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Evaluating Nigeria's Oil And Gas Resources in the Global Energy Mix from a Circular Economy Perspective

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Abstract: Oil and gas have shaped Nigeria's economy and energy system for more than six decades, providing the majority of government revenue and foreign exchange earnings. This study evaluates their role in Nigeria's energy mix while situating the findings within the broader global energy transition. A descriptive survey design was employed, combining stakeholder questionnaires with secondary data from national and international sources to capture economic, environmental, and governance dimensions. Results show that oil and gas remain the backbone of Nigeria's economy, contributing over seventy percent of government revenue and more than ninety percent of foreign exchange earnings. Stakeholders strongly affirmed their economic importance but highlighted vulnerabilities, particularly exposure to global oil price volatility and weak diversification into other industries. Environmental impacts emerged as a critical concern, with widespread agreement that gas flaring, oil spills, and greenhouse emissions have severely damaged ecosystems and livelihoods. Governance challenges, including corruption, poor transparency, and weak regulatory enforcement, were also identified as major obstacles preventing the sector from delivering equitable benefits. The study concludes that while hydrocarbons will continue to play a central role in Nigeria's energy mix in the short term, long-term sustainability requires a focus on integrating a circular economy into the oil and gas sector, decisive diversification into renewable energy, stronger institutions, and transparent governance. Nigeria's abundant solar, wind, and hydro resources offer significant opportunities to reduce dependence on oil, while reforms that mitigate environmental harm and stabilize revenue can align the country with global energy transition goals. These findings reflect broader tensions in the global energy mix, where hydrocarbons remain indispensable yet increasingly unsustainable, underscoring the urgency of balancing energy security with climate commitments
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Keywords: *Nigeria Energy Mix, Oil and Gas, Circular Economy, Environmental Sustainability, Energy Policy.*

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I. INTRODUCTION

Nigeria's energy system has been shaped by a linear model of oil and gas extraction for more than sixty years. The discovery of oil in the 1950s transformed the country's economy, making Nigeria one of Africa's largest oil producers [1]. Since then, hydrocarbons have remained the dominant source of energy and government revenue, contributing heavily to Gross Domestic Product (GDP) and national income [2], [3].

However, this long-standing reliance on a "take-make-waste" linear approach has created a paradox: while the nation exports vast energy resources, it faces internal energy poverty. This linear paradigm is increasingly being challenged by the framework of a Circular Economy (CE). Unlike the traditional model, a CE is an industrial system that is restorative and regenerative by intention and design [4]. It aims to decouple economic growth from finite resource consumption by focusing on three core principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems [5]. In the context of the oil and gas industry, this involves moving toward "closed-loop" processes where waste streams—previously discarded—are captured and reintegrated into the production cycle as valuable inputs [6].

Many households still rely on firewood and traditional fuels because they do not have access to reliable electricity [7]. The power sector continues to struggle with blackouts and low efficiency, highlighting a failure to circularize available resources—such as waste gas—to meet domestic industrial needs [8].

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Oil and gas have brought both benefits and challenges. They have created jobs, supported economic growth, and provided foreign exchange [9]. At the same time, dependence on hydrocarbons has raised concerns about energy security, environmental damage, and climate change [10]. In a circular economy, waste is viewed as a resource, yet Nigeria continues to experience significant resource loss through gas flaring and oil spills, which have severely harmed communities and ecosystems [11]. Transitioning toward a Circular Economy (CE) offers a framework to recover these lost resources, turning environmental liabilities into economic assets.

Nigeria has strong potential for renewable energy—solar, wind, and hydropower are all available in large amounts [12]. However, the country still relies mostly on fossil fuels, and efforts to diversify the energy mix have been slow [13], [14].

This study evaluates the circular economy opportunities within Nigeria's oil and gas sector. By analyzing the current state of the industry, the research identifies how waste-to-value strategies can promote sustainability and protect the environment [15]. It also explores how systemic governance issues, such as corruption and lack of transparency, act as barriers to a circular transition [16].

Natural gas is often seen as a "bridge fuel" that can help reduce emissions compared to coal and oil. Nigeria has large gas reserves, but development must be managed carefully to avoid environmental harm and ensure fair distribution of benefits [10]. Another challenge is oil price volatility. Because Nigeria depends heavily on crude exports, sudden drops in global oil prices can destabilize the economy and reduce government revenue [1]. Diversifying the economy into agriculture, manufacturing, and services is necessary to reduce this risk and achieve long-term stability [9], [14].

