



Research Article

Evaluating Nigeria's National Grid and Its Constraints on Power Generation, Transmission, and Distribution

Oliver Linus Sunday^{1, 2, *} 

¹Independent Researcher, University of Uyo, Nigeria

²Royal Salt Industries Limited, Port Harcourt, Nigeria

Abstract

Nigeria's national electricity grid was established to unify power generation and supply across the country and to support broader economic development. Over time, however, it has become a critical bottleneck in the energy sector rather than the anticipated solution. This paper critically analyzes the effects of the national grid on Nigeria's electricity system across generation, transmission, and distribution. Drawing on secondary data from regulatory reports, international energy assessments, and policy documents, the study identifies several interconnected setbacks: stranded and underutilized generation capacity due to limited evacuation infrastructure. These often result in frequent partial and total grid collapses, chronic undersupply and instability at the distribution level, and a distorted cost structure driven by pervasive reliance on self-generation. The analysis further highlights governance and regulatory setbacks, weak investment incentives, and the historical neutrality of some state governments in grid-connected power development as key institutional factors causing an overreliance on a single, fragile backbone. In response, the paper proposes a reform pathway that repositions the national grid as one layer in a multi-level architecture, combining targeted transmission expansion, systematic promotion of private generation and distribution, and a policy framework that obliges and enables each state to take explicit responsibility for securing power for its residents. The study concludes that only a coordinated package of technical, institutional, and market reforms, anchored in decentralization, stronger state participation, and credible regulation, can transition Nigeria from a grid-dominated, high-risk system toward a more resilient, diversified, and sustainable electricity sector.

Keywords

Nigeria, National Grid, Electricity, Decentralization, Green Energy, Generation, Transmission, Distribution

1. Introduction

Nigeria's national electricity grid was designed to be the backbone of a modern economy: a unified, centrally coordinated system that would connect large power plants to every part of the country, enable efficient transmission of bulk elec-

tricity, and ensure that homes, industries, and public institutions receive reliable power. In theory, a national grid allows a country to balance regional disparities in supply and demand, achieve economies of scale in generation, and support industrialization and socio-economic development. In practice,

*Correspondence: Oliver Linus Sunday (oliversunday22@gmail.com)

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however, Nigeria's national grid has increasingly become the single most critical bottleneck in the energy value chain. Rather than solving the country's longstanding electricity crisis, it now amplifies systemic weaknesses across generation, transmission, and distribution, and has effectively transformed into an infrastructural and institutional trap for the sector.

On the generation side, Nigeria's challenge is not merely a deficit of installed capacity. Successive reforms and privatization efforts have led to a mix of large hydroelectric stations, numerous grid-connected gas-fired plants, and a small but growing portfolio of renewable projects. Official data suggest that installed capacity exceeds 12,000 MW, but the actual available capacity fluctuates widely and often falls below 4,500 MW to 5,000 MW [7, 9]. A major reason for this chronic underperformance is the grid's limited ability to evacuate and absorb power. Generating companies (GenCos) are frequently constrained by dispatch instructions they need to ramp down, not because they lack fuel or functional turbines, but because the transmission system cannot safely carry additional load without destabilizing the network [11]. In gas-rich areas, significant megawatts remain stranded, unable to reach demand centers due to weak or non-existent transmission corridors. Thus, the very platform that should harmonize and optimize generation across regions has become a structural ceiling on output, undermining investor confidence and distorting the economics of new generation projects.

The transmission segment, under the purview of the Transmission Company of Nigeria (TCN), reveals even more starkly how the national grid has evolved into a systemic vulnerability. Nigeria's high-voltage network comprises 330 kV and 132 kV lines and associated substations that cover a large, geographically diverse territory. However, this infrastructure has not been robustly expanded, modernized, or maintained in line with population growth, urbanization, and rising demand for electricity [5]. The result is a fragile system operating close to its technical limits. Grid disturbances, line overloads, voltage instabilities, and frequency deviations are common, and they often cascade into partial or total system collapses. Publicly available records show that Nigeria experiences multiple grid collapses virtually every year, with some years recording more than ten incidents [8, 10]. Each collapse, whether classified as "partial" or "total", remains symptomatic of a network that lacks adequate redundancy, automation, reactive power support, and real-time control.

