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GREEN INDUSTRIALIZATION IN NIGERIA: POLICY DESIGN FOR CLIMATE-COMPATIBLE MANUFACTURING HUBS

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ABSTRACT

Nigeria's industrial development is progressing amid escalating climate challenges. While the manufacturing sector is key to economic diversification and job creation, it remains a major contributor to national greenhouse gas emissions due to outdated technologies and inefficient energy use. This study investigates how Nigeria can align industrial expansion with environmental sustainability through the development of climate-compatible manufacturing hubs. Adopting a qualitative, document-based approach, the paper reviews key national frameworks, including the Climate Change Act (2021), Energy Transition Plan (2022), and the Carbon Market Activation Plan (2023), alongside two industry case studies (Sacral Industries and Nigerian Breweries Plc) that illustrate practical decarbonization pathways. Findings point to persistent barriers including regulatory fragmentation, limited green financing, infrastructure gaps, and low technical capacity. The study proposes an integrated policy framework emphasizing regulatory alignment, targeted investment incentives, infrastructure modernization, and institutional capacity building. This paper offers actionable policy pathways for harmonizing Nigeria's industrial ambitions with climate imperatives and fostering a resilient, low-carbon economic future.

KEYWORDS: Green industrialization, Climate-compatible manufacturing, Sustainable development, Industrial policy, Nigeria, Renewable energy, Low-carbon economy.

1.0 INTRODUCTION

1.1 Background of the Study

Industrialization has long been regarded as a fundamental pathway toward economic transformation, job creation, and technological advancement. For Nigeria, Africa's most populous country and largest economy, industrial growth is central to national development and economic diversification, especially in the context of reducing dependence on oil revenues. The manufacturing sector has emerged as a key component in driving inclusive and sustainable economic development, potentially catalyzing improvements in employment, infrastructure, and competitiveness (National Bureau of Statistics [NBS], 2022).

However, this growth trajectory unfolds against the backdrop of escalating global environmental concerns, including climate change, biodiversity loss, and resource depletion. Nigeria is particularly vulnerable to the adverse effects of climate change, ranging from desertification in the northern region to flooding and coastal erosion in the southern parts of the country (Federal Ministry of Environment, 2021). Ironically, the very industrial activities intended to promote development contribute significantly to greenhouse gas (GHG) emissions due to outdated technologies, low energy efficiency, and reliance on fossil fuels (International Renewable Energy Agency [IRENA], 2021).

As such, there is a growing imperative for Nigeria to pursue a model of industrialization that harmonizes economic development with environmental stewardship. This vision is embodied in the concept of green industrialization, which advocates for the adoption of low-carbon technologies, circular economy principles, and renewable energy systems in industrial processes (Zeng et al., 2020). Green industrialization thus presents a viable approach for Nigeria to decouple industrial growth from environmental degradation, while also enhancing global competitiveness, attracting green investment, and creating resilient supply chains (UNIDO, 2022).

Recent policy initiatives, such as Nigeria's Climate Change Act (2021) and the Energy Transition Plan (ETP), which targets net-zero emissions by 2060, signal a governmental commitment to climate-compatible development (Federal Government of Nigeria, 2021). Despite these high-level policy commitments, translating them into implementable and scalable strategies remains a challenge.

2.0 LITERATURE REVIEW

2.1 Conceptual Framework of Green Industrialization

Green industrialization refers to the integration of environmental sustainability into industrial development through the adoption of clean technologies, renewable energy, resource efficiency, and circular economy principles (UNIDO, 2016; Zeng et al., 2020). Unlike traditional industrialization that often entails environmental degradation, green industrialization aligns economic growth with climate resilience by minimizing carbon emissions and optimizing material use (Zhu et al., 2019).

For developing economies like Nigeria, this concept holds transformative potential. It enables countries to leapfrog carbon-intensive pathways by fostering low-carbon manufacturing systems that generate green jobs, attract sustainable investments, and enhance long-term competitiveness (Luken & Van Rompaey, 2020; Nhamo et al., 2020). Moreover, it supports the achievement of global climate targets, particularly those outlined under the Paris Agreement and Sustainable Development Goals (SDGs), especially SDG 9 (Industry, Innovation and Infrastructure) and SDG 13 (Climate Action) (United Nations, 2015).