The role of oil and gas in Nigeria's energy mix is therefore complex. While hydrocarbons have powered past growth, their current linear application creates unsustainable vulnerabilities. This study also contributes to the discourse embracing circular economy principles in the present oil and gas sector, from a wasteful energy past toward a balanced, resource-efficient, and sustainable future while transitioning to other forms of renewable sources of energy.

Nigeria's oil and gas industry remains the backbone of the national economy, contributing over 70% of government revenue and more than 90% of foreign exchange earnings [1], [2]. Yet, its growth and performance have been consistently undermined by macroeconomic instability, policy inconsistency, and external shocks. Empirical studies reveal that exchange rate volatility has a significantly negative impact on company operations, while crude oil price fluctuations and government expenditure have shown limited statistical significance [8], [29].

This economic vulnerability underscores the urgent need to transition from a volatile, export-oriented linear model toward a more resilient Circular Economy (CE). By diversifying into non-oil exports and renewable energy, Nigeria can shield its economy from global market volatility [9], [16]. In this context, circularity serves as an economic stabilizer; by capturing and repurposing resources, such as converting flared gas into domestic power, the nation can reduce its exposure to external shocks while simultaneously addressing internal energy demands.

From a CE perspective, this high vulnerability underscores the urgent need to shift from raw resource extraction toward a diversified model. This transition requires a dual-track strategy: prioritizing value addition within the hydrocarbon chain—such as local refining and petrochemical manufacturing—while aggressively pursuing diversification into renewable energy [9], [16]. By integrating closed-loop industrial processes, Nigeria can shield its economy from global market volatility, using the revenue generated from high-value petroleum products to fund the scaling of solar, wind, and hydro resources [14].

Nigeria's strategic role in global energy diplomacy further complicates its domestic challenges. As Africa's largest oil producer and a founding member of the Organization of the Petroleum Exporting Countries (OPEC), Nigeria has consistently participated in production quota negotiations, balancing national revenue needs with global oil market stability [16]. Beyond OPEC, Nigeria has sought bilateral and multilateral energy partnerships, particularly with China and India, which are major consumers of Nigerian crude [10]. At the same time, Nigeria's engagement in international climate agreements, including the Paris Accord, reflects its commitment to align domestic energy policies with global sustainability objectives. Scholars argue that Nigeria's gradual investment in renewable energy diplomacy signals a shift from an oil-centric identity to a more diversified energy profile [15].

Climate change has intensified the urgency of this transition. Global energy demand is projected to nearly double by 2050, driven largely by emerging economies [7]. Natural gas, often described as the cleanest-burning fossil fuel, is expected to play a central role. Yet Nigeria continues to flare large volumes of gas, wasting a valuable resource and contributing to climate change [11]. In response, the Federal Government adopted the National Gas Policy [18], ratified the Paris Agreement [19], and launched the Nigerian Gas Flare Commercialization Programme (NGFCP), which is expected to attract $3.5 billion in investments, generate up to 85 projects, create 300,000 jobs, and reduce CO_2 emissions by 13 million tonnes annually [17], [20].

Market trends also highlight the sector's paradox. While hydrocarbons continue to dominate wealth creation globally, their environmental costs are increasingly unsustainable. Nigeria's reliance on oil exposes it to market volatility and environmental risks. Energy transition strategies such as "maximum energy–minimum emissions" aim to balance growing energy needs with climate goals, targeting net-zero carbon emissions through decarbonization technologies [15]. For Nigeria, embracing these strategies could position the country as a leader in sustainable energy development [21].

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Operational restructuring has also shaped the industry. Business Process Outsourcing (BPO) has become a cost-saving measure, particularly after the 2014–2016 oil price collapse. Outsourcing non-core activities can reduce costs by up to 25% for on-site operations and by 50–75% for offshore operations [22]. Nigeria's oil industry has increasingly relied on contract workers, reversing the traditional employment structure by 2010, with 60% of workers on temporary contracts. This has raised concerns among labor unions about poor welfare conditions, prompting government guidelines on staff contracting and outsourcing [10].

