International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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TECHNOLOGICAL INNOVATIONS, ENERGY POLICIES AND SUSTAINABLE DEVELOPMENT GOALS IN NIGERIA (2015 – 2025)

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International Journal of Science and Research Archive, 2026, 21(02), 496–505

Publication history: Received on 09 October 2026; revised on 15 November 2026; accepted on 17 November 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.21.2.2024

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ABSTRACT

Energy in Nigeria is essentially governed by the Concurrent Legislative list as clearly stipulated in the second schedule of the Nigeria's 1999 Constitution (As amended). What this implies is that both the Federal Government and the State have rights to legislate on Energy generation and distribution in Nigeria. The Sustainable Development Goals refer to a universal call to action by the United Nations, to protect the planet while ensuring improved quality of life for all nations of the world. The period from 2015 to 2025 witnessed significant developments in Nigeria's energy sector, driven by technological innovations, policy reforms, and growing commitment to the Sustainable Development Goals (SDGs) as espoused by the United Nations. Despite possessing abundant energy resources, Nigeria has continued to face challenges relating to clean and sustainable energy access. Nigeria's government introduced a number of policy initiatives aimed at promoting renewable energy adoption, energy efficiency, and sustainable economic growth. These policies have encouraged the deployment of solar photovoltaic systems, mini-grids, smart metering technologies, clean cooking solutions, and decentralized energy systems. This study examines how technological innovations have supported the implementation of energy policies and contributed to the attainment of Sustainable Development Goals in Nigeria. The researchers relied on documentary method for data collection and analysis. The paper argued that challenges such as inadequate financing, regulatory bottlenecks, infrastructural deficits, and limited technological capacity are inhibiting implementation of energy policies. It concluded that sustained investment in technological innovations and strengthened policy implementation are critical for accelerating sustainable and transformational development in Nigeria's Energy sector.

Keywords: Technological Innovation, Energy Policy, Renewable Energy, Sustainable Development Goals, Energy Transition.

1 INTRODUCTION

The quest for sustainable development has become a central concern for governments across the world, particularly in developing countries where energy access remains a major challenge. Energy is widely recognized as a critical driver of

economic growth, industrialization, poverty reduction, and environmental sustainability. Consequently, technological innovations and energy policies have emerged as essential instruments for achieving sustainable development objectives. In Nigeria, efforts to harness technological advancements and implement effective energy policies have gained increasing prominence, especially since the adoption of the Sustainable Development Goals (SDGs) in 2015.

Nigeria possesses abundant energy resources, including crude oil, natural gas, coal, hydropower, solar, wind, and biomass. Despite this vast resource endowment, the country has historically faced persistent challenges in energy generation, transmission, distribution, and access. Since independence in 1960, Nigeria's energy sector has been characterized by inadequate infrastructure, policy inconsistencies, underinvestment, and overdependence on fossil fuels. These challenges have constrained economic development and limited access to reliable and affordable energy for millions of citizens.

The evolution of Nigeria's energy policy framework can be traced to various government initiatives aimed at improving energy security and supporting national development. Early efforts focused primarily on the exploitation of petroleum resources, which became the backbone of the national economy following the oil boom of the 1970s. However, growing concerns about environmental degradation, climate change, and energy poverty prompted a gradual shift toward renewable energy development and energy diversification. This shift became more pronounced in the twenty-first century with the introduction of policies designed to encourage clean energy adoption and improve energy efficiency.

A significant milestone in global sustainable development occurred in September 2015 with the adoption of the Sustainable Development Goals (SDGs) by the United Nations. The seventeen SDGs provided a comprehensive framework for addressing economic, social, and environmental challenges by 2030. Of particular relevance to this study are SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action). Following the adoption of the SDGs, Nigeria committed itself to implementing policies and programmes aimed at achieving these goals through improved energy governance and technological innovation.