These technical weaknesses carry significant economic and social consequences. Grid collapses translate directly into lost production for manufacturers, disrupted health and education services, and increased reliance on expensive self-generation - primarily diesel and petrol generators, which themselves impose substantial environmental and economic costs [6]. For many businesses, the grid has become an unreliable backdrop rather than a dependable utility, forcing them to internalize energy provision at great expense. This reality undermines the original rationale for a national grid: instead of lowering system-wide costs and enabling scale efficiencies, the current

configuration externalizes costs onto consumers, who pay twice, once through tariffs and again through private generation.

At the distribution level, the weaknesses of the national grid compound the longstanding structural and commercial challenges of the distribution companies (DisCos). Distribution networks in Nigeria are characterized by high technical and non-technical losses, inadequate metering, aging infrastructure, and widespread voltage instability [9]. Yet even where DisCos have the potential to serve more customers or improve service quality, their performance is intrinsically tied to the quantity and stability of power supplied through the grid. When the transmission system delivers insufficient or highly variable load, DisCos are forced into aggressive load shedding, rotating blackouts, and rationing, often without transparent schedules. This creates a vicious cycle: poor supply undermines revenue collection, weak revenue constrains investment in network upgrades and metering, and underinvestment in turn reinforces high losses and service unreliability.

Furthermore, the centralized nature of the national grid has historically limited the scope for localized solutions that could transform distribution performance. For many years, regulatory and policy frameworks assumed that the national grid would remain the dominant, almost exclusive, pathway for bulk power delivery. This discouraged the development of embedded generation, regional mini-grids, and state-level initiatives that might otherwise have relieved pressure on the central system or provided more tailored solutions to local demand patterns [11]. Only recently, following constitutional amendments and new

Regulations, have states begun to take more active roles in developing their own electricity markets and alternative grid or off-grid arrangements. However, the legacy of dependence on a vulnerable national grid continues to shape investment decisions, operational practices, and consumer expectations across the distribution landscape.

Underpinning these technical and operational issues is a complex political economy that reinforces the grid's problematic role. The national grid is not a neutral technical artifact; it is embedded in a web of institutional mandates, financial arrangements, and political interests that collectively determine how decisions about planning, investment, and operation are made. Federal agencies, the TCN, NERC, state governments, private GenCos and DisCos, development partners, and labour unions all exert influence over the direction of grid development. Disagreements over cost-reflective tariffs, subsidy regimes, market settlements, and risk allocation slow down urgently needed investments in grid reinforcement and modernization [7, 11]. In this setting, the centrality of the national grid becomes a liability: because so much hinges on a single, contested infrastructure system, reform is both politically sensitive and technically complex, often resulting in incremental, fragmented measures rather than the comprehensive restructuring that the sector requires.

Consequently, Nigeria's national grid today stands at the

heart of the country's electricity challenges. It constrains generation by limiting the evacuation and dispatch of available capacity, it undermines transmission reliability through frequent collapses and systemic fragility, and it impairs distribution performance by delivering unstable and insufficient power to already strained networks. More importantly, its dominance has delayed the emergence of diversified, decentralized, and resilient alternatives that could complement or partially displace a failing central architecture. This article interrogates how the national grid, initially conceived as the long-awaited solution to Nigeria's power deficit, has become the central problem of the energy sector. By examining its effects on generation, transmission, and distribution, and situating these within broader institutional and policy dynamics, the discussion will argue that any sustainable pathway out of Nigeria's energy crisis requires not just technical fixes but a fundamental rethinking of the role, structure, and centrality of the national grid itself.

