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REVIEW ARTICLE

Assessment of Compressed Natural Gas (CNG) Facilities in Kogi State, Nigeria: Socioeconomic Benefits, Infrastructure and Adoption Constraints

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ABSTRACT

Nigeria possesses substantial natural gas resources, yet its transport system remains heavily exposed to the cost and supply instability associated with conventional petroleum fuels. This study assesses the availability and accessibility of Compressed Natural Gas (CNG) facilities in Kogi State, with particular attention to the socioeconomic gains and adoption constraints experienced by commercial transport operators in Kogi Central Senatorial District. The study adopted a descriptive mixed-method design. Quantitative data were obtained from 110 commercial transport operators through total enumeration, while 10 key informants were purposively selected for qualitative interviews. Questionnaire data were analyzed using descriptive statistics in the Statistical Package for the Social Sciences (SPSS), while interview evidence was thematically analyzed. The findings indicate that CNG adoption is associated with substantial perceived socioeconomic gains. Respondents strongly agreed that switching to CNG reduces fuel expenditure (mean, M = 1.33; standard deviation, SD = 0.53), improves business planning (M = 1.65, SD = 0.57), provides environmental advantages (M = 1.56, SD = 0.55), and creates employment opportunities (M = 1.69, SD = 0.48). At the same time, adoption is constrained by high vehicle-conversion costs (M = 1.15, SD = 0.38), concerns about cylinder safety and maintenance (M = 1.46, SD = 0.52), irregular CNG supply (M = 1.55, SD = 0.82), and inadequate information on safe operation (M = 2.33, SD = 0.85). The study concludes that the economic case for CNG is strong, but infrastructure, financing, technical capacity, safety assurance, and public awareness must develop alongside the expansion of demand. The paper contributes location-specific evidence to Nigeria's sustainable-energy-transition literature and argues for coordinated public–private investment in refueling and conversion infrastructure, targeted conversion finance, technician certification, reliable gas supply, and enhanced regulatory oversight.

Keywords: Compressed Natural Gas; CNG infrastructure; Socioeconomic Benefits; Transport Sector; Energy Transition; Kogi State; Nigeria; Diffusion of Innovation

INTRODUCTION

Nigeria's energy transition debate has acquired renewed urgency as households and businesses confront high transportation costs while the country seeks to translate its large natural-gas endowment into greater domestic energy use. Official data from the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) put Nigeria's total proven gas reserves at 215.19 trillion cubic feet (TCF) as of 1 January 2026, comprising 100.21 TCF of associated gas and 114.98 TCF of non-associated gas[1]. The scale of this resource base contrasts with the continuing importance of petroleum fuels in road transport and underscores the policy relevance of diversifying the transport-fuel mix.

The Presidential Compressed Natural Gas Initiative (PiCNG) was established in 2023 as a federal response

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to the economic effects of fuel-subsidy removal and to accelerate the transition toward CNG-fueled transportation. In March 2026, its mandate was expanded to include electric vehicles and renamed the Presidential Initiative on Compressed Natural Gas and Electric Vehicles (PiCNG & EV). The expanded program continues to support CNG infrastructure, vehicle conversion, and financing arrangements designed to make conversion more accessible[2,3].

CNG offers several potential advantages over conventional petroleum fuels. For transport operators, lower fuel expenditure can improve operating margins and make business planning more predictable. At the wider economic level, substitution of domestically available gas for imported refined petroleum products can reduce foreign-exchange requirements. CNG can also contribute to cleaner urban transport because combustion generally produces lower levels of several conventional pollutants than petrol and diesel. The source literature further identifies employment opportunities along the CNG value chain, including construction, compression, distribution, vehicle conversion, maintenance and technical services.

The benefits, however, cannot be separated from the infrastructure required to deliver them. CNG vehicles require reliable refueling access, specialized storage and compression systems, certified conversion centers, trained technicians and effective safety regulation. High upfront conversion costs may also exclude low-income users and small transport operators from the transition. In a developing transport market, these constraints can create a two-speed transition in which larger fleets benefit earlier while individual vehicle owners remain dependent on conventional fuels.

The practical importance of this inquiry is heightened by the structure of Nigeria's road-transport economy. Commercial operators make frequent fuel purchases, so changes in fuel prices can affect both operating margins and the fares paid by passengers. A transport-fuel transition can therefore have implications that extend beyond individual vehicle owners to household mobility, small-business income and the affordability of local transportation. However, the magnitude of these benefits depends on whether users can obtain the fuel consistently and whether the initial cost of conversion is financially manageable.

Kogi State is also an instructive setting because it links several dimensions of Nigeria's emerging gas economy: proximity to major gas infrastructure, an active commercial-transport sector, and the federal objective of expanding CNG use beyond the largest metropolitan markets. Examining the experience of operators in Kogi Central can therefore illuminate the practical distance between national policy objectives and local implementation. The study is particularly concerned with this implementation gap rather than with estimating national CNG demand.

Against this background, the present study examines CNG facilities and their socioeconomic implications in Kogi State, with emphasis on Kogi Central Senatorial District. It addresses three practical questions: whether existing infrastructure is adequate and accessible; what socioeconomic benefits users perceive; and which barriers most strongly constrain adoption. The article responds to the limited localized evidence identified in the source study and links the findings to Rogers' Diffusion of Innovation (DOI) theory.