The period between 2015 and 2025 witnessed substantial developments in Nigeria's energy sector. The government introduced and strengthened several policy frameworks to promote renewable energy and facilitate energy transition pathways. Notable among these were the National Renewable Energy and Energy Efficiency Policy (NREEEP), the Renewable Energy Master Plan, the Economic Recovery and Growth Plan, and later the Energy Transition Plan. These policies sought to diversify the country's energy mix, expand access to electricity, reduce greenhouse gas emissions, and support sustainable economic growth.

Technological innovations also became increasingly important during this period. Advances in solar photovoltaic systems, mini-grids, smart metering technologies, battery storage systems, digital energy management platforms, and off-grid electrification solutions contributed significantly to expanding energy access, particularly in rural and underserved communities. Government agencies, private sector actors, and international development partners invested in innovative energy technologies aimed at addressing the country's longstanding electricity deficit. The emergence of renewable energy startups and digital energy solutions further transformed the landscape of energy provision in Nigeria.

Furthermore, broader digital infrastructure innovations—such as automated document-sharing platforms, artificial intelligence, and data-driven systems—have fundamentally optimized institutional efficiency, governance transparency, and resource management across public and private sectors in Nigeria (Akobundu *et al.*, 2022; Akobundu *et al*., 2024). Aligning these intelligent digital solutions with green energy frameworks establishes a robust foundation for modernizing both administrative institutions and power grids.

The enactment of the Petroleum Industry Act in 2021 represented another landmark development in the Nigerian energy sector. The Act introduced reforms intended to improve governance, attract investment, and promote efficiency within the petroleum industry while supporting broader energy sector transformation. Similarly, the launch of Nigeria's Energy Transition Plan in 2022 reflected the country's commitment to achieving net-zero emissions by 2060 while simultaneously addressing developmental priorities.

Despite these advancements, numerous challenges continued to hinder the effective implementation of energy policies and technological innovations. Inadequate funding, infrastructural deficits, regulatory bottlenecks, policy inconsistencies, weak institutional capacity, and limited technological penetration remained significant obstacles. These challenges affected the pace and effectiveness of efforts to attain relevant SDGs, particularly those related to energy access, industrial development, environmental sustainability, and climate resilience.

Against this backdrop, it becomes necessary to examine the extent to which technological innovations have contributed to sustainable development outcomes, evaluate the performance of energy transition policies, and assess the impact of funding constraints on policy implementation in Nigeria between 2015 and 2025. Such an investigation provides

valuable insights into the role of technology and policy in advancing sustainable development and offers evidence-based recommendations for strengthening Nigeria's energy transition and SDG attainment efforts.

1.1 Statement of the Problem

Nigeria faces a significant energy deficit despite its vast energy resources. Millions of households and businesses lack access to reliable electricity, thereby limiting economic productivity and social development. Traditional dependence on fossil fuels has contributed to environmental degradation and increased greenhouse gas emissions.

Despite the introduction of numerous energy policies and technological innovations since 2015, Nigerians seem not to be getting the desired results, thus questioning the effectiveness of these energy policies and technological innovations in promoting sustainable development and achieving the relevant Sustainable Development Goals (SDGs). Challenges including poor implementation, inadequate financing, weak regulatory structures, and infrastructural limitations are believed to be hindering progress. Therefore, this study critically examines how technological innovations and policies enabling energy transition pathways have contributed to the attainment of the relevant Sustainable Development Goals' trajectory in Nigeria.

1.2 Objectives of the Study

This study has general and specific objectives. The general objective of the study is to critically examine how technological innovations and policies enabling energy transition pathways have contributed to the attainment of the relevant Sustainable Development Goals' trajectory in Nigeria. For the specific objectives, this study seeks to:

- Assess the contribution of the technological innovations to the attainment of Sustainable Development Goals (SDGs) in Nigeria between 2015 and 2025.
- Examine the performance of policies enabling energy transition pathways in pursuit of attaining the relevant Sustainable Development Goals (SDGs) in Nigeria.
- Ascertain whether inadequate funding has affected the implementation of energy policies in Nigeria within the period under review.
- Recommend strategies for enhancing sustainable energy development in Nigeria.