2. Major Setbacks Caused by Nigeria's National Grid

Although the national grid was designed to unify and stabilize Nigeria's electricity system, it has become a central source of structural and operational setbacks. These setbacks cut across generation, transmission, distribution, market design, governance, and investment. This section outlines the key constraints, including the often-overlooked role of historical state neutrality in power generation.

2.1. Stranded and Underutilized Generation Capacity

A core paradox of Nigeria's power sector is the disconnect between installed capacity and actual delivered electricity. While total installed generation capacity is reported to exceed 12,000 MW, the power that reaches consumers frequently falls below 4,500 MW to 5,000 MW [7, 9]. This shortfall is not solely a function of fuel shortages or plant breakdowns; it is also a direct consequence of grid constraints.

Transmission bottlenecks, overloaded lines, and limited substation capacity mean that many gas-fired and hydropower plants are not dispatched at their technical potential.

The Transmission Company of Nigeria (TCN) frequently issues load-shedding and dispatch instructions that require generating companies (GenCos) to operate below capacity to prevent overloading and instability [11]. In effect, available megawatts become "stranded" at power stations because the national grid cannot safely evacuate them.

The implications are substantial. Investors and public authorities cannot fully recover the value of capital already invested in plants, discouraging additional generation investments. At the same time, industries and households continue to face chronic shortages, perpetuating a situation in which

Nigeria appears to have power plants on paper, but insufficient electricity in practice.

2.2. Frequent Grid Collapses and System Instability

The national grid has become synonymous with fragility. Nigeria experiences multiple partial and total system collapses almost every year, with some years recording more than ten incidents (8, 10). These collapses are triggered by a mix of technical and operational weaknesses:

- 1) Aging, poorly maintained transmission lines and equipment.
- 2) Inadequate reactive power and voltage control.
- 3) Weak system protection and automation.
- 4) Imbalances between generation, load, and available transmission capacity.

Because the grid is highly centralized and interconnected, local disturbances can rapidly cascade, forcing generators offline and plunging large geographic areas into darkness. Each collapse disrupts industrial output, essential services, and commercial activity, pushing consumers and firms toward expensive self-generation [6].

Even outside major collapse events, the system operates with frequent frequency and voltage fluctuations. These instabilities damage sensitive equipment, shorten the lifespan of appliances, and reduce the perceived value of grid power. Instead of functioning as a stabilizing backbone, the grid often transmits and amplifies instability across the network.

2.3. Chronic Undersupply to Distribution Companies

Distribution companies (DisCos) are the face of the power sector for most Nigerians, yet their performance is tightly constrained by the national grid. DisCos routinely receive less power than their declared demand, forcing them to ration supply and implement aggressive load shedding [9]. The problem is not only internal inefficiency, but structural undersupply from upstream.

This chronic undersupply produces a vicious cycle:

- 1) Operationally, DisCos cannot provide reliable service, regardless of consumer demand.
- 2) Financially, low energy volumes limit revenue, undermining their ability to invest in network rehabilitation, metering, and loss reduction.
- 3) Socially, erratic supply and opaque load-shedding schedules erode public trust, encourage non-payment, and normalize illegal connections.

In this way, the grid's inability to provide stable, adequate bulk power cascades directly into last-mile dysfunction. Even the most efficiently managed distribution utility would struggle under such upstream constraints.

2.4. Suppression of Decentralized and Alternative Solutions

Historically, Nigeria's power policy has been heavily grid-centric. Planning, regulation, and investment strategies were built around the assumption that the national grid would be the dominant vehicle for electricity delivery. This paradigm inadvertently suppressed or slowed alternative approaches, such as:

- 1) Embedded generation feeding directly into distribution networks.
- 2) Industrial cluster power plants with dedicated local grids.
- 3) Community-level mini-grids and off-grid systems.
- 4) Regionally coordinated or state-level power markets.