2.2 Nigeria's Climate Commitments and Industrial Policy Nexus

Nigeria has signalled strong intent to reconcile climate and industrial objectives. The Climate Change Act (2021) legally enshrines climate governance, introducing carbon budgeting and oversight through the National Council on Climate Change (Adegbite & Nwafor, 2022). This is complemented by the Energy Transition Plan (2022), which outlines a net-zero trajectory by 2060 and prioritizes clean energy in industry (Federal Government of Nigeria, 2022).

Nigeria's updated Nationally Determined Contributions (NDCs) commit to reducing emissions by 20% unconditionally and 47% conditionally by 2030 (Federal Ministry of Environment, 2021). The 2023 Carbon Market Activation Plan further positions Nigeria to attract international climate finance through emissions trading systems and a national carbon registry (Nwachukwu et al., 2023).

However, implementation remains hindered by weak institutional coordination, regulatory overlap, and insufficient integration of climate goals into industrial planning (Onyekuru & Eze, 2020). The disconnect between policy ambition and execution continues to challenge Nigeria's industrial sustainability.

2.3 Green Manufacturing Initiatives in Nigeria

Various national and international initiatives are paving the way for green manufacturing. The United Nations Industrial Development Organization (UNIDO) has supported Nigeria in phasing out high-GWP refrigerants and deploying energy-efficient manufacturing processes (UNIDO, 2021). Additionally, the Green Manufacturing Policy and Investment Guide, developed in partnership with SEforALL offers strategic blueprints for sustainable industrial growth (SEforALL, 2022).

Green financing mechanisms, including the Bank of Industry's climate-aligned credit schemes and the Green Bond Programme, have been launched to support clean technology adoption (Vanguard News, 2025; CBI, 2022). Furthermore, the emergence of eco-industrial parks in Ogun and Bayelsa States powered by solar and natural gas demonstrates a shift toward low-carbon industrial zoning (Industrial Times, 2023).

Despite progress, these initiatives remain pilot-scale and often face financial, technical, and infrastructural barriers. Many manufacturers, especially SMEs, struggle to access affordable capital and lack technical expertise for green transformation (Ighodaro & Adeyemi, 2023).

3.0 METHODOLOGY

3.1 Research Design

This study adopts a qualitative, document-based research design to analyze Nigeria's evolving landscape of green industrialization. Given the policy-oriented nature of the research, this method enables in-depth exploration of legal, institutional, and infrastructural dimensions influencing the transition toward climate-compatible manufacturing.

3.2 Data Sources

Data were drawn from a purposive selection of secondary sources published between 2015 and 2025. Key documents include national policy frameworks such as the Climate Change Act (2021), the Energy Transition Plan (2022), the updated Nationally Determined Contributions (2021), and the Green Manufacturing Policy Guide (2022). Supplementary sources included technical reports and publications from international development organizations (e.g., UNIDO, IRENA, SEforALL UNEP), academic journals, and press releases from Nigerian agencies and media outlets.

3.3 Data Analysis

Thematic content analysis was employed to identify policy linkages, institutional gaps, and enabling mechanisms for green industrialization. Data were coded based on recurring themes such as policy coherence, financing instruments, technological infrastructure, and capacity building. Comparative insights from selected industry case studies were used to ground policy proposals in practical contexts.

To operationalize the thematic content analysis, the study used NVivo 12 software to code and categorize qualitative data from the reviewed documents. Coding was initially inductive, allowing themes to emerge organically from the data. A coding matrix was subsequently developed and refined as more documents were analyzed. Key themes included: policy coherence and misalignment, financing instruments and constraints, technological and infrastructural gaps, and institutional coordination. Cross-case analysis was used to validate emergent themes by comparing findings from policy documents with those drawn from the case studies. This approach ensured analytical rigor and consistency.

3.4 Case Study Selection

Two case studies, Sacral Industries and Nigerian Breweries Plc, were analyzed to illustrate successful applications of green industrial practices in Nigeria. These cases were selected based on relevance to industrial decarbonization, availability of verifiable data, and alignment with the country's climate goals.