1.3 Research Questions

- How have technological innovations contributed to the attainment of the Sustainable Development Goals (SDGs) in Nigeria between 2015 and 2025?
- Have policies enabling energy transition pathways been effectively implemented pursuant to the attainment of the relevant Sustainable Development Goals (SDGs) in Nigeria?
- Has inadequate funding affected the implementation of energy policies in Nigeria within the period under review?
- What strategies are recommended for enhancing sustainable energy development in Nigeria?

2 LITERATURE REVIEW

2.1 Technological Innovations and the Attainment of Sustainable Development Goals (SDGs) in Nigeria Between 2015 and 2025

Iyeshim, M. (2023): Studied information and communication technology and the attainment of sustainable development goals in Nigeria: A digital economy perspective. The study examined the role of Information and Communication Technology (ICT) in facilitating the achievement of Sustainable Development Goals within Nigeria's emerging digital economy. It found that ICT has become a major driver of sustainable development through improved access to information, enhanced digital governance, financial inclusion, and economic participation. The researcher concluded that the National Digital Economy Policy and Strategy has the potential to accelerate SDG attainment if effectively implemented.

Nnamdi, B. U., Eneh, I., & Ozoagu, C. (2023): Studied the roles of information communication technology (ICT) in the achievement of sustainable development goals in Nigeria. The researchers found that ICT improves learning outcomes, promotes access to education, enhances creativity, and supports knowledge dissemination. The study further revealed that ICT contributes significantly to SDG 4 (Quality Education) by facilitating online learning and expanding educational opportunities.

Dunmade, A. O., Awe, O. D., & Mejabi, O. V. (2023): Studied information and communication technologies in the actualisation of the Sustainable Development Goals (SDGs) in Nigeria. The researchers found that ICT serves as a catalyst

for economic development, social inclusion, healthcare improvement, agricultural productivity, and governance efficiency. They argued that ICT possesses the capacity to accelerate progress across virtually all SDGs if adequately integrated into development planning.

Ibikunle, B. Q., Fatile, J. O., Sanusi, O. S., & Eweje, A. O. (2024): Studied technology of the Fourth Industrial Revolution (4IR) and Sustainable Development Goals in Nigeria. They found that artificial intelligence (AI), blockchain technology, and the Internet of Things (IoT) have significant potential to improve public service delivery, enhance governance efficiency, and accelerate SDG implementation.

Ufua, D. E., Emielu, E., Olujobi, O. J., et al. (2021): Investigated digital transformation: A conceptual framing for attaining Sustainable Development Goals 4 and 9 in Nigeria. The researchers found that digital technologies enhance educational delivery, support industrial innovation, and improve infrastructure development.

Akobundu, C. I., Ezeano, V. N., Abanobi, G. C., Nwachukwu, B. N., & [Co-authors] (2022): Implemented a document-sharing system for enhanced communication and operational efficiency in institutional frameworks. Their study demonstrated how secure digital platforms eliminate bureaucratic bottlenecks, streamline administrative workflows, and support sustainable institutional management in developing economies.

Akobundu, C. I., Julius, M. S., Nkeanyi, G. N., Abanobi, G. C., & Chieme, G. C. (2021); Akobundu, C. I., Enyinnaya, V. C., Nnakwuzie, D. N., Ezeano, V. N., & Julius, M. S. (2024): Investigated the integration of intelligent digital systems and machine learning techniques to safeguard financial assets and detect enterprise fraud in Nigeria. Their findings highlight how advanced technological applications secure digital economies and reinforce institutional integrity, which serves as a vital pillar for sustainable national growth.

