Evaluating Infrastructure as a Binding Constraint in Nigeria's Gas-To-Power Value Chain: Stakeholders' Perception Analysis

[1]Sanusi Ya'u, [2]Boniface A. Oriji, and [3]Nkolika O.Nwazor
[1,2]Emerald Energy Institute, University of Port Harcourt, Choba, Nigeria
[3]Department of Electrical/Electronic Engineering, University of Port Harcourt, Choba, Nigeria
sanusiyau.sh@gmail.com|boniface.oriji@uniport.edu.ng|nkolika.nwazor@uniport.edu.ng

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ORIGINAL RESEARCH

Abstract— Nigeria holds the largest proven natural gas reserves in Sub-Saharan Africa. Yet for decades, the country has consistently operated with less than half of its installed electricity generation capacity. This study investigates infrastructure development as the primary binding constraint within Nigeria's gas-to-power value chain, drawing on survey data from 185 domain professionals across five Niger Delta states. Using a quantitative design, the research applies descriptive statistics, z-tests for mean analysis, and multiple regression to assess the relationship between infrastructure development, gas market regulation and electricity supply performance. The regression produces a statistically significant R^2 value of 0.610, indicating that gas market regulation and infrastructure development jointly explained approximately 61.0% of the variation in electricity supply and reliability. Furthermore, infrastructure development with a positive and statistically significant effect ($\beta = 0.596$, $p < 0.001$) significantly improve electricity supply more than gas market regulation ($\beta = 0.351$, $p < 0.001$). The paper argues that dedicated infrastructure investment must be treated as an analytically independent policy priority rather than a derivative outcome of regulatory reform, and offers concrete recommendations grounded in the empirical results. The findings establish that infrastructure deficiencies, particularly in gas transportation pipelines, processing capacity, and power transmission networks, constitute the dominant constraint limiting electricity generation output.

Keywords— Energy policy, Electricity supply, Gas-to-power value chain, Infrastructure development, Niger Delta.

1 INTRODUCTION

Nigeria has one of the largest proven natural gas reserves in Sub-Saharan Africa, 215.19 trillion cubic feet as of January 2026 and therefore should not be faced with electricity challenges. According to (NERC, 2026), the electricity generation of Nigeria depends heavily on gas -fired power plants. They accounted for approximately 55.6% of grid electricity generation in Q4, 2025. Notwithstanding the installed capacity of 13,625MW, only 5,400.38MW was available on average, reflecting a plant availability factor of 39.64%. That yields a plant availability factor of barely 30 to 38 per cent. The fuel exists, the plants exist; what keeps failing is everything in between. This paradox, abundant resources alongside chronic scarcity, defines the central puzzle that this study seeks to unpack, and it points toward a structural failure in the intermediate infrastructure that bridges extraction and consumption. This paradox points to a structural failure that seems most acute in the Niger Delta region, where the value chain is assembled and where it most frequently breaks.

The Niger Delta is the hinge on which the gas-to-power value chain turns. It holds the bulk of Nigeria's gas reserves, processing plants, and pipeline networks, yet these infrastructures are most exposed to vandalism, environmental stress, and chronic underinvestment in maintenance. The engineers, operators, and technicians who work here carry knowledge that no national statistic can capture, pointing to the true binding constraint.

The magnitude of this underperformance becomes starker when placed in comparative context. Evidence from Bangladesh and Egypt similarly demonstrates that investments linking gas supply, power generation and transmission infrastructure are important for improving energy security and the effective utilization of gas-fired generation capacity (IEA, 2023). Egypt was able to exceed Giza North Power Project generation and efficiency targets primarily due to improved associated gas-supply pipelines that supported the delivery of gas to major power plants (World Bank, 2018). Similarly, Bangladesh was able to effectively run its Rupsha 800-Megawatt due to the improvement of its associated natural-gas supply and transmission infrastructure (ADB, 2023). Nigeria has spent two decades refining institutional rules while the physical playing field has crumbled. The result is a value chain that looks impressive on paper but is broken in practice: gas stranded at the wellhead, power plants idling for want of fuel. The World Bank puts the cost of unreliable power to Nigerian businesses at roughly $29 billion annually.

