy. This paradox is highlighted by Nigeria's potential for sustainable energy development. The

country is endowed with substantial conventional energy resources, including oil, natural gas, lignite, and coal. Additionally, Nigeria possesses significant renewable energy resources, such as wood, solar, hydropower, and wind. This combination of conventional and renewable resources presents a unique opportunity for Nigeria to enhance its energy supply and meet growing demand sustainably. By leveraging its diverse energy resources, Nigeria can address its current energy shortfalls and support future economic and social development.

Energy usage in Nigeria's economy can be categorized into industrial, transport, commercial, agricultural, and household sectors. Among these, the household sector consumes the largest share of energy, accounting for approximately 65%. This high percentage is primarily attributed to the relatively underdeveloped state of the other sectors. The low levels of development in industrial, transport, commercial, and agricultural sectors contribute to the heavy reliance on energy within households. This distribution highlights the need for balanced energy development across all sectors to improve overall efficiency and support economic growth.

In Nigeria, the main energy sources for domestic and commercial use include fuel wood, charcoal, kerosene, cooking gas, and electricity. Less common alternatives are sawdust, agricultural residues like corn stalks and cassava sticks, and occasionally cow dung. In urban areas, kerosene and gas are the primary cooking fuels. Most people rely on kerosene stoves for their domestic cooking needs, with only a minority using gas or electric cookers. This reliance on traditional fuels reflects the broader energy consumption patterns and infrastructure challenges in Nigeria.

Rural areas in Nigeria face limited access to conventional energy sources like electricity and petroleum products due to poor road infrastructure. Consequently, petroleum products such as kerosene and gasoline are sold at significantly higher prices in these regions compared to official rates. With basic needs driving energy demand, the rural population heavily relies on fuel wood as a primary energy source. It is estimated that around 86% of rural households depend on fuel wood for their energy needs. This heavy reliance on fuel wood has led to a supply and demand imbalance in certain areas, posing a serious threat to the energy security of rural communities. Addressing this imbalance is crucial for ensuring sustainable energy access and improving living conditions in these regions.

3.3. Current electricity situation in Nigeria

In Nigeria, the electricity system is predominantly managed by the Power Holding Company of Nigeria (PHCN), which is responsible for about 98% of the country's total electricity generation. Unlike PHCN, other electricity-generating

agencies in Nigeria, such as the Nigerian Electricity Supply Company, primarily use thermal power for their electricity production. PHCN, on the other hand, utilizes a combination of hydro and thermal power sources. Electricity generation, regardless of the source, consumes significant amounts of fuel and energy, including fuel oil, natural gas, and diesel oil. Over recent years, the reliance on these traditional fuel sources has diminished. Hydropower, which is relatively more cost-effective compared to fuel oil, natural gas, and diesel oil, has increasingly become a more important component of Nigeria's electricity generation mix. This shift towards hydropower reflects a growing emphasis on more sustainable and economically viable energy sources. As Nigeria continues to develop its energy infrastructure, enhancing the role of hydropower could help address energy supply challenges and reduce dependency on more expensive and less environmentally friendly fuels. Improving the efficiency and capacity of hydropower resources is thus crucial for achieving a more reliable and sustainable electricity supply in Nigeria. Recently, the Power Authority has diversified its electricity generation methods, utilizing a combination of both thermal and hydro systems. The entire network of power generation, distribution, and substations is interconnected through a transmission system commonly referred to as the national grid. This national grid plays a crucial role in pooling all generated electricity into the National Control Centre in Osogbo. From there, the electricity is systematically distributed to various regions across Nigeria. This centralized approach aims to efficiently manage and supply electricity to meet the needs of the entire country, ensuring a more cohesive and reliable energy infrastructure.

The national electricity grid in Nigeria currently includes 14 generating stations, comprising 3 hydro and 11 thermal facilities, with a total installed capacity of approximately 8,039 MW. The transmission network spans 5,000 km of 330-kV lines and 6,000 km of 132-kV lines. It features 23 substations with 330/132-kV capacity, totaling 6,000 MVA or 4,600 MVA at an 80% utilization factor. Additionally, there are 91 substations with 132/33-kV capacity, providing a combined total of 7,800 MVA or 5,800 MVA at a 75% utilization factor.