Ukanwa, C. A. (2025): Studied industrial development strategies for advancing the Sustainable Development Goals in Nigeria. Using a descriptive survey and regression analysis involving manufacturing firms and government agencies, the study tested the relationship between technology adoption and SDG advancement, and found a significant positive relationship between technology adoption and SDG achievement.

Odiche, A., & Amodu, A. (2024): Conducted a review of issues and challenges of digital transformation and sustainable development in Nigeria. They found that digital technologies promote economic growth, environmental sustainability, and improved governance. However, they also identified challenges such as digital inequality, inadequate infrastructure, cybersecurity concerns, and technological exclusion.

Dada, K. S. J. (2025): Interrogated harnessing ICT as a catalyst for achieving Sustainable Development Goals in Nigeria. The study concluded that ICT significantly improves educational outcomes, governance, food security, healthcare delivery, and democratic participation. It provides one of the strongest arguments for viewing ICT as a comprehensive driver of sustainable development.

2.2 Critical Gap in the Literature Reviewed:

The reviewed studies under this sub-theme collectively demonstrate that technological innovations contribute significantly to sustainable development in Nigeria. However, most of the studies focus exclusively on ICT and digital technologies while paying limited attention to renewable energy technologies, smart grids, energy-transition innovations, and how systemic digital governance infrastructure interconnects with energy sector performance. This leaves a yearning gap for this study.

2.3 Nigeria's Energy Policies and the Attainment of Sustainable Development Goals (SDGs)

Oyedepo, S. O. (2015): Examined sustainable energy development in Nigeria: Current status and policy options. The study found that sustainable development in Nigeria depends largely on the successful implementation of energy policies that promote renewable energy technologies, energy efficiency, and improved utilization of conventional energy resources. The researcher concluded that policy inconsistency, weak institutional frameworks, and inadequate investment have hindered the achievement of sustainable energy objectives. This study established a foundational link between energy policy implementation and the attainment of SDGs, particularly SDG 7 (Affordable and Clean Energy), SDG 8 (Economic Growth), and SDG 13 (Climate Action).

Roche, M. Y., Verolme, H., Agbaegbu, C., Binnington, T., & others (2019): Explored achieving Sustainable Development Goals in Nigeria's power sector: Assessment of transition pathways. The study evaluated transition pathways within Nigeria's electricity sector and their implications for achieving the SDGs. The study found that expanding electricity access through renewable energy and decentralized energy systems could significantly accelerate progress toward SDG 7.

Iwuagwu, M., & Ighodalo, A. (2019): Looked at improving Nigeria's renewable energy policy design: A case study approach. The study critically examined the effectiveness of Nigeria's renewable energy policies. A case-study approach was employed to assess renewable energy policy frameworks and implementation mechanisms. The study found that Nigeria's renewable energy policies were largely ineffective due to weak policy design, poor implementation mechanisms, and the absence of strong legislative backing.

Edomah, N. (2021): Investigated the governance of energy transition: Lessons from the Nigerian electricity sector. The study examined governance structures and institutional arrangements influencing energy transition in Nigeria. The researcher employed a qualitative policy analysis approach focusing on energy governance institutions and transition frameworks. The study found that successful energy transition requires strong governance systems, effective institutions, stakeholder engagement, and policy coherence. Weak institutional capacity and fragmented governance structures were identified as major barriers to achieving sustainable energy goals.

Ayangeaor, B. (2022): Reviewed Nigeria's National Renewable Energy and Energy Efficiency Policy. The study found that NREEEP established important targets for renewable energy development and energy efficiency improvements. However, implementation was constrained by inadequate financial incentives, weak enforcement mechanisms, and limited institutional coordination.

Okafor, C., & Adeleye, O. (2023): Worked on keeping the lights on or off: Tracking the progress of access to electricity for sustainable development in Nigeria. The study found that progress in electricity access remains uneven across Nigeria. Southern states and urban centers recorded higher electricity visibility, while many rural areas continued to experience severe energy deficits. The researchers concluded that existing energy policies have not sufficiently addressed regional inequalities in energy access.