To ensure relevance and analytical value, the case studies were selected based on three core criteria: Their practical demonstration of green industrial practices in Nigeria, the availability of verifiable secondary data, and their direct alignment with national climate or industrial policies. Sacral Industries was selected for its adoption of low-GWP refrigerant technologies in partnership with UNIDO, aligning with Nigeria's Kigali Amendment commitments. Nigerian Breweries Plc was chosen due to its integration of solar photovoltaic systems under a Power Purchase Agreement (PPA), reflecting the goals outlined in the Energy Transition Plan (2022). These cases represent diverse sectors and different decarbonization strategies, providing a comparative lens for assessing policy impact.

Table 1: Thematic Categories and Examples.

Theme	Description	Example Source
Policy coherence	Alignment or conflict between climate and industry laws	Climate Change Act (2021), ETP (2022)
Financing mechanisms	Green funding models and access constraints	BOI schemes, Green Bond Framework
Infrastructure readiness	Energy/logistics challenges in industrial zones	IRENA (2021), Industrial Times (2023)
Technical capacity and skills	Workforce development and regulatory competence	UNIDO training reports, UNEP (2021)

Source: Author's thematic analysis using NVivo 12 (based on reviewed documents and case studies, 2015–2025)

4.0 RESULTS AND DISCUSSION

4.1 Overview of Nigeria's Green Industrialization Policy Landscape

The evolution of Nigeria's policy framework reflects growing alignment between industrial growth and climate objectives. The Climate Change Act (2021) serves as the cornerstone legal instrument, mandating sectoral carbon budgets and establishing the National Council on Climate Change (NCCC) as the central coordinating body (Adegbite & Nwafor, 2022). Complementary instruments, such as the Energy Transition Plan (2022) and the National Renewable Energy and Energy Efficiency Policy (NREEEP), offer strategic direction for low-carbon industrialization, emphasizing the integration of clean energy, resource efficiency, and sustainable infrastructure.

However, findings reveal persistent fragmentation in regulatory frameworks. Overlaps among the Ministry of Environment, Ministry of Industry, Trade and Investment, and Energy Commission of Nigeria contribute to poor coordination and inconsistent enforcement. Weak institutional synergy limits the scalability of pilot projects and hinders the mainstreaming of climate-compatible industrial practices (Onyekuru & Eze, 2020).

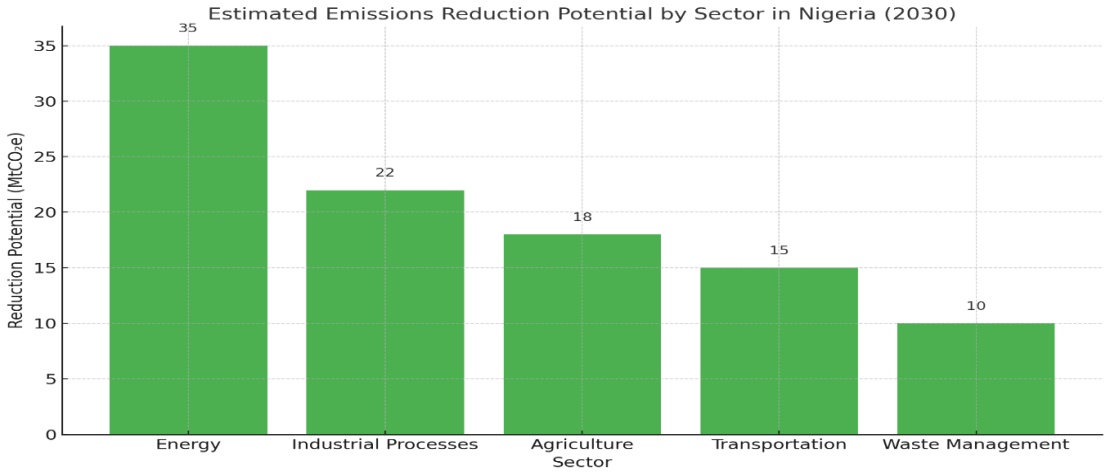

Figure 1: Estimated Emissions Reduction Potential by Sector in Nigeria (2030).

Source: Adapted from Nigeria's First Biennial Transparency Report (2024) and UNEP Sectoral Mitigation Potentials Report (2023).

This figure highlights that the energy sector presents the largest emissions reduction opportunity, primarily through renewable energy integration and grid modernization. Industrial processes and transportation also offer substantial mitigation potential, emphasizing the need for targeted technology upgrades and cleaner fuels in these sectors. These findings reinforce the urgency of sector-specific strategies within Nigeria's green industrialization agenda.