Energy planning and investment remain critical. Nigeria's Liquefied Natural Gas (LNG) project has suffered delays, despite its potential to reduce gas flaring and supplement dwindling oil revenues. Scholars emphasize the need for decisive action to diversify the energy mix, invest in LNG infrastructure, and reduce wasteful flaring [9], [18]. Similarly, shale oil and gas development has been proposed as a "bridge fuel" to complement renewables. While shale could expand reserves and diversify the energy mix, hydraulic fracturing poses environmental risks such as groundwater contamination and excessive water use. A hybrid regulatory framework guided by the "3Ps" principle—pre-emptory, pro-active, and participatory—has been recommended to ensure responsible development [7], [15], [23].

Holistic solutions are needed across upstream, midstream, and downstream segments. Despite generating billions of dollars, Nigeria's petroleum industry has underperformed due to mismanagement, corruption, and weak regulatory frameworks. Public debates often describe oil wealth as a "resource curse" [16]. Addressing systemic inefficiencies requires reforms that strengthen governance, diversify energy sources, and encourage private sector participation [10].

Environmental liabilities further complicate the sector's sustainability. Oil spills, gas flaring, and deforestation have degraded the Niger Delta's fragile ecosystems. Geographic Information System (GIS) based studies reveal widespread ecological damage between 1963 and 2013, with severe oil spills in the 1980s–1990s and resurgence in the 2000s [24]. These liabilities are linked to weak regulatory enforcement and socio-economic pressures, underscoring the need for stronger environmental policies and continuous impact assessments [15].

Legal compliance and efficiency frameworks have been proposed to address governance gaps. These frameworks emphasize adherence to local and international regulations, adoption of advanced technologies such as automation and data analytics, and continuous monitoring through Key Performance Indicators (KPIs) and audits. Capacity building and training are also essential to equip personnel with the skills to navigate complex regulatory landscapes [15], [25].

Legislative milestones have transformed Nigeria's oil and gas sector. The Petroleum Industry Act (PIA, 2021), the Nigeria Liquefied Natural Gas (NLNG) Act, the Local Content Act, and the Niger Delta Development Commission (NDDC) Act represent significant reforms aimed at improving governance, diversifying revenue streams, and addressing environmental concerns [10], [16]. While these laws provide a strong foundation, enforcement gaps and governance challenges persist. Robust implementation is necessary to realize their transformative potential and align Nigeria's oil and gas sector with global sustainability goals [26].

Financing challenges remain central to Nigeria's energy sector. Floating Production Storage and Offloading (FPSO) units, crucial for offshore production, face decommissioning delays due to cash call inefficiencies. Cash calls—financial commitments from the Nigerian National Petroleum Company (NNPC) and its joint venture partners—have historically suffered from delays and shortfalls, creating financing gaps that hinder decommissioning projects. These delays increase environmental risks, operational hazards, and prolonged liabilities for operators [10], [16]. From a Circular Economy (CE) perspective, these "prolonged liabilities" represent a failure to recover materials and manage waste effectively. Comparative studies with other oil-producing nations suggest alternative funding models such as decommissioning trust funds and public-private financing strategies to ensure timely and sustainable decommissioning [27].

Joint ventures and alternative funding mechanisms have also been explored as strategies to address financial constraints, infrastructure deficits, and technological gaps. Public-private partnerships and project financing models have proven effective in enhancing financial sustainability and technological advancement in Nigeria's oil and gas sector. However, challenges such as conflicting stakeholder interests, transparency issues, and regulatory bottlenecks must be addressed for these strategies to be effective [15], [28]. Scholars emphasize the need for regulatory reforms, transparent governance, and strategic partnerships to foster long-term industry growth [28].

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Table 1. Comparative Analysis of Global Producers

Dimension	Nigeria	Saudi Arabia	United States	Russia	Norway
Revenue Dependence	>70% of government revenue, >90% foreign exchange earnings	80% of government revenue from oil exports	Oil and gas-8% of GDP, but critical or exports	40% of federal budget from hydrocarbons	20% of GDP but sovereign wealth fund reduces dependence
Global Role	Largest African producer, OPEC member, major supplier to India and China	World largest crude exporter, OPEC leader	Top oil producer, shale revolution reshaped global supply	Major exporter to Europe and Asia geopolitical leverage	Smaller producer but influential in energy diplomacy, strong renewable
Environmental Impact	Severe gas flaring, Niger Delta oil spills, deforestation	High emission, but investing in carbon capture	Methane leak from shale, offshore oil spills	Arctic drilling risk, methane emission	Strict regulations, reinvests oil wealth into renewable
Governance and Institution	Corruption, weak regulations, transparency issues	Centralized governance, strong state control	Private sector dominance, fragmented regulations	State-owned dominance, sanctions affect governance	Strong institution, transparent management, sovereign wealth
Energy Transition Strategy	Slow diversification, renewables potential untapped	Investing in renewables but still on oil-centric	Shale gas as bridge fuel, rapid renewables growth	Focus on gas experts, limited renewables	Leading in renewables, net-zero-target 2050
Vulnerability to Price Volatility	High vulnerability, economy destabilized by oil price shocks	High vulnerability, but large reserves cushion impact	Less vulnerable due to diversified economy	Vulnerable, sanctions amplify risk	Low vulnerability, diversified economy and sovereign wealth fund buffer