While recent reforms have begun to promote mini-grids and state participation, years of prioritizing the national grid created a "wait-for-the-grid" culture, particularly in underserved regions [11]. Many communities and industrial clusters that could have been effectively served by localized or hybrid solutions remained tethered to a central system that could not reliably meet their needs.

The result is a structurally unbalanced architecture: a single overstretched backbone is tasked with serving diverse geographic and economic realities that decentralized or multi-level configurations may better address.

2.5. Distorted Cost Structure and Heavy Reliance on Self-Generation

The failure of the national grid to deliver reliable power has pushed Nigeria toward a de facto generator economy. Households, small businesses, and large industrial firms invest heavily in diesel and petrol generators or captive power plants to protect themselves from grid unreliability. Studies consistently show that the cost per kilowatt-hour of self-generated power is several times higher than regulated grid tariffs [6, 11].

This has several distorting effects:

- 1) Businesses divert capital away from expansion and job creation into backup generation.
- 2) Small and medium enterprises struggle to remain competitive under high energy costs.
- 3) Households face significant financial burdens and health risks due to fuel costs, emissions, and noise.

In theory, a national grid should lower overall system costs by leveraging economies of scale. In Nigeria, the opposite has occurred: the grid's unreliability has driven up the true cost of reliable electricity, which is now borne privately by millions of users instead of efficiently shared through a robust public network.

2.6. Governance Gridlock and Politicization of Infrastructure

The national grid is deeply embedded in Nigeria's political economy. Decisions about planning, tariffs, subsidies, and investment in transmission infrastructure involve numerous

stakeholders, including federal ministries, TCN, NERC, state governments, private operators, labor unions, and development partners [11]. Because so much of the sector's performance depends on the grid, these decisions are highly contentious.

Efforts to introduce cost-reflective tariffs, restructure TCN, or prioritize certain transmission corridors often encounter resistance on political, social, or regional grounds. The high stakes associated with grid decisions frequently result in partial, delayed, or compromised reforms. Consequently, the grid's centrality intensifies governance challenges: it is simultaneously too important to neglect and too politically sensitive to reform quickly and comprehensively. This governance gridlock perpetuates underinvestment and technical weakness, reinforcing a cycle in which a politicized grid remains both structurally fragile and institutionally difficult to change.

2.7. Reduced Attractiveness for Long-Term Investment

From the perspective of investors, the national grid introduces multiple layers of risk into Nigeria's power sector. Reliable returns on investment require confidence in three things: the ability to generate power, the ability to evacuate and deliver it, and the ability to collect revenue from end-users. Grid weaknesses undermine each of these dimensions.

- 1) Volume risk: Generators face uncertainty about how much of their capacity will be dispatched due to evacuation constraints.
- 2) Delivery risk: Frequent collapses and instability threaten continuous bulk supply.
- 3) Revenue risk: Chronic undersupply and service unreliability affect DisCos' revenue collection and, by extension, payments to GenCos and other market participants [8].

These risks raise the cost of capital, shorten investment horizons, and discourage long-term commitments, particularly in grid-dependent assets. As a result, Nigeria struggles to mobilize the scale of patient capital required to overhaul its transmission network and significantly expand generation, perpetuating the sector's financing gap.

2.8. Historical State Neutrality and Over-centralization of Power Generation

An often-underemphasized structural setback is the historical "neutrality" or marginalization of state governments in grid-connected power generation. Under the 1999 Constitution and the Electric Power Sector Reform Act (EPSRA) 2005, key aspects of large-scale generation and transmission were largely centralized at the federal level [2]. Until the more recent constitutional amendment and the Electricity Act 2023, states had limited formal authority to develop and regulate their own grid-connected markets.

This over-centralization produced several adverse effects:

1) Slowed capacity expansion at the subnational level.

States that possessed the political will, resource endowment, and industrial base to support local generation projects were heavily dependent on federal planning and licensing. Decisions on siting new plants, integrating them into the grid, and structuring power purchase arrangements were driven predominantly from Abuja [7]. This slowed the pace at which state-specific opportunities could be converted into operational capacity.