Agbaitoro, G. A., & Oyibo, K. I. (2022): Examined the chances of realizing Sustainable Development Goals 7 and 13 in Sub-Saharan Africa by 2030: Synergizing energy and climate justice perspectives. The researchers found that equitable energy policies are essential for ensuring universal energy access while addressing climate change challenges. They argued that energy justice principles should guide policy design to ensure that vulnerable populations benefit from energy transition programs.

Ajia, A. T. (2025): Worked on renewable energy policy and sustainable development in Nigeria: A systematic scoping review. The researcher employed a systematic scoping review of studies published between 2000 and 2025, and found that renewable energy policies have both direct and indirect effects on sustainable development. It pointed out that renewable energy policy positively influences energy access, environmental sustainability, and economic development; but also maintained that regulatory bottlenecks, inadequate technological support, and poor implementation continue to limit policy effectiveness. This is one of the most recent studies directly examining the relationship between energy policy and sustainable development in Nigeria.

2.4 Inadequate Funding and Implementation of Energy Policies in Nigeria (2015–2025)

Iwuagwu, M., & Ighodalo, A. (2019): Studied improving Nigeria's renewable energy policy design: A case study approach. The study evaluated the effectiveness of Nigeria's renewable energy policies and examined factors affecting their implementation. The researchers adopted a case-study approach and analyzed major renewable energy policies, institutional frameworks, and implementation structures in Nigeria. The study found that Nigeria's renewable energy policies suffered from poor design, weak institutional coordination, and inadequate implementation mechanisms. They concluded that policy implementation was hindered more by institutional deficiencies than by policy formulation itself.

Adelaja, A. O. (2020): Examined the barriers to national renewable energy policy adoption: Insights from a case study of Nigeria. The research utilized policy analysis and stakeholder evaluation to identify institutional and financial constraints affecting renewable energy policy adoption. The study found that inadequate financing, weak political commitment, regulatory uncertainty, and limited stakeholder participation constituted major barriers to policy implementation. This study directly links funding inadequacies to poor implementation outcomes in Nigeria's energy sector.

Ayangeaor, B. (2022): Conducted a review of Nigeria's National Renewable Energy and Energy Efficiency Policy (NREEEP). The study found that although NREEEP established ambitious targets for renewable energy development, implementation was constrained by insufficient financial incentives, weak enforcement mechanisms, and inadequate institutional coordination. The review further showed that government funding allocations were insufficient to drive large-scale renewable energy deployment. This work is particularly important because it evaluates one of Nigeria's most significant energy policies during the SDG implementation era.

Ugwu, J., Odo, K. C., Oluka, L. O., & Salami, K. O. (2022): Did a systematic review on renewable energy development, policies and challenges in Nigeria with an international perspective and public opinions. The researchers found that despite abundant renewable energy resources, policy implementation remained slow due to inadequate funding, poor infrastructure, weak regulatory frameworks, and insufficient investor confidence. The study emphasized that financing gaps represented one of the most critical barriers to energy sector transformation. The study provides comprehensive evidence regarding the relationship between funding availability and policy implementation effectiveness.

Edomah, N. (2021): Again studied the governance of energy transition: Lessons from the Nigerian electricity sector. The study found that weak institutional capacity, fragmented governance arrangements, and poor inter-agency coordination limited effective implementation of energy policies. The researcher concluded that adequate funding alone cannot guarantee policy success without strong governance structures and implementation institutions. This study highlights the importance of governance and institutional capacity in energy policy implementation.

Erebor, E. M., & Adedire, F. M. (2023): Worked on energy transition policy, efficiency and implementation strategies in the Nigerian built environment. The researchers employed a qualitative review of policy frameworks and implementation experiences, and found that although numerous renewable energy policies and technological initiatives have been introduced, actual implementation has remained slow. They attributed this to inadequate financing, low investment levels, weak policy enforcement, and overdependence on fossil fuels. The study demonstrates the disconnect between policy formulation and practical implementation in Nigeria's energy sector.