4.2 Financial and Technological Constraints

Green manufacturing in Nigeria is largely constrained by access to finance. While initiatives such as the Bank of Industry's green credit schemes and the Green Bond Programme have been introduced, uptake remains low among manufacturers, particularly SMEs, due to limited awareness, high interest rates, and lack of bankable project pipelines (Ighodaro & Adeyemi, 2023). Moreover, financial institutions lack the technical capacity to evaluate low-carbon investment opportunities.

Technologically, the industrial sector continues to rely heavily on obsolete, fossil-fuel-powered equipment. The absence of modern energy-efficient machinery, pollution control technologies, and renewable power solutions exacerbates GHG emissions and operational inefficiencies (IRENA, 2021). Infrastructure deficits, including unreliable grid power, inadequate transport systems, and weak waste management, further constrain progress.

Table 2: Comparative Summary of Nigeria's Key Climate-Industrial Policies.

Policy Instrument	Year	Primary Objective	Target Sector(s)	Implementation Status	Noted Gaps
Climate Change Act	2021	Establish legal framework for carbon budgeting	All sectors	Operational but under-resourced	Overlapping agency roles, weak enforcement
Energy Transition Plan (ETP)	2022	Net-zero emissions by 2060; clean energy in industry	Energy, Manufacturing	In progress	Sector-specific rollout unclears
Nationally Determined Contributions (NDCs)	2021	Reduce emissions by 20% (unconditional) and 47% (conditional) by 2030	All sectors	Updated and submitted	Limited integration into industrial policy
Green Manufacturing Guide	2022	Provide investment roadmap for low-carbon manufacturing	Manufacturing	Reference document	Weak institutional uptake
Carbon Market Activation Plan	2023	Monetize emissions reductions through carbon trading	Industrial, energy	Early stage	Requires MRV system, investor confidence

Source: Author's synthesis from national policy documents (2021–2023)

4.3 Emerging Best Practices: Evidence from Case Studies

4.3.1 Sacral Industries

Sacral Industries offers a successful example of green technology adoption. With technical assistance from UNIDO, the firm transitioned to using R-32 refrigerants with low global warming potential (GWP), thereby reducing over 27,000 tonnes of CO_2-equivalent emissions annually (UNIDO, 2021). This shift enhanced energy efficiency and reduced production costs while aligning with Nigeria's commitments under the Kigali Amendment. The case illustrates how regulatory incentives, technology transfer, and donor engagement can catalyze industrial transformation.

4.3.2 Nigerian Breweries Plc

Nigerian Breweries Plc has demonstrated leadership in renewable energy integration by deploying solar PV systems across brewery plants in Lagos and Ibadan. Facilitated through a

power purchase agreement (PPA) with Cross Boundary Energy, the installations are projected to offset 84,758 tonnes of CO_2 over 20 years and displace over 31 million litres of diesel (Industrial Times, 2023). The project highlights the potential of market-based instruments, such as PPAs, in enabling low-carbon manufacturing without significant upfront capital.

Table 3: Comparative Summary of Case Studies – Sacral Industries vs. Nigerian Breweries.

Feature	Sacral Industries	Nigerian Breweries Plc
Industrial Sector	Refrigeration and HVAC manufacturing	Beverage production
Green Intervention	R-32 refrigerant transition	Solar PV deployment under PPA
Emissions Reduction	27,000 tCO_2e/year	84,758 tCO_2e over 20 years
Funding Mechanism	UNIDO technical support	CrossBoundary Energy (private PPA model)
Policy Alignment	Kigali Amendment, UNIDO partnership	Energy Transition Plan, NDCs
Additional Benefits	Energy efficiency, cost savings	Diesel displacement, energy security

Source: UNIDO (2021); Industrial Times (2023); Nigerian Breweries Plc Sustainability Reports

4.4 Toward a Climate-Compatible Manufacturing Framework

Based on policy analysis and empirical examples, four strategic pillars emerge as essential for advancing climate-compatible manufacturing in Nigeria:

1. Policy Harmonization: Streamlining existing climate and industrial frameworks under a unified governance mechanism, led by the NCCC.
2. Green Financing Reform: Expanding concessional loans, green bonds, and emissions monetization tools while strengthening project bankability.
3. Technological and Infrastructure Upgrading: Scaling renewable energy deployment, modernizing manufacturing equipment, and investing in eco-industrial parks.
4. Capacity Building: Embedding green skills in vocational and tertiary curricula and enhancing the evaluative capacity of regulatory and financial institutions.