The distribution sector includes 23,753 km of 33-kV lines, 19,226 km of 11-kV lines, and 679 substations with 33/11-kV capacity. It also has 1,790 distribution transformers and 680 injection substations. This extensive network is designed to facilitate the efficient transmission and distribution of electricity across the country. For a detailed overview of the generation capabilities of PHCN power stations, refer to Table 3, which provides a summary of their operational performance from January to December 2018.

Table 3: Summary of generation capabilities of PHCN power stations

Plant	Operator	Age (year)	Type	Installed capacity (MW)	Average availability (MW)	Availability factor	Number of units installed	Current number available
Kainji	PHCN	38 to 40	Hydro	760	438.86	0.58	8	6
Jebba	PHCN	25	Hydro	578.4	529.40	0.92	6	4
Shiroro	PHCN	22	Hydro	600	488.82	0.81	4	4
Egbin	PHCN	23	ST	1320	694.97	0.53	6	5
AES	AES	7	GT	315	233.91	0.77	9	9
Ajaokuta	STS	NA	GT	110	24.88	0.23	2	2
Sapele	PHCN	26 to 30	ST/GT	1020	156.60	0.15	10	1
Okpai	AGIP	3	GT/ST	480	394.56	0.88	3	3
Afam	PHCN	8 to 45	GT	709.6	82.12	0.09	20	3

Delta	PHCN	18	GT	912	211.67	0.24	18	12
Geregu	PHCN	NA	GT	414	305.14	0.74	3	3
Omoku	RS	3	GT	150	87.27	0.87	6	4
Omotosho	PHCN	1	GT	335	256.58	0.77	8	2
Olorunsogo	PHCN	1	GT	335	271.46	0.81	8	2
Total				8,039	4176.24	0.50	93	45

Source: U.S. Energy Information Administration, International Energy Statistics database

As it can be seen in Table 3, the existing plants operate at far below their installed capacity as many of them have units that need to be rehabilitated, retrofitted, and upgraded. The percentage of generation capability from hydro turbines is 34.89%; from gas turbine, 35.27%; and from steam turbines, 29.84%. The relative contribution of the hydropower stations to the total electricity generation (megawatt per hour) is greater than that of the thermal power stations.

Electricity consumption in Nigeria can be categorized into three main groups: industrial, residential, and street light consumption. In 1970, the total electricity consumption was 145.3 MW/h, which grew to approximately 536.9 MW/h by 1980. By 2005, this figure had surged to 1,873.1 MW/h. On the generation side, electricity generation in 1970 was 176.6 MW/h, increasing to 815.1 MW/h in 1980. By the end of 2005, total electricity generation had reached 2,997.3 MW/h. Despite these increases, Nigeria's per capita power generation remains the lowest compared to other countries, with the USA having the highest per capita electricity generation. This stark contrast highlights the significant energy availability and consumption gap between Nigeria and more developed nations.

3.4. The Nigerian energy challenge

Nigeria faces a growing energy challenge as its population continues to increase, yet the energy development program does not adequately address this rising demand. The current energy policy is primarily focused on urban areas, neglecting the energy needs of rural and sub-rural communities. In these rural areas, residents rely heavily on burning wood and traditional biomass for energy, leading to severe deforestation, greenhouse gas emissions, and environmental pollution. These practices contribute to global warming and broader environmental issues.

The primary focus of the energy policy has been on supplying energy to cities and industrial regions, resulting in an imbalance in the country's energy distribution. This urban-centered approach has exacerbated disparities in energy access between urban and rural areas, affecting the socioeconomic and political landscapes. The contrast between the rapidly growing population and the limited capacity of existing power stations highlights Nigeria's struggle to meet the energy needs of its people. As a result, many rural communities continue to lack reliable electric power, underscoring the need for a more inclusive and balanced energy development strategy that addresses the needs of both urban and rural areas.