II. METHODOLOGY

A. Research Design

This study adopts a descriptive survey design, a methodological choice well-suited to capturing both quantitative and qualitative dimensions of Nigeria's energy mix. The design enables systematic collection of data on economic, environmental, and social impacts of oil and gas, while allowing integration of secondary statistics with stakeholder perspectives. This approach ensures that findings reflect sector realities rather than abstract theoretical assumptions.

B. Population and Sampling Techniques

The population of interest consists of regulators, including officials from the Nigerian Upstream Petroleum Regulatory Commission (NUPRC), the Ministry of Petroleum Resources, and the Energy Commission of Nigeria. It also includes operators, such as managers and economists from both indigenous and international oil companies. In addition, service providers and experts, including consultants, academics, and engineering firms engaged in upstream petroleum activities, form part of the population. A purposive sampling technique was employed to ensure that respondents possessed relevant expertise, while stratification across regulators, operators, and service providers captured diverse perspectives. The sample size was determined using statistical adequacy principles, balancing feasibility with representativeness.

C. Data Collection Methods

Primary data were collected through structured questionnaires administered to stakeholders. These questionnaires were divided into sections covering demographic background, perceptions of Nigeria's energy mix, economic contributions of oil and gas, environmental impacts, and governance challenges. Secondary data were obtained from reports published by the National Bureau of Statistics (NBS), the Central Bank of Nigeria (CBN), the Nigerian National Petroleum Company (NNPC), the Nigeria Extractive Industries Transparency Initiative (NEITI), the International Energy Agency (IEA), the World Bank, and relevant academic studies. To ensure clarity and reliability, the questionnaire was pre-tested with a small group of professionals, and revisions were made to eliminate ambiguity.

D. Data Analysis Techniques

Descriptive statistics, including frequency distributions, mean scores, and relative importance indices, were used to summarize stakeholder views. Inferential statistics, such as regression and correlation analysis, were applied to test relationships between oil and gas dependence, economic performance, and environmental outcomes. Comparative analysis was conducted by benchmarking Nigeria's energy mix against global trends, thereby situating the findings within the broader discourse of petroleum economics. This analytical framework ensures that the study not only describes prevailing conditions but also explains causal linkages between oil and gas reliance, governance, and sustainability.

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E. Ethical Considerations

Ethical integrity was maintained throughout the research process. Participation was voluntary, and respondents were assured of confidentiality and anonymity. The research adhered to established ethical standards in social science, ensuring transparency, respect, and accountability throughout the processes of data collection and analysis.

III. RESULT AND DISCUSSION

A. Presentation of Collected Data

Data were obtained through questionnaires administered to regulators, operators, and service providers. Out of the distributed instruments, a satisfactory proportion was returned and deemed valid for analysis, thereby yielding a credible response rate. Tables and figures are used to present the distribution of questionnaires across stakeholder categories, dominant perceptions of oil and gas's role in Nigeria's energy mix, and stakeholder views on economic, environmental, and governance impacts. This structured presentation ensures clarity and enhances the robustness of subsequent findings.

B. Questionnaire Distribution and Response Rate

A total of 39 questionnaires were administered across regulators, operators, and service providers. 28 were returned, representing a 72% response rate. Table 2 indicates that a total of 39 questionnaires were disseminated among principal stakeholders within Nigeria's upstream oil and gas sector, of which 28 were duly completed and returned. This represents an overall response rate of 72%, a figure that may be considered satisfactory given the specialized nature of the population under research.

