American Journal of Sciences and Engineering Research

E-ISSN– 2348–703X, Volume 9, Issue 4, 2026

Governance, Regulation, and Measurement Integrity in Nigeria's Gas Sector: Case Study of the Eastern Gas Network

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Abstract: *Nigeria's natural gas sector is central to the country's industrialization and energy transition. However, institutional fragmentation, weak regulatory enforcement, and underinvestment in infrastructure have limited market development. The Nigerian Gas Transportation Network Code (NGTNC) 2020 and the Petroleum Industry Act (PIA) 2021 were introduced to address these governance challenges, but their success relies on the technical and structural integrity of fiscal metering systems. This study uses a mixed-methods governance diagnostic approach, combining a macro-level analysis of overlapping mandates between the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) with a 10-year case study (2015–2024) of a metering station in the Eastern Gas Network. The national assessment identifies ongoing institutional overlap, insufficient calibration oversight, and a lack of digital data validation platforms. The case study reveals significant asset degradation, with the Metering Infrastructure Condition index deteriorating from 0.4 to 1.8 over ten years. Extended calibration intervals of up to 11 months, coupled with regulatory enforcement gaps, led to increased metering errors (9.2%–11.6%) and a network system imbalance of 8.9% by 2024. The study frames fiscal measurement integrity as a core governance institution essential for commercial trust and investor confidence. To address revenue leakages, reduce reconciliation disputes, and implement the NGTNC effectively, the paper proposes a five-pillar reform blueprint. Key recommendations include formalizing an inter-agency memorandum of understanding to harmonize regulatory oversight, launching a National Metering Infrastructure Renewal Program, and creating a unified national gas data platform with blockchain technology to ensure data integrity and transparency.*

Keywords: *Metering; Institutional Fragmentation; Measurement; Integrity; Gas transportation; Governance, Regulation, Nigeria.*

I. Introduction

Nigeria's natural gas sector sits at the center of the country's industrialization ambitions, energy transition strategy, and long-term economic diversification agenda. With over 200 trillion cubic feet of proven reserves, Nigeria possesses one of the largest natural gas endowments in the world (World Bank, 2020). Yet, despite this abundance, the governance and regulatory architecture of the gas sector has historically been characterized by institutional fragmentation, weak enforcement, opaque commercial practices, and chronic infrastructure underinvestment (Iledare, 2022; Sovacool & Walter, 2019). These governance failures have constrained the development of a competitive, transparent, and efficient gas market capable of supporting industrial growth and attracting private capital.

The introduction of the Nigerian Gas Transportation Network Code (NGTNC) in 2020 and the

 Received-16-06-2026 Accepted- 25-06-2026

enactment of the Petroleum Industry Act (PIA) 2021 represent the most ambitious attempts to reform the governance of Nigeria's gas sector in decades (NGTNC, 2020; PIA, 2021). The NGTNC seeks to establish a transparent, rules-based framework for capacity allocation, system balancing, and commercial settlement in the gas transportation network. The PIA 2021 restructures regulatory institutions, clarifies roles, and aims to create a more predictable investment environment (NUPRC, 2022; NMDPRA, 2022). Together, these reforms are intended to modernize the sector, reduce regulatory uncertainty, and align Nigeria with global best practices (Bhattacharyya, 2019; Stern, 2014).

However, the effectiveness of these reforms depends critically on the integrity of the underlying governance systems, institutional coordination, and technical infrastructure—particularly fiscal metering, which serves as the commercial backbone of the gas market. Fiscal metering determines how gas volumes are measured, allocated, and monetized. Without accurate measurement, the mechanisms of the NGTNC—such as nominations, imbalance charges, and cash-out processes—cannot function reliably (Arpino et al., 2014; Jami & Raghunathan, 2021). Similarly, the regulatory objectives of the PIA 2021 cannot be achieved if institutional fragmentation and weak enforcement undermine the credibility of measurement systems (Hauge et al., 2020).

This paper argues that fiscal metering is not merely a technical subsystem but a governance institution—one that shapes incentives, determines revenue flows, and influences investment decisions (Li et al., 2022; Mutezo & Mulopo, 2022). In Nigeria, fiscal metering infrastructure has suffered from years of underinvestment, inconsistent calibration, and weak regulatory oversight (Oladokun & Akinyemi, 2020). These governance failures have contributed to measurement drift, system imbalance, revenue leakage, and commercial disputes (Brito et al., 2022). Yet, despite metering's centrality to gas-sector governance, the academic literature has paid limited attention to the institutional and regulatory dimensions of measurement integrity in African gas markets.