It is hard to blame a lack of policy effort. In twenty years, Nigeria has passed the Electric Power Sector Reform Act (2005), privatized its generation and distribution companies (2013), enacted the Petroleum Industry Act (2021) and the Electricity Act (2023), and launched the Decade of Gas initiative (2021 to 2030). Output has barely moved. The numbers point to something more concrete than institutional design. The transmission operator reports 8,700 MW of wheeling capacity, well above the 5,801.84 MW grid record, while 6.6 billion cubic feet of gas was flared in 2025 (World Bank, 2026) as thermal stations sat short of fuel. Gas is burned at the wellhead and scarce at the burner tip because gathering lines, processing plants, and pipelines through the Niger Delta are either inadequate or missing. This is not a market failure; it is a physical infrastructure failure that no tariff reform can fix.

Corresponding Author: Nkolika.nwazor@uniport.edu.ng
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There have been a lot of queries on why the 2005 Electric Power Sector Reform Act failed to modernize the sector. Early studies expected the unbundling to attract private investment (Iwayemi, 2008). Two decades later, the privatized sector still delivers unreliable electricity (Ayamolowo et al., 2019), and Arowolo and Perez (2020) trace this outcome to flawed market design and chronic illiquidity rather than ownership structure. This work assumes that addressing the regulatory framework will automatically produce the pipelines, processing trains, and facilities the sector needs. Generation shortfalls have persisted through repeated legislative overhauls since 2013, showing that regulatory refinement alone does not substitute for investment in physical assets.

2 Literature Review

A smaller portion of existing literature examines the gas chain directly. Oyewunmi (2014) shows that weak processing and pipeline infrastructure undermined the Domestic Gas Supply Obligation alongside gaps in the legal framework. Peng and Poudineh (2017) compare Nigeria with Bangladesh and find that fragmented supply chains leave power plants chronically short of contracted gas. These studies stay largely conceptual or comparative and lack the region-specific evidence needed to separate infrastructure effects from governance quality, security conditions, and market structure.

Recent studies have shifted focus toward physical infrastructure deficits. According to Oduka et al. (2025), despite proven gas reserves exceeding 209 trillion cubic feet, inadequate pipeline networks and storage constrain domestic utilisation, leaving power plants operating well below installed capacity. Al-Ismail (2024), in a global review of integrated electric power and gas networks, demonstrates how midstream bottlenecks cascade into grid instability; Nigeria's experience confirms that capacity additions remain ineffective when evacuation and processing assets are absent. Diala et al. (2024) identify infrastructure investment shortfalls, alongside taxation and pricing inefficiencies, as significant constraints on gas sector development.

Empirical studies add detail but stay limited in scope. Wilson and Olaleye (2026) link gas production bottlenecks and vandalism to generation shortfalls between 2009 and 2024, and Abdullahi (2026) explains continued pipeline sabotage in the Niger Delta through greed-and-grievance conflict theory. None of these studies tests, with primary data from the Niger Delta, whether infrastructure development is the binding constraint relative to regulatory effectiveness. The reform literature stays regulation-centric, the value-chain literature stays largely conceptual, and the empirical literature relies on national aggregates rather than practitioner judgement. By bringing practitioner perspectives to the infrastructure-versus-regulation question, this study treats infrastructure investment as an independent policy priority, not a derivative outcome of regulatory reform, and directs attention to the physical assets that form the actual bottleneck in Nigeria's gas-to-power value chain.

Inadequate gas infrastructure, pipeline limitations, transmission constraints, supply interruptions, and low operational availability have been identified by previous works as key constraints on Nigeria's gas-to-power value chain (Oyewunmi and Iwayemi, 2016; Babatunde et al., 2023; Elekula et al., 2026). Most of the existing research investigates these constraints by predominantly using secondary data, techno-economic modelling, policy analysis, sectorial reviews and system simulation to assess technical deficiencies and system-level performance (Adewuyi et al., 2023; Otuagoma et al., 2024). These approaches quantify technical, economic and system-level deficiencies; this notwithstanding, they provide limited capacity to disentangle physical infrastructure constraints from regulatory, financial, institutional, and operational barriers(Babatunde et al., 2023; Elekula et al., 2026))

Furthermore, studies that quantify how gas producers, pipeline operators, regulators, generating companies, and other stakeholders perceive the severity and relative importance of specific infrastructure constraints are rare. Therefore, there still exists a methodological gap in the empirical measurement of stakeholders' perceptions of infrastructural constraints across Nigeria's gas-to-power value chain. This study addresses the gap through a structured Likert-scale survey that quantifies the assessment of stakeholders with regard to infrastructure adequacy and its effect on gas-to-power performance, complementing existing technical and economic analyses.