2) Missed opportunities for regional and state-led grids.

In many federal systems, state or regional utilities complement the national grid, providing redundancy and targeted investments. In Nigeria, constitutional and regulatory constraints discouraged states from developing robust, state-owned or state-regulated grid systems that could operate alongside the national grid or partially relieve it [1]. This reinforced a single-grid model, making the national system.

A solitary backbone rather than one layer in a multi-tiered network.

3) Inadequate tailoring of solutions to local conditions.

Nigeria's states differ widely in resource profiles, with gas-rich states in the South, high solar potential in the North, and hydro opportunities across riverine belts. Yet a primarily federal, grid-centric planning model often applied relatively uniform approaches, rather than enabling states to design integrated power strategies aligned with their specific economic structures and energy resources [5]. State neutrality in core generation decisions limited the emergence of differentiated, locally optimized solutions.

4) Reinforcement of grid dominance and vulnerability.

By sidelining states in fundamental generation and transmission decisions, the institutional framework deepened the dominance of the national grid. Nearly all significant grid-connected investments had to be routed through a single national architecture and decision-making center [11]. This increased the burden on a system that was already technically fragile and underfunded, reducing the likelihood of parallel state or regional systems that could share risk and load.

5) Delayed transition to a multi-level electricity market.

The Electricity Act 2023 and recent constitutional changes now enable states to create their own electricity markets and regulatory regimes, including intrastate generation and distribution [4]. However, the decades-long history of centralization means that institutional capacity, regulatory expertise, and financing frameworks at the state level are still nascent [9]. The benefits of decentralization will therefore take time to materialize.

In sum, the historical neutrality of states in grid-connected power generation is more than a legal curiosity; it is a structural factor that reinforced overdependence on the national grid and limited the emergence of a more diversified, resilient, and competitive electricity landscape.

3. Re-Engineering Nigeria's Power Architecture Beyond a Fragile National Grid

The diagnosis of Nigeria's electricity crisis points to a central conclusion: the national grid, as currently structured and governed, is too fragile and too centralized to carry the entire weight of the country's energy ambitions. Overcoming the setbacks identified as: stranded capacity, recurrent collapses, chronic undersupply, distorted economics, governance bottlenecks, weak investment signals, and long-standing state neutrality requires a deliberate shift from a monolithic grid model to a more diversified, multi-actor, and multi-level power system. This section outlines key strategic directions for such a transition, with particular emphasis on deepening private sector participation and assigning clearer, enforceable responsibilities to state governments.

3.1. Recasting the National Grid as One Layer in a Multi-Level System

The first strategic step is conceptual: the national grid should no longer be treated as the sole backbone of the power system, but as one important layer in a networked architecture.

3.1.1. Regional and Subnational Transmission Networks

Developing more robust regional and sub-transmission networks can reduce the system-wide impact of disturbances and allow parts of the country to maintain supply even when the main grid is stressed. Carefully designed regional "loops" and subnational networks can host state-backed and private generators that serve local loads while still connecting to the wider grid under normal conditions [6]. This reduces the probability that a single fault cascades into a nationwide collapse.

3.1.2. Modernizing System Operations

Technically, Nigeria's transmission operations require significant modernization. Investment in advanced SCADA systems, phasor measurement units for wide-area monitoring, better protection coordination, and enforcement of updated grid codes would strengthen operational visibility and control [8, 11]. These tools are essential if the grid is to manage a more complex mix of central, state-led, and distributed generation sources without heightened instability.

3.2. Strategic Transmission Expansion to Release Stranded Capacity

Addressing stranded and underutilized generation requires

transmission planning that is proactive and integrated.