The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) demonstrated particularly strong engagement, returning 11 of the 15 questionnaires distributed (73.3%). Indigenous oil and gas firms accounted for 8 of 12 responses (66.7%), while consultancy and engineering firms exhibited the highest level of participation, with 7 of 8 questionnaires returned (87.5%), underscoring their evident willingness to contribute technical perspectives. By contrast, international oil companies recorded the lowest response rate, with only 2 of 4 questionnaires completed (50%), a result plausibly attributable to confidentiality considerations.

Taken together, these figures provide a credible and sufficiently representative dataset for the analysis of bidding strategies and auction practices in Nigeria's upstream petroleum sector. The distribution of responses across regulatory, indigenous, technical, and international stakeholders ensures that the sample captures diverse institutional perspectives, thereby enhancing the robustness of subsequent findings.

Table 2: Distribution and Collection of Questionnaires

S/N	Respondent category (Organizations/Firms)	Questionnaires Administered	Questionnaires Returned	%age Returned
1	Nigerian Upstream Petroleum Regulatory Commission (NUPRC)	15	11	73.3%
2	International Oil Companies (IOCs) operating in Nigeria	4	2	50%
3	Indigenous Oil & Gas Firms	12	8	66.7%
4	Consultancy and service firms	8	7	87.5%
	Total	39	28	71.7%

Source: Researcher's Field Survey, 2025

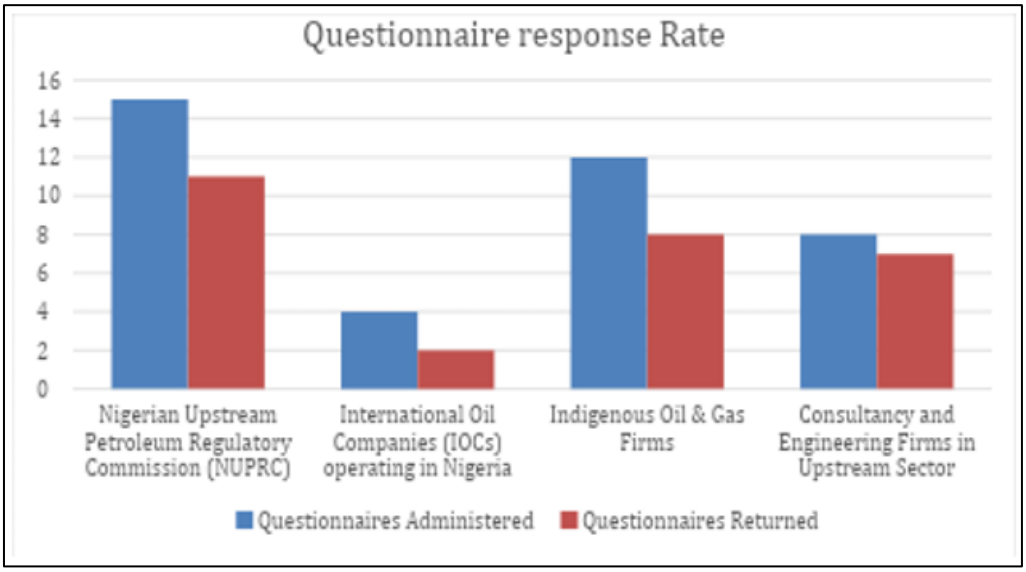

Fig 1: Questionnaire response rate

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C. Economic Role of Oil and Gas

Table 3 Stakeholder Perceptions on the Economic role of Oil and Gas

Variables	4	3	2	1	∑X	∑FX	Mean	RII	Agreement
Oil and gas as the main source of government	18	8	2	0	28	100	3.57	0.83	92.90%
Oil and gas as driver of GDP	16	7	5	0	28	95	3.39	0.96	82%
Oil and gas exports as source of foreign	17	9	2	0	28	99	3.54	0.98	92.90%

Source: Researchers field survey, 2025

Most respondents affirmed oil and gas as the backbone of Nigeria's economy. This means Nigeria's economy depends heavily on oil money. However, fewer respondents strongly agreed that oil drives GDP growth, showing that while oil is important, it has not created balanced growth across the oil sector. This dependence makes Nigeria's economy weak when oil prices fall, because the country does not earn enough from other industries like agriculture and manufacturing.