Nigeria's energy crisis can be primarily attributed to two critical factors. First, the country faces persistent and severe shortages in its petroleum product market, particularly for kerosene and diesel. Although Nigeria operates five government-owned refineries with a combined capacity to process 450,000 barrels of oil per day, these refineries have struggled to maintain a capacity utilization rate above 40% over the past two decades. As a result, more than 75% of the country's petroleum product needs are met through imports.

The gasoline market, by contrast, is better supplied than the kerosene and diesel markets, largely due to its higher political profile. This discrepancy has led the government to import large quantities of gasoline to address domestic shortages. In 2021, the subsidy required to support these gasoline imports was projected to range between 700 and 800 billion naira, according to the Minister for Energy. This heavy reliance on imports and subsidies underscores the ongoing challenges in Nigeria's energy sector, including the inefficiencies of domestic refining operations and the need for significant reforms to ensure a more stable and self-sufficient energy supply.

The second aspect of Nigeria's energy crisis is evident through frequent electricity blackouts, brownouts, and widespread dependence on self-generated power. This issue persists despite the country's substantial energy resources. The electricity market, primarily controlled by the state-owned Power Holding Company of Nigeria (PHCN), formerly known as NEPA, has struggled to meet minimum international standards for reliability, accessibility, and availability of electricity for over thirty years. This failure has led to persistent power outages and an increasing reliance on private generators to supplement the inconsistent supply from the national grid.

In summary, the factors contributing to Nigeria's energy crisis can be outlined as follows:

Price Control Regime: The widespread implementation of price controls has distorted market dynamics, affecting both the supply and demand of energy resources. This intervention often leads to inefficiencies and imbalances in the energy sector.

Lack of Economic Incentives: There is insufficient concern for cost recovery and a lack of effective economic incentives to encourage the state-owned companies, such as the Nigerian National Petroleum Corporation (NNPC) and the Power Holding Company of Nigeria (PHCN), to adopt efficient production and investment practices. This issue is compounded by significant input and output subsidies, which further distort market behavior.

Conflicting Objectives: The pursuit of multiple economic and non-economic objectives without a clear understanding of the trade-offs involved has led to suboptimal pricing policies in both the electricity and petroleum products markets. This misalignment impedes the development of a cohesive and effective energy strategy.

Institutional and Governance Failures: Institutional and governance issues have resulted in severe distortions and inefficiencies in production and investment. These failures manifest in high operational costs, low returns on investment, costly delays, and frequent cost overruns in state-run energy enterprises. The lack of effective oversight and management has exacerbated the challenges facing Nigeria's energy sector, making it difficult to achieve a stable and reliable energy supply.

3.5. Energy and sustainable development in Nigeria

Sustainable energy refers to the delivery of energy services in a manner that ensures long-term viability and meets several crucial criteria. To be considered sustainable, energy services must be available to all people, both now and in the future, while meeting basic needs. This involves providing energy that is not only sufficient and affordable but also environmentally friendly and socially acceptable. The concept of sustainable energy encompasses a broad range of factors, including energy efficiency and economic growth.

Research has explored how sustainable energy intersects with these factors, revealing important connections. For example, enhancing energy efficiency can significantly reduce environmental impacts while lowering costs, thereby contributing to economic growth. Sustainable energy practices ensure that the environmental footprint of energy production and consumption is minimized, thus supporting overall ecological balance. Additionally, aligning energy strategies with sustainable principles can foster economic development by creating jobs, improving energy access, and driving technological innovation. As such, sustainable energy is integral to achieving a balanced approach that supports both current needs and future generations while promoting economic and environmental well-being.

The energy sector is crucial in the pursuit of sustainable development, serving as a key factor in balancing economic and social progress with environmental protection. This role is highlighted by the 2002 Johannesburg World Summit on Sustainable Development, which emphasized the concept of "people, planet, and prosperity." Energy is integral to nearly every facet of sustainable development, as it underpins all economic activities. Energy's significance extends beyond its role in driving economic growth; it also affects how resources are managed and utilized. From its natural sources to the processes involved in converting and reconvertng energy, and finally to its use in producing goods and services as well as for household consumption, energy is central to these activities. This comprehensive view underscores the importance of managing energy resources effectively to support sustainable development goals. By focusing on energy's role in the economy, we recognize the need for efficient and sustainable energy practices that align with broader environmental and social objectives.