To address this gap, this study combines a national-level governance analysis with a detailed case study of a Gas Metering Station in the Eastern Gas Network. The case study provides empirical evidence of how governance failures manifest in operational systems. At the same time, the national analysis situates these failures within the broader institutional context of the NGTNC and PIA 2021. This dual approach allows for a comprehensive assessment of governance challenges and regulatory reform opportunities, consistent with best practices in institutional economics and energy-sector governance research (Eberhard & Godinho, 2017; Joskow, 1997).

The study is motivated by three key considerations:

1. Institutional Fragmentation: Nigeria's gas-sector governance has historically been fragmented, with overlapping mandates among regulatory agencies, unclear accountability structures, and inconsistent enforcement (Iledare, 2022). The PIA 2021 attempts to address these issues by creating two new regulators—the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) and the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA). However, early evidence suggests that fragmentation persists, particularly in areas such as metering oversight, data governance, and system balancing.
2. Technical Alignment: The success of the NGTNC depends on the integrity of technical systems such as fiscal metering, SCADA, and data-governance platforms. Without accurate measurement and transparent data flows, the Code's market-based mechanisms cannot function effectively (Helm, 2017; Stern, 2014). This raises important questions about the alignment between regulatory design and technical capability.
3. Industrial Demand: Nigeria's industrial gas demand is expanding rapidly, driven by growth in fertilizer production, petrochemicals, manufacturing, and power generation (World Bank, 2020). As demand increases, the economic consequences of governance failures become more pronounced. Weak governance increases commercial risk, reduces investor confidence, and undermines the competitiveness of the industrial sector (Mutezo & Mulopo, 2022).

This paper provides the first integrated governance-and-infrastructure analysis of fiscal metering under the NGTNC and PIA 2021, introducing a specialized governance diagnostic framework to evaluate institutional fragmentation, regulatory enforcement, and data governance integrity. Empirical evidence from the Eastern

Gas Network demonstrates how these governance failures directly translate into severe operational and economic losses. Ultimately, the analysis builds toward a comprehensive governance-reform blueprint that outlines actionable pathways for institutional harmonization, digital governance, regulatory strengthening, and infrastructure renewal.

1.1 Governance and Institutional Economics in Energy Markets

Governance in energy markets shapes decision-making, resource allocation, and institutional behavior (Bhattacharyya, 2019; Sovacool & Walter, 2019). The institutional economics literature emphasizes that the quality of governance determines market efficiency, investment flows, and sectoral performance (Joskow, 1997). In natural gas markets, governance frameworks regulate access to infrastructure, define commercial rules, enforce technical standards, and ensure transparency (Stern, 2014). Nigeria's gas sector has long suffered from governance weaknesses, including regulatory overlap, inconsistent enforcement, and opaque commercial practices (Iledare, 2022; World Bank, 2020). These issues have contributed to underinvestment, infrastructure degradation, and limited market development (Eberhard & Godinho, 2017).

1.2 Regulatory Fragmentation and Institutional Overlap

Regulatory fragmentation occurs when multiple agencies share overlapping mandates, leading to duplication and weak accountability (Helm, 2017). Before the PIA 2021, Nigeria's regulatory landscape was fragmented among the Department of Petroleum Resources (DPR), the Petroleum Products Pricing Regulatory Agency (PPPRA), and the Petroleum Equalization Fund (PEF) (Iledare, 2022). While the PIA 2021 sought to explicitly address these issues by creating two distinct regulatory bodies—the NUPRC for upstream regulation and the NMDPRA for midstream and downstream regulation—early evidence suggests that institutional fragmentation stubbornly persists. This ongoing overlap and lack of clarity are particularly evident in critical areas such as metering oversight, data governance, system balancing, tariff regulation, and infrastructure monitoring (NMDPRA, 2022; NUPRC, 2022).

1.3 Measurement Integrity as a Governance Institution

Fiscal metering is increasingly recognized as a governance institution rather than a purely technical subsystem (Li et al., 2022). Accurate measurement underpins core functions like revenue allocation, tariff settlement, system balancing, contract enforcement, and overall market transparency (Arpino et al., 2014). When metering is inaccurate, it introduces significant uncertainty into commercial transactions, thereby increasing disputes and undermining trust among market participants. Studies across Europe, North America, and the Middle East confirm that maintaining strict measurement integrity is essential for driving market efficiency and sustaining investor confidence.

1.4 The Nigerian Gas Transportation Network Code (NGTNC)

The NGTNC represents Nigeria's first attempt to create a transparent, rules-based gas transportation market by establishing clear capacity allocation rules, structured nominations and scheduling procedures, and robust balancing mechanisms (NGTNC, 2020). Furthermore, the Code implements formalized cash-out processes alongside strict metering and data-governance requirements to ensure market integrity. Early assessments of the NGTNC suggest that implementation has been seriously constrained by weak metering infrastructure, inconsistent data reporting, limited digital governance, and ongoing regulatory fragmentation (World Bank, 2020).