Ola, T. (2025): Studied Nigeria's Energy Transition Plan: Emerging challenges and recommendations. The study identified financing constraints, infrastructure deficits, institutional barriers, and regulatory weaknesses as major obstacles to successful implementation of the Energy Transition Plan. It further provides contemporary evidence on funding challenges affecting energy policy implementation between 2022 and 2025.

Nigeria Energy Transition Office (2024): Investigated finance and investment framework for Nigeria's Energy Transition Plan. The report assessed financing requirements for implementing Nigeria's Energy Transition Plan, and revealed that Nigeria requires approximately $410 billion in additional investment between 2021 and 2060 to achieve its energy transition objectives. It further identified an initial investment portfolio of approximately $23 billion, with about $17 billion expected from private-sector financing. The report concluded that funding remains the most critical factor determining successful implementation of energy policies. The report therefore provides the most authoritative estimate of financing requirements for energy policy implementation in Nigeria.

Malabu, M. B., Magaji, S., & Jafaru, Y. (2025): Examined the contribution of Nigeria's renewable energy policy environment to investment growth and sectoral advancement: 2015–2025. The researchers utilized a mixed-method approach involving stakeholder surveys and key informant interviews, and found that improvements in the renewable energy policy environment encouraged greater investor interest and sectoral growth. However, investment flows remained below expectations due to financing risks, policy uncertainty, and implementation bottlenecks. The study demonstrates how funding availability influences the effectiveness of policy implementation.

World Bank (2024): Examined Nigeria Electricity Distribution Recovery Programme. The evidence from Nigeria's electricity sector indicated that funding challenges remained central to implementation failures. In 2024, Nigeria secured a $500 million World Bank loan to improve the technical and financial performance of electricity distribution companies. Despite earlier privatization reforms, funding shortages, grid failures, gas supply constraints, and rising sector debt continued to undermine implementation outcomes. This study demonstrated the continuing dependence of Nigeria's energy sector on external financing to support policy implementation.

2.5 Research Gap

2.5.1 Despite extensive literature on Nigeria's energy policies, these gaps remain:

Most studies examined either funding or implementation separately rather than analyzing how one affects the other. Studies available also failed to provide a comprehensive assessment covering the entire 2015–2025 period. How funding and implementation challenges affect the contribution of the avalanche of energy policies, thereby hampering the attainment of the relevant Sustainable Development Goals (SDGs) have equally not received significant attention.

These gaps justify further research on "Funding and Implementation of Energy Policies in Nigeria, especially as they affect the attainment of the SDGs (2015–2025)."

3 METHODOLOGY

This study adopted a qualitative, ex-post facto documentary research design to evaluate the interplay between technological innovations, energy transition policies, and the attainment of Sustainable Development Goals (SDGs) in Nigeria between 2015 and 2025. Consistent with the scope outlined in the abstract, the documentary method was selected because it enables a systematic, longitudinal interrogation of statutory instruments, policy frameworks, empirical peer-reviewed literature, and macroeconomic financing reports over the ten-year review window.

3.1 Sources and Scope of Data

Data were gathered exclusively from secondary documentary sources published between 2015 and 2025, categorized into three primary streams:

Legal and Policy Instruments: Nigeria's 1999 Constitution (as amended, Second Schedule Concurrent Legislative List), the National Renewable Energy and Energy Efficiency Policy (NREEEP, 2015), the Renewable Energy Master Plan (REMP), the Economic Recovery and Growth Plan (ERGP), the Petroleum Industry Act (PIA, 2021), the Nigeria Energy Transition Plan (ETP, 2022), and the Electricity Act (2023).

Institutional and Financial Reports: Official datasets and investment evaluations from the Nigeria Energy Transition Office (2024), the World Bank (2024), and the Nigerian Electricity Regulatory Commission (NERC).