These pillars collectively address systemic barriers and provide a roadmap for operationalizing Nigeria's climate-industrial agenda.

5.0 SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary of Key Findings

This study examined the policy, institutional, and infrastructural requirements for advancing green industrialization in Nigeria. Findings reveal that while Nigeria has enacted progressive climate frameworks, including the Climate Change Act (2021), Energy Transition Plan (2022), and Nationally Determined Contributions (2021), a coherent strategy for translating these into scalable green manufacturing practices remains underdeveloped. Key barriers include:

1. Fragmented regulatory structures and limited institutional coordination;
2. Inadequate access to climate-aligned financing and project structuring expertise;
3. Technological obsolescence and critical infrastructure deficits;
4. Low technical capacity among SMEs and regulatory bodies.

Notably, case studies from Sacral Industries and Nigerian Breweries Plc demonstrate that climate-compatible manufacturing is feasible under the right mix of policy incentives, financial instruments, and technical assistance.

5.2 CONCLUSION

Nigeria stands at a pivotal crossroads where the quest for rapid industrialization must be reconciled with the growing urgency of climate change mitigation. This study has highlighted that green industrialization is not merely a desirable aspiration but an imperative for sustainable and inclusive development. It provides a viable framework for transforming Nigeria's industrial base into a low-carbon, resource-efficient, and competitive engine of growth, one that aligns national economic objectives with international environmental obligations.

The research revealed that Nigeria has made commendable policy advances, notably through the enactment of the Climate Change Act (2021), the development of the Energy Transition Plan (2022), and the implementation of updated Nationally Determined Contributions (2021). These frameworks collectively provide a strategic foundation for climate-compatible manufacturing. However, the evidence also points to significant gaps in regulatory coherence, infrastructure readiness, institutional capacity, and financial ecosystem design. These systemic issues continue to inhibit the full operationalization and scaling of green industrial practices across the country.

The selected case studies, Sacral Industries and Nigerian Breweries Plc, demonstrate that green industrial transformation is achievable and economically beneficial when supported by enabling policies, appropriate financing instruments, and targeted technical assistance. These examples serve as microcosms of what could be achieved at scale with deliberate policy harmonization, private sector engagement, and multi-stakeholder coordination.

Ultimately, this study concludes that green industrialization offers Nigeria an unprecedented opportunity to simultaneously achieve environmental sustainability, industrial modernization, and socio-economic resilience. The transition, however, will not occur organically. It requires intentional, coordinated, and sustained action across policy, finance, infrastructure, technology, and human capital development. Only by embedding green imperatives at the core of its industrial agenda can Nigeria chart a path toward a climate-resilient, inclusive, and prosperous future, one that not only fulfils its national development goals but also strengthens its position as a regional leader in sustainable industrial transformation.

5.3 Recommendations

- **Harmonize Climate and Industrial Policies**

Green industrialization requires a coherent and integrated policy environment. Currently, Nigeria's climate-related and industrial policies operate in silos, often leading to duplication, inefficiencies, and weak enforcement. Harmonizing these frameworks involves aligning the Climate Change Act (2021), Energy Transition Plan (2022), Nationally Determined Contributions (2021), and the Industrial Policy and Competitiveness Strategy into a unified national green industrial strategy.

Such integration should be anchored by the National Council on Climate Change (NCCC), which should be empowered to coordinate cross-sectoral policy implementation, conduct joint planning across ministries (e.g., Environment, Industry, Finance, and Energy), and ensure that climate targets are mainstreamed into national industrial development objectives. Additionally, establishing inter-agency working groups and institutionalizing a unified Monitoring, Reporting, and Verification (MRV) system will improve accountability and track progress toward emission reduction goals. This will also minimize regulatory overlap and foster consistency in compliance requirements for industries.

- **Expand and De-risk Green Financing**

One of the most persistent barriers to green industrialization in Nigeria is inadequate access to affordable and long-term climate finance. Financial institutions often lack the expertise to evaluate green projects, and industrial stakeholders, particularly SMEs, face high entry costs, limited creditworthiness, and lack of technical support to develop bankable proposals.