3.2.1. Corridor-Based Investment Priorities

Transmission expansion should be guided by corridor-based planning that explicitly targets:

- 1) Evacuation of existing gas and hydro capacity is currently constrained by weak lines.
- 2) Connection of major industrial and urban load centers to multiple sources of supply.
- 3) Future integration points for state-level and private generation projects.

A corridor-focused approach, rather than ad hoc line additions, increases the probability that new transmission infrastructure will meaningfully increase delivered energy [7].

3.2.2. Integrated Generation-Transmission Planning Mechanisms

Formal mechanisms that link generation expansion decisions to transmission planning, such as integrated resource planning or periodic least-cost expansion studies, are needed. These should be participatory processes that involve federal institutions, TCN, NERC, and state-level stakeholders, reducing the frequent mismatch between where new plants are built and where the grid can actually evacuate power [1].

3.3. Systematic Promotion of Private Power Generation and Distribution

Private participation is already present in Nigeria's power sector, but its potential remains underexploited. A more deliberate framework is needed to make private investment central, not peripheral, to future capacity and network development.

3.3.1. Expanding Private Generation Across Multiple Scales

A coherent strategy for private generation should recognize three complementary tiers:

- 1) Utility-scale IPPs: Bankable, long-term contracts backed by improved sector creditworthiness and partial risk guarantees can draw in large-scale independent power producers, especially in gas and renewables.
- 2) Embedded generation: Smaller plants directly connected to distribution networks can relieve.

pressure on the grid and supply power close to demand centers. Standardized interconnection rules, predictable tariffs, and simplified licensing procedures would help unlock this segment [11].

- 3) Captive and third-party generation: Industries with captive plants should be allowed, under transparent wheeling and commercial rules, to supply nearby consumers where economically efficient. This increases overall system utilization and can help stabilize local supply.

3.3.2. Strengthening Private Roles in Distribution

While the distribution companies are privately owned, additional private participation can be mobilized through structured models such as:

- 1) Franchise or sub-franchise arrangements within Distribution Company territories, allowing specialized operators to manage certain zones (e. g., industrial clusters, dense urban areas) under performance-based contracts.
- 2) Service concessions for metering, loss reduction, and network rehabilitation, tied to clearly defined performance indicators and timelines.

Such models can inject capital, managerial capacity, and targeted technical expertise.

Into distribution, provided that regulatory oversight is credible and contract enforcement is reliable [9].

3.4. From State Neutrality to Structured State Responsibility for Power Supply

Historically, Nigeria's constitutional and regulatory framework limited state governments' direct role in grid-connected generation and transmission, reinforcing a pattern of "state neutrality." With the 2023 constitutional amendment and the Electricity Act, this configuration is now open to change [4].

3.4.1. Policy Framework that Requires Each State to Secure an Adequate Supply

A forward-looking approach would move beyond simply allowing state participation to requiring each state to assume clear responsibility for meeting the bulk of its demand over time. This does not imply that every state must own power plants outright, but that each state must be accountable for:

- 1) Developing a State Electricity or Energy Plan, including projections of demand, supply mix, and infrastructure needs.
- 2) Facilitating or procuring generation and network projects—through public, private, or hybrid models, that are sufficient to serve its residents.
- 3) Establishing and empowering state-level regulatory institutions, within the national legal framework, to oversee intrastate generation and distribution [9].

A "duty-to-serve" concept at the state level would help counteract the long-standing practice of deferring responsibility solely to federal institutions and the national grid.

3.4.2. Capacity Building and Federal Support for State-Level Markets

To make such a policy credible, capacity support is essential. States will require technical assistance in power system planning, regulatory design, tariff setting, and contract negotiation. Federal agencies and development partners can provide structured programs to build this capacity, recognizing that states start from different institutional baselines [11]. At the same time, the federal government should continue to set minimum

technical, safety, and environmental standards and coordinate interstate power exchanges to avoid market fragmentation [1]. The goal is a layered system where empowered states complement, rather than undermine, national objectives.