Traditionally, energy has been considered merely an intermediate input in the production process, which underestimates its true significance and contribution to development. In reality, every economic activity and process relies on some form of energy, highlighting its role as a crucial primary factor of production. As technological advancements progress, capital and labor take on supporting roles, facilitating the conversion, direction, and enhancement of energy. This process enables the production of goods and services essential for economic growth and poverty reduction. Recognizing energy as a fundamental component underscores its pivotal role in driving economic and social development.

Energy services are fundamental to the three pillars of sustainable development: economic, social, and environmental. Countries that have successfully replaced human and animal labor with more efficient and convenient energy sources and technologies tend to experience the fastest economic growth. No nation in contemporary times has significantly reduced poverty without a corresponding increase in energy provision and usage to drive material

progress. This underscores the critical role of energy in fostering economic development, improving living standards, and achieving sustainable growth. Without providing minimum access to energy services for a significant portion of the population, advancing economic development in developing countries like Nigeria beyond mere subsistence remains a major challenge. Ensuring that more people have reliable energy access is crucial for achieving meaningful economic progress and improving overall living standards.

At the national level, energy is a crucial driver of economic development. It acts as a foundation for industrial growth and enhances access to international markets and trade through transport and communications. Reliable, efficient, and competitively priced energy supplies are vital for attracting foreign investment, which has become increasingly important for boosting economic growth. On the local level, energy plays a significant role in economic development by increasing productivity and facilitating local income generation. It supports agricultural development through improvements in irrigation, crop processing, storage, and transportation to markets. Additionally, energy fosters non-farm employment opportunities and micro-enterprise development, contributing to broader economic growth. In Nigeria, the importance of energy for business operations is evident. When manufacturers were surveyed about the constraints on their activities, power breakdowns and voltage fluctuations were identified as the top two issues. This highlights how critical reliable energy is for the smooth functioning and growth of businesses.

4. Conclusions

Nigeria's energy outlook reveals a stark contrast between rapidly growing energy demand and insufficient, insecure, and increasingly irregular supply. The current energy mix is heavily reliant on fossil resources, which are depleting quickly and are environmentally harmful. To address these issues, Nigeria must diversify its energy supply mix. This involves investing in appropriate infrastructure and raising awareness to promote and develop the country's abundant renewable energy resources. Such measures are essential for improving energy security and ensuring a more sustainable and reliable energy future. Nigeria is undeniably rich in both fossil fuels and renewable energy resources. However, the country faces a significant challenge due to inefficient energy use. To address this, it is crucial to develop an energy mix that prioritizes the conservation of petroleum resources. This approach would ensure that these valuable resources are preserved for as long as possible, allowing Nigeria to continue exporting them and generating foreign earnings. By focusing on improving energy efficiency and strategically managing resource use, Nigeria can enhance its energy sustainability and economic benefits. This study examines four economic growth scenarios to assess energy requirements. The reference scenario projects a 7% annual GDP growth rate, aimed at achieving the Millennium Development Goals (MDGs) of halving poverty levels from the year 2000 by 2015. The high-growth scenario anticipates a 10% annual GDP increase, targeting poverty eradication by 2030. Additionally, two optimistic scenarios are considered: one with an 11.5% GDP growth rate and another with a 13% growth rate, both aimed at further accelerating economic development. These scenarios provide a framework for evaluating the energy needs associated with varying levels of

economic growth. The government must strengthen its commitment to renewable energy and energy efficiency initiatives to guarantee a sustainable energy supply and foster the country's long-term economic development. Successful examples from countries like Germany, Denmark, and Japan highlight the importance of a robust and sustained governmental commitment to advancing renewable energy policies. Such a commitment is essential for effectively implementing strategies supporting renewable energy resource growth and overall sustainable development. By prioritizing these programs, the government can drive significant progress toward a more reliable and eco-friendly energy future.

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