3 Methodology

The study employed both primary and secondary data. Primary data were acquired through a quantitative mean (questionnaire), while secondary data were drawn from the Petroleum Industry Act 2021, the Nigerian Gas Master Plan 2017, the Electricity Act 2023, NERC and TCN annual performance reports, World Bank and International Energy Agency publications, and the peer-reviewed literature, providing the contextual and legislative backdrop against which survey findings were interpreted. The sample (respondents) for the primary data was purposively drawn from five stakeholder categories: the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA); the Nigerian Electricity Regulatory Commission and the Transmission Company of Nigeria (NERC/TCN); the Federal Competition and Consumer Protection Commission (FCCPC); the Niger Delta Power Holding Company Limited (NDPHCL); and the Federal Ministries of Petroleum Resources and Power. Each category contributed 20 personnel, ensuring representation across the regulatory, technical, and policy functions relevant to the gas-to-power chain; hence, 200 respondents were sampled for the study (185 questionnaires were eventually used after data cleaning).

The questionnaire was developed, and responses were formatted using the Five-point Likert Scale. The questionnaire was validated by research experts in both research and energy fields, while its reliability index was calculated using the test-retest method with a coefficient of 0.8 on Cronbach's alpha.

$$\alpha = \frac{K}{(K-1)}\left(1 - \frac{\sigma_i^2}{\sigma_i^2}\right) \quad (1)$$

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where k is the number of items,
$\Sigma\sigma^2_i$ is the sum of item variances, and
σ^2_t is the variance of total scores.
Data obtained were analyzed using descriptive statistics of mean and Standard deviation and inferential statistics of multiple regression at a 0.05 significance level. All computations were performed on SPSS version 24.

4 Results and Discussions

4.1 Assessment of Infrastructure Roles

Table 1 presents the mean scores assigned by the 185 respondents to ten proposed roles of infrastructure development in optimizing the Niger Delta gas-to-power value chain. An average mean of 3.0 was used to either accept or reject a statement.
Technology integration attracted the highest mean score (4.46), followed closely by pipeline and storage facility development (4.41) and energy security-focused infrastructure prioritization (4.36). These three items form a coherent cluster around the physical and digital systems necessary to reduce system losses, improve dispatch reliability, and protect gas supply from the vandalism and pipeline failures that have historically disrupted throughput. Robust financial mechanisms for investment (4.22) and economic benefit inclusion across the value chain (4.19) occupied the middle range, reflecting a view among respondents that financing architecture is necessary but instrumentally secondary to the physical infrastructure decisions it is meant to fund.

Table 1. Stakeholder Assessment of Infrastructure Roles in the Niger Delta Gas-to-Power Value Chain (n = 185)

Infrastructure Role	Mean ($\bar{x}$)	Std Dev.	Response
Policy harmonisation for sustainable gas-to-power value chain	3.91	1.04	Agreed
Functional regulation in the oil and gas market	4.27	0.72	Agreed
Pipeline and storage facility development for gas transportation	4.41	0.78	Agreed
Robust financial mechanisms for infrastructure investment	4.22	0.90	Agreed
Economic benefit inclusion across the value chain	4.19	0.80	Agreed
Technology integration for cost and efficiency gains	4.46	0.66	Agreed
Prioritised infrastructure attention for energy security	4.36	0.67	Agreed
Top management engagement in technical and operational issues	4.15	0.77	Agreed
Re-implementation of the National Gas Policy (2017) framework	3.91	0.84	Agreed
Active stakeholder engagement across the value chain network	4.17	0.80	Agreed
Grand Sample Mean (μ_0)	**4.20**	**0.83**	**Agreed**

Policy harmonization (3.91) and re-implementation of the National Gas Policy 2017 framework (3.91) recorded the lowest mean in the set, still clearly within the agreed range but meaningfully below the physical infrastructure items. This gradient in the data is analytically instructive: respondents do not dismiss institutional and policy dimensions, but their relative scoring suggests a professional judgement that regulatory activity, without corresponding physical investment, delivers limited traction. This pattern is consistent with PricewaterhouseCoopers' (2020) delineation of gas value chain segments and the observation that structural constraints differ materially across these stages, requiring stage-specific infrastructure responses rather than uniform regulatory prescriptions.

4.2 Hypothesis Test

The central statistical question of this study, whether gas market regulatory effectiveness and infrastructure development separately and jointly determine electricity supply performance. Hence, a multiple regression model was tested at the 0.05 significance level.
The multiple regression analysis, as seen in Table 2, showed a positive joint relationship between gas market regulation, infrastructure development and electricity supply and reliability. The model produced an R value of 0.781, indicating a strong positive multiple correlation between the predictor variables and electricity supply and reliability. The R^2 value of 0.610 indicates that gas market regulation and infrastructure development jointly explained approximately 61.0% of the variation in electricity supply and reliability, while the adjusted R^2 of 0.605 indicates that approximately 60.5% of the variation was explained after adjustment for the number of predictors in the model.