Peer-Reviewed Academic Literature: Empirical and scoping studies indexed in academic databases examining renewable energy deployment, smart grid technologies, digital governance infrastructure, and SDG performance in Nigeria (including works by Oyedepo, 2015; Roche *et al*., 2019; Edomah, 2021; Akobundu *et al*., 2021, 2022, 2024; Ugwu *et al*., 2022; Okafor & Adeleye, 2023; Ajia, 2025; and Malabu *et al.*, 2025).

3.2 Method of Data Analysis

The collected documents were analyzed using qualitative thematic content analysis structured around the study's four research questions. Policy provisions and technological interventions were cross-examined against empirical implementation outcomes, budgetary allocations, and SDG target indicators, specifically **SDG 7** (Affordable and Clean Energy), **SDG 9** (Industry, Innovation, and Infrastructure), and **SDG 13** (Climate Action), to identify implementation gaps and causal bottlenecks.

4 RESULTS

4.1 Contribution of Technological Innovations to SDG Attainment in Nigeria (2015–2025)

Documentary evidence demonstrates that technological innovation served as the primary operational catalyst for expanding energy access and institutional efficiency between 2015 and 2025, albeit with uneven sectoral penetration.

Decentralized Clean Energy and Off-Grid Access (SDG 7): Advances in solar photovoltaic (PV) systems, hybrid mini-grids, battery storage, and pay-as-you-go (PAYG) off-grid electrification models significantly expanded electricity visibility in underserved peri-urban and rural communities where national grid extension proved economically unviable (Roche *et al.*, 2019; Okafor & Adeleye, 2023). Furthermore, the rollout of smart metering technologies began curbing aggregate technical, commercial, and collection (ATC&C) losses across distribution networks.

Digital Infrastructure and Institutional Efficiency (SDGs 8, 9, and 16): Beyond physical power hardware, Fourth Industrial Revolution (4IR) technologies—including artificial intelligence (AI), Internet of Things (IoT), and automated digital platforms—transformed public service delivery and resource governance (Ibikunle et al., 2024; Dada, 2025). Specifically, implementing automated document-sharing ecosystems and intelligent machine learning frameworks strengthened institutional communication, reduced operational waste, and curbed fiscal leakages across Nigerian institutions and enterprises (Akobundu *et al.*, 2021; Akobundu *et al*., 2022; Akobundu *et al.*, 2024).

Discussion: While technological adoption exhibits a statistically positive relationship with industrial and SDG advancement in Nigeria (Ukanwa, 2025), overall impact remained constrained by limited local manufacturing capacity, high import duties on solar components, and persistent digital and infrastructural deficits (Odiche & Amodu, 2024).

4.2 Performance of Energy Transition Policies Toward SDG Targets

Between 2015 and 2025, Nigeria demonstrated strong policy formulation capacity, transitioning from centralized fossil-fuel regulation toward decentralized, low-carbon governance. Key milestones included NREEEP (2015), the Petroleum

Industry Act (2021), the Energy Transition Plan (2022) targeting net-zero emissions by 2060, and the constitutional devolution of electricity generation and distribution powers to sub-national states under the Concurrent Legislative List via the Electricity Act (2023).

Discussion: Despite this robust legislative architecture, policy performance fell short of 2030 SDG trajectories. Empirical evaluations reveal a persistent disconnect between policy formulation and execution (Iwuagwu & Ighodalo, 2019; Erebor & Adedire, 2023). Fragmented governance structures, overlapping regulatory mandates, and weak enforcement mechanisms diluted policy effectiveness (Edomah, 2021; Ayangeaor, 2022; Ajia, 2025). Consequently, electricity access remained heavily skewed toward urban centers and southern economic hubs, leaving rural populations reliant on carbon-intensive petrol and diesel generators—directly undermining **SDG 7** and **SDG 13** (Agbaitoro & Oyibo, 2022; Okafor & Adeleye, 2023).