1.5 The Petroleum Industry Act (PIA) 2021 and Governance Reform

The PIA 2021 represents the most comprehensive petroleum-sector reform in Nigeria's history, aiming to improve regulatory clarity, attract private investment, and strengthen institutional governance across the industry (PIA, 2021). However, institutional reform literature warns that legal changes alone are insufficient; effective implementation requires robust institutional capacity, modern technical infrastructure, clear accountability structures, and strong enforcement mechanisms (Eberhard & Godinho, 2017).

1.6 System Imbalance, Data Governance, and Transparency

The literature shows that system imbalance increases significantly when metering systems are inaccurate, data governance is weak, calibration is inconsistent, and infrastructure is aging (Brito et al., 2022). In mature gas markets, imbalance is tightly controlled—typically remaining below 2%—through digital metering,

automated data validation, real-time monitoring, and strong regulatory oversight (Stern, 2014). In Nigeria, imbalance levels are significantly higher, reflecting deep-seated weaknesses in governance and infrastructure (World Bank, 2020).

1.7 Governance Failures and Investment Risk

Investment in gas infrastructure is highly sensitive to governance quality (Mutezo & Mulopo, 2022). Weak enforcement, data opacity, and infrastructure degradation increase commercial risk and reduce investor confidence (Helm, 2017). Investors require predictable revenue flows, transparent rules, and reliable measurement systems. When governance is weak, the cost of capital increases, investment is delayed, and infrastructure deteriorates.

1.8 Gaps in the Literature

This study addresses critical gaps in the governance dimensions of fiscal metering (Li et al., 2022), the need for an integrated governance-and-infrastructure analysis (Sovacool & Walter, 2019), and the persistent issue of institutional fragmentation in emerging gas markets (Iledare, 2022). By addressing these gaps, this study contributes new insights to the broader literature on energy-sector governance, regulatory reform, and measurement integrity.

II. Methodology

2.1 Research Design

This study adopts a mixed-methods governance-diagnostic design that integrates national-level institutional and regulatory analysis with a targeted case-study analysis of a metering station within the Eastern network. The facility was selected as a case study due to its role as a critical custody-transfer node, where gas volumes distributed between the operator and downstream off-taker are quantified. To build a comprehensive assessment, the design couples a documentary analysis of key regulatory instruments—specifically the NGTNC and PIA 2021—with qualitative coding of identified governance failures and empirical quantitative evidence drawn directly from metering performance data.

2.2 National-Level Governance Analysis

The national-level analysis focuses on the implementation of the NGTNC (2020) and the PIA 2021, specifically examining the evolving institutional roles of the NUPRC and NMDPRA. It evaluates historical governance failures, persistent regulatory fragmentation, ongoing enforcement gaps, and critical data-governance weaknesses within the network.

Data Sources: The analysis draws on a comprehensive body of evidence, including the PIA 2021 legislation, NGTNC operational guidelines, regulatory circulars, and official directives. Each of these foundational documents is systematically analyzed using a specialized Governance-Diagnostic Framework (GDF).

2.3 Case-Study Methodology

The case study method follows established best practices in infrastructure governance research (Eberhard & Godinho, 2017). The facility was selected due to its role as a high-volume custody-transfer point, aging infrastructure, documented calibration irregularities, significant system imbalance, regulatory enforcement gaps, and the availability of 10 years of continuous data.

2.4 Qualitative Coding and Thematic Analysis

To systematically evaluate governance performance, the study develops a Governance-Diagnostic Framework (GDF) structured around five core pillars: Institutional Clarity, Regulatory Enforcement, Technical Governance, Transparency & Data Integrity, and Accountability & Compliance. The study employed a three-stage qualitative coding process (open, axial, and selective).

2.5 Quantitative Evidence Integration

The study integrates metering error trends and calibration intervals to track progressive measurement drift

and verify whether instrument maintenance meets industry standards. These technical variances are directly linked to system imbalance percentages, which quantify volumetric gaps.

2.6 Triangulation Strategy

Triangulation of regulatory documents, operational data, and institutional reports follows established governance assessment methodologies (Sovacool & Walter, 2019).

2.7 Methodological Contribution

This study contributes methodologically by developing a Governance-Diagnostic Framework tailored to gas-sector regulation and integrating governance analysis with technical-infrastructure evidence.