Expanding green financing requires a combination of direct government support and market-based mechanisms. First, public institutions such as the Bank of Industry should scale up concessional lending programs specifically targeted at clean technologies, renewable energy, and energy-efficient industrial processes. Second, the government must work with the financial sector to design credit enhancement mechanisms, such as partial risk guarantees, viability gap funding, and green insurance products, to mitigate investment risk.

- **Develop Climate-Resilient Industrial Infrastructure**

Infrastructure is a foundational enabler of green industrial transformation. However, Nigeria's industrial zones are often characterized by unreliable electricity supply, weak logistics systems, and poor waste management infrastructure, conditions that undermine sustainability efforts and deter green investment.

To address this, the government should prioritize the nationwide rollout of climate-compatible eco-industrial parks (EIPs). These parks should be equipped with renewable energy systems (e.g., solar mini-grids, gas-fired cogeneration), shared utilities (e.g., steam, water recycling), industrial symbiosis infrastructure (e.g., waste-to-energy facilities), and digital tools for emissions monitoring and energy management. Existing pilot projects in Ogun and Bayelsa states should be scaled nationally, supported by blended finance and donor-backed infrastructure investment.

Moreover, off-grid renewable energy deployment, especially in industrial corridors and export processing zones, can enhance energy reliability while reducing reliance on diesel generators. Investment in green logistics infrastructure, including electrified or gas-powered transport fleets, intermodal terminals, and smart warehousing, will further enhance industrial efficiency and environmental performance.

- **Institutionalize Technical Capacity and Innovation**

Technical capacity gaps remain a critical constraint to operationalizing green manufacturing across Nigeria. Many industrial operators lack the technical knowledge to implement clean technologies, while regulators and financiers often struggle to assess the environmental and financial viability of green projects.

Institutionalizing green skills development involves embedding sustainability content into vocational training, technical education, and university curricula. These programs should focus on renewable energy systems, energy auditing, lifecycle assessment, circular economy models, and industrial symbiosis. Training the future workforce in these areas ensures that local industries have the human capital required for long-term green transformation.

Simultaneously, government agencies, commercial banks, and regulatory institutions must be equipped with tools and training to evaluate green industrial projects, enforce compliance, and manage MRV systems effectively. South-South collaboration, technical assistance from multilateral agencies (e.g., UNIDO, SEforALL), and public-private partnerships in research and development (R&D) should be promoted to foster innovation hubs and demonstration projects.

- **Leverage Private Sector and Market Mechanisms**

The private sector is a crucial driver of innovation, investment, and operational efficiency in green industrialization. However, many Nigerian manufacturers operate in a regulatory vacuum with limited incentives to adopt sustainable practices.

To activate market-based engagement, the government should establish a national green certification scheme that recognizes companies for meeting specified sustainability benchmarks, such as reduced emissions, efficient resource use, and circularity. Certification can be tied to tax incentives, export promotion, and preferential access to public procurement contracts.

Encouraging participation in voluntary and compliance-based carbon markets will also allow industries to monetize emissions reductions, thereby turning sustainability into a competitive advantage. Introducing carbon pricing mechanisms, emissions trading platforms, and standardized project evaluation frameworks will deepen the domestic carbon market.

Finally, innovation ecosystems, including climate-tech incubators, clean manufacturing accelerators, and ESG-compliant investment platforms, should be developed to scale indigenous solutions and entrepreneurship in green manufacturing. Incentivizing R&D through fiscal allowances, grants, and patent support can further localize green technologies and reduce dependence on imports.

Table 4: Summary of Policy Recommendations and Responsible Institutions.

Recommendation	Key Actions	Lead Institutions
Harmonize climate and industrial policies	Policy review, inter-agency task force	National Council on Climate Change (NCCC), FMITI
Expand green financing access	Loan guarantees, blended finance, tax credits	Ministry of Finance, Bank of Industry (BOI)
Develop green infrastructure	Scale eco-industrial parks, invest in RE mini-grids	FMITI, Rural Electrification Agency (REA)
Build institutional & workforce capacity	TVET curriculum reform, regulator upskilling	NBTE, NUC, UNIDO, NESREA
Engage the private sector through markets	Green certification, carbon pricing, and procurement reform	NESREA, NCCC, Nigerian Exchange (NGX)

Source: Author's policy synthesis based on document analysis and case study findings

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