3.5. Scaling Mini-Grids, Embedded Systems, and Industrial Cluster Power

Decentralized solutions are a necessary complement, not a rival, to grid and state-level developments.

3.5.1. Rural and Peri-Urban Electrification Through Mini-Grids

For many rural communities, extending the main grid is neither economically nor technically optimal. Mini-grids and stand-alone systems offer a more sustainable pathway to electrification, especially if supported by clear rules for tariffs, quality of service, and eventual interconnection with the main or state grids where appropriate [6]. Results from existing Nigerian mini-grid projects demonstrate that, with proper regulation and viability gap funding, such systems can provide more reliable power than the current grid alternative.

3.5.2. Power for Industrial and Commercial Hubs

Embedded generation linked to industrial parks, special economic zones, and commercial corridors can create self-reinforcing pockets of reliability and economic growth. Allowing flexible tariff arrangements and clear third-party access rules in these zones would encourage private investors to build and operate plants tailored to the specific needs of industrial users, while still respecting broader regulatory safeguards [5].

3.6. Reforming Sector Economics: Tariffs, Cost Recovery, and Targeted Protection

Technical measures will not yield sustainable improvements unless the sector's financial base is stabilized.

3.6.1. Predictable Path Toward Cost-Reflective Tariffs

A transparent, phased approach to tariff adjustment, anchored in a published methodology and automatic adjustment mechanisms, can restore credibility. While full cost reflectivity may not be immediate, reducing the gap between allowed revenue and actual costs is essential for attracting investment in both grid and off-grid segments [8].

3.6.2. Protecting Vulnerable Consumers Through Targeted Measures

To maintain social legitimacy, tariff reforms should be paired with targeted social protection instruments. Options include lifeline tariffs for minimal consumption, means-tested

subsidies delivered through existing social registers, and carefully designed cross-subsidies among consumer classes where feasible [11]. This approach preserves incentives for efficiency while safeguarding low-income households.

3.7. Governance, Transparency, and Contract Enforcement

Institutional reform must underpin all technical and market changes.

3.7.1. Clearer Mandates and Reduced Overlaps

Clarifying the respective roles of the Federal Ministry of Power, TCN, NERC, the Market Operator, and emerging state-level regulators is crucial. Overlapping mandates and blurred lines of authority have historically inhibited decisive action and accountability [1]. Streamlined institutional arrangements would enable faster, more coherent reform implementation.

3.7.2. Data Transparency and Performance-Based Regulation

Routine publication of high-quality data on grid performance, outages, dispatch patterns, and financial flows is vital for evidence-based regulation and scholarly scrutiny. Performance-based regulation, linking incentives and penalties to measurable indicators such as reliability, losses, and customer service, can help shift the sector from a culture of blame to one of measurable improvement [9].

3.7.3. Strengthening Contract and Market Rule Enforcement

For private and state-level investment to scale, participants must have confidence that contracts, PPAs, wheeling agreements, franchises, and concessions will be enforced predictably. Strengthening dispute-resolution mechanisms and insulating regulatory decision-making from ad hoc political interference are central to building this confidence [11].

3.8. Aligning Power Sector Reform with Industrial Strategy and Climate Goals:

Finally, power sector reform should be embedded in a wider development and sustainability agenda.

3.8.1. Linking Electricity Investments to Industrial Policy

Electricity planning should explicitly prioritize projects that support high-value economic activity, manufacturing corridors, agro-processing centers, logistics hubs, and digital infrastructure. Doing so increases the economic return per unit of new capacity installed and strengthens the political case for sustained sector investment [5].

3.8.2. Managing the Low-Carbon Transition

Nigeria's abundant solar potential and existing hydro resources provide an opportunity to reduce dependence on diesel and inefficient self-generation. Grid and market reforms should be designed to accommodate increasing shares of renewable energy, supported by flexible gas generation, storage, and demand-side management. This trajectory is consistent with both energy security and climate commitments [7].