4.3 Impact of Inadequate Funding on Energy Policy Implementation

Analysis of financial records confirms that chronic underfunding was the single most critical bottleneck impeding energy policy execution between 2015 and 2025.

Table 1: Summary of Financial Records for Energy Policy Execution between 2015 and 2025

Financial Matric / Intervention	Estimated Requirement / Allocation	Source & Policy Context
Total Energy Transition Investment Need (2021 -2026)	$410 Billion (additional capital)	Nigeria Energy Transition Office (2024)
Initial ETP Investment Portfolio	$23 Billion ($17B expected from private sector)	Nigeria Energy Transition Office (2024)
Distribution Grid Recovery Financing	$500 Million (World Bank loan)	World Bank (2024), DISCO Recovery Programme

5 DISCUSSION

Insufficient budgetary allocations, high macroeconomic risk, foreign exchange volatility, and weak financial incentives deterred private-sector capital inflows (Adelaja, 2020; Ugwu *et al*., 2022; Malabu *et al.*, 2025). As documented by the Nigeria Energy Transition Office (2024), achieving net-zero and universal energy access requires roughly $410 billion through 2060, far exceeding domestic fiscal capacity. Even with multilateral interventions such as the $500 million World Bank loan in 2024 to rescue distribution companies (DISCOs), legacy sector debt, gas supply constraints, and grid collapses continued to stall renewable energy integration (World Bank, 2024; Ola, 2025).

6 CONCLUSION

Between 2015 and 2025, Nigeria established an ambitious constitutional and policy foundation for clean energy transition and sustainable development, supported by growing adoption of decentralized solar technologies, smart metering, and digital governance platforms. However, the translation of these policies into measurable progress toward **SDGs 7, 9, and 13** remained suboptimal. The study establishes that Nigeria's energy transition deficit is driven not by a lack of policy frameworks or renewable resources, but by an acute intersection of inadequate financing, fragmented institutional governance, aging grid infrastructure, and limited indigenous technological capacity. Without bridging the multi-billion-dollar funding gap and synchronizing technological innovation with enforceable regulatory execution, Nigeria risks missing its 2030 SDG targets and delaying its 2060 net-zero commitment.

Recommendations

To accelerate sustainable energy development and SDG attainment in Nigeria, the following evidence-based strategies are recommended:

- **De-Risk and Expand Clean Energy Financing:** The Federal and State Governments should operationalize blended finance vehicles, sovereign green bonds, and targeted tax/import-duty waivers on solar PV, battery storage, and smart-grid components to attract the $17 billion private-sector capital targeted under the Energy Transition Plan
- **Operationalize State-Level Electricity Markets:** State governments should leverage their constitutional authority under the Concurrent Legislative List and the Electricity Act (2023) to establish independent sub-

national electricity regulators, prioritizing rural mini-grid concessions and clean cooking initiatives to close regional energy access inequalities

- **Integrate Smart Grid and AI-Driven Digital Governance:** Power sector agencies and distribution companies should scale smart metering, IoT-enabled grid monitoring, and AI-powered billing/auditing systems to eliminate ATC&C losses, curb revenue leakages, and strengthen institutional transparency
- **Strengthen Institutional Coherence and Policy Enforcement:** Harmonize overlapping mandates among the Federal Ministry of Power, NERC, the Rural Electrification Agency (REA), and the Energy Commission of Nigeria (ECN) through binding performance benchmarks and legislative enforcement mechanisms
- **Invest in Indigenous R&D and Green Technical Capacity:** Establish public-private technical hubs in Nigerian universities and polytechnics to localize renewable energy component assembly, smart-grid maintenance, and digital energy management skills, reducing dependence on costly foreign technical imports

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The authors declare that this study was self-funded, with no financial support from external organizations or funding agencies. We sincerely appreciate the scholars and authors whose published works are cited in this manuscript, as their contributions significantly informed our research framework and analysis.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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