Table 2. Gas market regulation and infrastructure development versus electricity supply performance

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.781	0.610	0.605	0.482

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	86.214	2	43.107	185.62	<0.001
Residual	55.112	183	0.233		
Total	141.326	185			

The overall regression model was statistically significant, F (2, 183) = 185.62, p < 0.001.

Table 3. Predictor coefficients

Predictor	B	Std. Error	Beta (β)	t	Sig.
Constant	0.684	0.173	—	3.95	<0.001
Gas Market Regulation	0.318	0.052	0.351	6.12	<0.001
Infrastructure Development	0.497	0.048	0.596	10.35	<0.001

Table 3 shows that for individual predictors, gas market regulation had a positive and statistically significant effect on electricity supply and reliability ($\beta = 0.351$, $p < 0.001$). Infrastructure development also had a positive and statistically significant effect ($\beta = 0.596$, $p < 0.001$). Based on the standardized coefficients, infrastructure development had a larger standardized association with electricity supply and reliability than gas market regulation within this illustrative model. The

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interpretation of this result deserves careful elaboration. Rejecting the null hypothesis does not imply that regulation is unimportant; rather, it shows that regulatory improvement, even if achieved, cannot be assumed to produce commensurate infrastructure development. Nigerian energy reform has long operated on the implicit assumption that a sufficiently improved regulatory environment will automatically attract the investment required to deliver infrastructure. The regression result demonstrates empirically that this causal chain cannot be assumed and that infrastructure investment must be treated as an independently planned and resourced activity, not a market response expected to follow once the regulatory climate improves.

4.3 Discussion of Results

The results of this study are consistent with and extend the broader literature on infrastructure as a binding constraint in gas-to-power systems. They confirm Adenikinju's (2003) foundational observation that regulatory inadequacy and physical underinvestment are structurally related but analytically separable, and that the failure to treat them as such produces reform cycles in which regulatory effort does not translate into supply improvement. They also corroborate Adenikinju's (2005) analysis of infrastructure failure costs in Nigeria's electricity sector, in which physical deficits at any point in the value chain—from upstream gas processing through midstream pipeline transport, generation, transmission, and distribution—generate cascading losses that render single-point interventions insufficient to improve aggregate system performance.

The relative ranking of technology integration as the highest-scoring infrastructure role (mean 4.46) deserves particular attention. Respondents appear to view digital and monitoring technologies not as supplementary improvements but as foundational to the ability of physical infrastructure to perform reliably. Smart pipeline monitoring has real potential to reduce the economic and supply disruption costs of vandalism by enabling faster detection and isolation of breaches. Flare gas commercialization technology could simultaneously convert a long-standing waste stream into domestic supply. These positions are consistent with the policy direction embedded in the Petroleum Industry Act 2021, whose host community trust provisions and gas commercialization incentives create a legislative basis for some of this investment, even if implementation remains nascent.

The finding that policy harmonization and National Gas Policy re-implementation scored lowest among the infrastructure items, while still registering clear agreement, also carries interpretive weight. Stakeholders are not dismissive of the institutional framework; they regard it as necessary but insufficient. The policy framework can be harmonized, the 2017 Gas Master Plan can be reaffirmed and regulatory mandates can be clarified, but none of these actions will move gas from wellhead to consumer without the pipelines, processing trains, generation turbines, transmission lines, and distribution networks that remain either absent or inadequate across the Niger Delta. The regression result quantifies this intuition: the statistical separation between regulatory effectiveness and infrastructure development is not merely professional opinion but an empirically verifiable property of the system

5 Conclusion

The study concludes that infrastructure development and regulatory reform are wo important factors that have the ability to significantly improve the performance of Nigeria's gas-to-power value chain. Evidence from 185 sector professionals across the five Niger Delta states consistently identified pipeline and storage systems, technology integration, and energy security infrastructure as the most critical determinants of reliable electricity supply. The high grand mean (4.20) confirms that the sector's major challenge is inadequate physical infrastructure, with regulatory weakness also playing a significant role.

The regression results further establish that regulatory effectiveness and infrastructure development are statistically distinct determinants of electricity supply performance. The significant F-statistic (185.62, $p = 0.001$) demonstrates that improvements in gas market regulation have a strong connection with infrastructure development. Consequently, while regulatory reforms remain important, they must be complemented by dedicated, adequately funded, and independently implemented infrastructure investment.

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