4. Conclusion

This paper has examined how Nigeria's national electricity grid, conceived as the backbone of the power system, has evolved into a structural constraint that shapes failures at every stage of the value chain. Evidence from regulatory data and international assessments shows that the grid's limited evacuation capacity leaves substantial generation potential stranded and underutilized, even as demand remains unmet [7, 9].

Recurrent partial and total grid collapses further expose the fragility of the transmission network and undermine confidence in grid-supplied power [8, 10]. At the distribution level, chronic undersupply and poor power quality translate into persistent rationing, high losses, and customer dissatisfaction, pushing households and firms toward expensive and polluting self-generation [6, 11].

Beyond these technical symptoms, the analysis underscores the importance of institutional and political economy factors. Overlapping mandates, regulatory uncertainty, and weak contract enforcement have constrained investment and slowed the implementation of needed reforms [1, 11]. For many years, constitutional and legislative arrangements effectively confined core grid-connected generation and transmission decisions to the federal level, relegating states to a largely neutral or passive role [2, 3]. This centralization reinforced dependence on a single national grid and delayed the emergence of diversified, state-driven, and decentralized solutions. Although the Electricity Act 2023 and recent constitutional amendments now allow greater state participation, the legacy of this historical neutrality continues to shape institutional capacity and investment patterns [4, 9].

The findings of this study suggest that improving technical performance within an unreformed institutional framework will not be sufficient. A more fundamental reconfiguration of Nigeria's power architecture is required. First, the national grid must be recast as one component of a multi-level system that includes stronger regional and subnational networks, as well as mini-grids, embedded generation, and industrial cluster power schemes [5, 6]. Second, private sector participation in both generation and distribution needs to be actively promoted through bankable contracts, predictable and progressively cost-reflective tariffs, and transparent regulation that reduces perceived risk [8, 11]. Third, a clear policy framework should place explicit responsibility on each state to plan for

and secure adequate electricity supply for its residents, whether through state-owned projects, public-private partnerships, or privately financed plants operating under state-level regulatory oversight [1, 9].

At the same time, financial and governance reforms are indispensable. A gradual movement toward cost-reflective tariffs, combined with targeted support for low-income consumers, is necessary to restore sector solvency without undermining equity [11]. Clarifying institutional mandates, improving data transparency, and strengthening enforcement of market rules and contracts are crucial to attracting long-term capital and sustaining reform momentum [1, 9]. Aligning electricity planning with industrial policy and climate objectives, by prioritizing investments that support productive sectors and facilitate the integration of low-carbon resources, can further enhance the development impact of power sector investments [5, 7].

In sum, the central argument of this paper is that Nigeria's electricity crisis cannot be resolved by focusing on the national grid in isolation. The grid must be situated within a broader, more plural power architecture in which federal institutions, empowered state governments, private actors, and decentralized providers share responsibility for generation, delivery, and governance. Moving from a fragile, overcentralized model to a diversified and multi-layered system offers the most credible pathway toward reliable, affordable, and sustainable electricity for Nigeria.

Abbreviations

GenCos	Generating Companies
DisCos	Distribution Companies
TCN	Transmission Company of Nigeria
MW	Mega-Watt
kV	Kilo-Volt
NERC	Nigerian Electricity Regulatory Commission
EPSRA	Electric Power Sector Reform Act
SCADA	Supervisory Control and Data Acquisition

Author Contributions

Oliver Linus Sunday: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review and editing.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Oliver Linus Sunday is an independent researcher, a member of the Nigerian Society of Engineers (NSE) and the Nigerian Institute of Electrical and Electronic Engineers (NIEEE), and a writer with a strong interest in energy policy, sustainable development, and environmental governance in Nigeria and Africa. His research explores how institutional reform, clean energy investment, and equitable policy design can drive inclusive economic growth. As a passionate advocate for sustainable energy solutions, Oliver Linus Sunday seeks to contribute to evidence-based policymaking and national reform through original research and commentary.