III. Results

3.1 National Governance Assessment Under the PIA 2021

The GDF reveals that while the PIA 2021 introduced significant structural reforms, implementation challenges persist across all five governance pillars:

3.1.1 Pillar 1: Institutional Clarity (Score: 2.5/5)

3.1.2 Pillar 2: Regulatory Enforcement (Score: 2.1/5)

3.1.3 Pillar 3: Technical Governance (Score: 1.8/5)

3.1.4 Pillar 4: Transparency and Data Integrity (Score: 2.3/5)

3.1.5 Pillar 5: Accountability and Compliance (Score: 2.0/5)

3.2 Regulatory Fragmentation and Institutional Overlap

Both NUPRC and NMDPRA continue to issue parallel directives on metering standards, calibration requirements, and data-reporting formats. This dual oversight creates confusion and inconsistent compliance.

3.3 Technical Governance and Measurement Integrity Findings

Across the Eastern Gas Network, infrastructure is severely outdated: 60% of meters exceed their recommended lifespan, 45% show advanced signs of measurement drift, and 30% lack digital diagnostics.

3.4 Case-Study Findings:

The case-study findings at the metering facility provide empirical evidence of how national governance failures manifest in operational systems. See the table below.

Period / Year	Metering Infrastructure Condition (MIC) (0-2 Scale)*	Average Index Error (%)	Metering Network Imbalance (%)	System Actual Calibration Interval (Months)
2015–2017	0.4 (Good)	2.8% – 4.1%	2.5% (2015)	4 - 5 (Standard)
2018–2021	1.1 (Moderate Degradation)	5.6% – 8.3%	Dynamic Drift	4 – 7
2022–2024	1.8 (Severe Degradation)	9.2% – 11.6%	8.9% (2024)	4 – 11

3.5 Synthesis of Results

The combined findings reveal that governance failures across the network are systemic rather than isolated. Institutional fragmentation severely undermines regulatory effectiveness, and technical governance has emerged as the weakest link in the chain of gas-sector reform.

IV. Discussion

4.1 Institutional Fragmentation and Regulatory Clarity

The findings demonstrate that institutional fragmentation remains a central governance challenge in Nigeria's gas sector, despite the structural reforms introduced by the PIA 2021. Although the Act clearly delineates upstream and midstream/downstream responsibilities between NUPRC and NMDPRA, operational realities reveal persistent overlap in key areas such as metering oversight, data governance, and system balancing.

4.2 Enforcement Capacity and Compliance Behavior

Regulatory enforcement is a critical determinant of governance effectiveness. The study finds that enforcement capacity in Nigeria's gas sector remains limited, despite the formal strengthening of regulatory institutions under the PIA 2021.

4.3 Measurement Integrity as a Governance Institution

One of the most important contributions of this study is the conceptualization of measurement integrity as a governance institution rather than a purely technical subsystem, echoing insights from metering integrity literature (Arpino et al., 2014; Li et al., 2022).

4.4 Implications for NGTNC Implementation

The NGTNC was designed to introduce transparency, efficiency, and non-discriminatory access into Nigeria's gas transportation system (NGTNC, 2020). However, the findings reveal that governance and technical weaknesses significantly hinder its implementation, yielding four key implications: Unreliable Capacity Allocation, Failure of Balancing Mechanisms, Compromised Data Transparency, and Prolonged Commercial Disputes.

V. Conclusion and Policy Recommendations

5.1 Conclusion

This study examined the governance, regulatory, and measurement-integrity challenges affecting Nigeria's gas transportation system under the NGTNC and the PIA 2021. By combining a national-level institutional analysis with a detailed case study of the chosen Gas Metering Station, the research provides a comprehensive assessment of how governance failures manifest in operational systems.

5.2 Policy Recommendations

Based on the findings, this study proposes a comprehensive governance-reform blueprint structured around five pillars:

5.2.1 Pillar 1 — Institutional Harmonization: Establish a formal MoU between NUPRC and NMDPRA.

5.2.2 Pillar 2 — Strengthening Regulatory Enforcement: Enforce strict calibration requirements aligned with ISO 15112 and OIML R140.

5.2.3 Pillar 3 — Technical Governance and Infrastructure Integrity: Launch a National Metering Infrastructure Renewal Program.

5.2.4 Pillar 4 — Digital Transformation and Data Governance: Establish a Unified National Gas-Data Platform.

5.2.5 Pillar 5 — Accountability, Transparency, and Market Confidence: Create a dedicated judicial/administrative tribunal.

5.3 Implications for Policy and Practice

The proposed reforms provide improved clarity of mandate, stronger enforcement capacity, enhanced technical oversight, and superior data visibility across the sector.

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