D. Environmental Impact

Table 4 Environmental Impact of Oil and Gas Activities

Variables	4	3	2	1	∑X	∑FX	Mean	RII	Agreement
Gas flaring contributes to climate change	16	7	5	0	28	95	3.39	0.85	82.10%
Oil spills damage ecosystems and livelihood	15	8	4	0	28	95	3.39	0.85	86%
Sector contributes to greenhouse gas emissions	17	8	3	0	28	99	3.54	0.88	89.30%

Source: Researchers field survey, 2025

The findings demonstrate that oil and gas activities harm the environment. Gas flaring adds to climate change, oil spills destroy farmlands and fishing areas, and emissions pollute the air. Communities in the Niger Delta suffer the most from these problems. The high agreement that people see environmental damage as a serious issue that government and companies must address with stronger laws and better enforcement. These environmental impacts represent "resource leakages" where byproduct gas and spilled oil are treated as waste rather than resources to be recovered and recirculated

E. Government and Institutional Challenges

The findings agreed that corruption, weak enforcement, and poor transparency are major problems in Nigeria's oil and gas sector. This means that even though oil brings in money, it is not managed properly. Funds are often misused, and rules are not enforced strictly. This stops the sector from benefiting citizens fully. Stronger institutions, better monitoring, and open reporting of oil revenues are needed to solve these problems. These institutional problems make it difficult to implement the advanced management and tracking systems needed to turn waste into resources and monitor the industry's lifecycle

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F. Energy Transition and Volatility

Table 5 Energy Transition and Market Volatility

Variables	4	3	2	1	∑X	∑FX	Mean	RII	Agreement
Gas flaring contributes to climate change	15	9	4	0	28	95	3.39	0.85	85.70%
Oil spills damage ecosystems and livelihood	16	8	4	0	28	96	3.43	0.86	86%
Sector contributes to greenhouse gas emissions	19	7	2	0	28	103	3.68	0.92	92.90%

Source: Researchers field survey,2025

The findings agreed that Nigeria should use natural gas as a temporary solution while moving to renewable energy. They have agreed that Nigeria has not made use of its solar, wind, and hydro resources. Almost all respondents agreed that changes in oil prices cause serious problems for government finances. This shows that Nigeria must invest more in renewable energy and create a savings system to protect the economy when oil price drops. The identification of natural gas as a bridge fuel is a primary circular economy opportunity, as it allows for the recovery of waste gas to provide a cleaner, more efficient energy source for the domestic economy. This is achieved by capturing associated gas that would otherwise be flared and converting it into Liquefied Petroleum Gas (LPG) for household cooking or Compressed Natural Gas (CNG) for industrial transport. By repurposing this "waste" as a valuable input, the sector can close the resource loop, reducing energy poverty and carbon emissions simultaneously while providing a more stable, low-carbon foundation for the future renewable energy transition.

IV. CONCLUSION AND RECOMMENDATION

This study confirms that oil and gas remain the backbone of Nigeria's economy, providing the majority of government revenue and foreign exchange earnings, yet their dominance has created deep vulnerabilities. Stakeholders emphasized that while hydrocarbons have powered growth and modernization, they have also exposed the country to severe environmental damage, governance weaknesses, and economic instability driven by global price volatility. Gas flaring, oil spills, and greenhouse emissions continue to undermine ecosystems and livelihoods, while corruption and weak regulatory enforcement prevent the sector from delivering equitable benefits. Comparative analysis with other global producers shows that Nigeria's slow diversification and underutilization of renewable resources place it at risk of lagging behind in the global energy transition. From a Circular Economy (CE) perspective, these challenges are not just pollution problems but are indicative of a failure to maximize the lifecycle value of petroleum resources.

To secure a sustainable energy future, Nigeria must balance short-term reliance on hydrocarbons with long-term reforms that strengthen institutions, improve transparency, and accelerate investment in renewables. Adopting circular strategies—specifically the commercialization of flared gas for domestic Liquefied Petroleum Gas (LPG) and power—offers an immediate pathway to reduce energy poverty while meeting climate commitments. Harnessing abundant solar, wind, and hydro potential will reduce dependence on oil, while stricter enforcement of environmental regulations and expansion of gas commercialization programs can mitigate ecological harm. Building sovereign wealth and stabilization funds will help cushion the economy against oil price shocks, and diversifying into agriculture, manufacturing, and services will broaden revenue streams.

At the same time, adopting advanced technologies such as carbon capture and automation, coupled with capacity building for regulators and operators, will improve efficiency and align Nigeria's energy system with global decarbonization goals. Ultimately, by shifting from a linear extraction model to a circular recovery model, Nigeria can stabilize its economy and position itself as a resilient contributor to the evolving global energy mix.

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The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g." Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

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