LITERATURE REVIEW

CNG and the Sustainable Energy Transition

The transition toward alternative transport fuels is shaped by concerns about energy security, environmental sustainability, fuel-price volatility, and economic resilience. The International Energy Agency (IEA) emphasizes the strategic role of gas in changing energy systems, while the Nigerian literature reviewed in the source study frames CNG as a potentially important bridge between petroleum dependence and a more diversified transport-energy mix[4]. For Nigeria, the case is especially relevant because the country simultaneously possesses large gas resources and experiences recurrent difficulties in the supply and pricing of refined petroleum products.

CNG adoption is therefore not simply a fuel-substitution issue. It is an infrastructure and institutional transition. The economic value of a CNG vehicle depends on whether the user can refuel conveniently, obtain safe and affordable conversion services, and access reliable technical support. The availability of these complementary assets determines whether the theoretical cost advantage of CNG becomes a realized economic benefit for households and businesses.

Socioeconomic Benefits of CNG

The literature reviewed identifies four closely related channels through which CNG can generate socioeconomic gains. First, lower fuel expenditure can directly reduce operating costs for commercial transport operators. Second, greater reliance on domestic gas can reduce exposure to imported refined petroleum products and associated foreign-exchange pressures. Third, CNG infrastructure creates direct and indirect employment in construction, engineering, conversion, maintenance, logistics, and training. Fourth, cleaner fuel use can generate social benefits through improved air quality and reduced exposure to transport-related pollutants.

These benefits are mutually reinforcing. Lower operating costs can improve business viability; stronger business viability can support investment and employment; and greater availability of CNG services can increase adoption. Conversely, inadequate infrastructure can weaken each link in the chain. The transition therefore depends on a coordinated expansion of both demand-side incentives and supply-side infrastructure.

Infrastructure availability should be understood as a network rather than as the simple presence of individual stations. A functional CNG ecosystem requires gas supply, compression, storage, transportation, refueling, vehicle conversion, inspection, maintenance, and technical support. A weakness in any one component can reduce the value of the others. For example, a vehicle may be successfully converted but remain commercially unattractive if refueling stations are distant or frequently experience supply shortages. Similarly, additional refueling stations may have limited impact if conversion services are unaffordable.

Infrastructure and Adoption Constraints

The literature identifies inadequate refueling coverage, limited storage and distribution systems, high vehicle-conversion costs, shortages of trained technicians, safety concerns, and regulatory weaknesses as central adoption constraints. Anyadiegwu et al. emphasize the economic importance of infrastructure and the conditions required for CNG to function as a viable vehicular fuel[5]. Kaur et al. similarly identify conversion cost and technical considerations as important determinants of adoption. The source study also reports evidence that irregular supply and limited awareness can discourage users even when CNG is cheaper in operation.

These constraints are particularly important in locations outside Nigeria's largest metropolitan markets. If refueling and conversion services are concentrated in a small number of urban centers, potential users may perceive CNG as inconvenient or risky. This reinforces a key proposition of technology-diffusion theory: the perceived relative advantage of an innovation must be accompanied by compatibility, observability and practical accessibility.

From the DOI perspective, relative advantage is likely to be especially important for commercial operators because fuel expenditure is a recurrent business cost. Compatibility is also important because operators must integrate CNG use into existing routes, schedules and vehicle-maintenance practices. Complexity may be reflected in conversion procedures, cylinder inspection and maintenance requirements. Trialability can be enhanced through demonstration vehicles, pilot fleets and financing schemes that allow potential users to experience CNG without bearing the entire initial cost. Observability can increase when operators see neighboring businesses obtaining measurable fuel savings and reliable service.

Diffusion of Innovation Theory

The study is anchored on Rogers' Diffusion of Innovation theory. DOI theory explains how new technologies spread through a social system and emphasizes the roles of relative advantage, compatibility, complexity, trialability, and observability. Applied to CNG, relative advantage is reflected in lower fuel expenditure and environmental benefits; compatibility relates to the fit between CNG and existing vehicles and transport routines; complexity includes conversion and maintenance requirements; trialability concerns users' ability to experience the technology at manageable cost; and observability concerns whether benefits are visible to other potential adopters.

The theory is particularly suitable for the Kogi context because adoption decisions are not determined by price alone. A transport operator may recognize that CNG is cheaper per unit of useful energy but still postpone conversion because conversion finance is unavailable, refueling is uncertain, or technical support is weak. The theory therefore helps explain the coexistence of strong perceived benefits and relatively slow diffusion.

Conceptual Synthesis

The study conceptualizes CNG adoption as the outcome of an interaction between infrastructure conditions, perceived socioeconomic benefits, and adoption barriers. Infrastructure accessibility influences the practical convenience of adoption; socioeconomic benefits create the incentive to switch; and conversion cost, safety concerns, information gaps, and supply instability can weaken the willingness or ability to adopt. This framework avoids treating CNG adoption as a purely technological decision and instead places it within the economic and institutional environment of commercial transportation.

Empirical Gap and Contribution

The source study identifies a clear geographical gap: much of the existing discussion of CNG in Nigeria is national in scope, while comparatively little evidence addresses the availability, accessibility, and user experience of CNG facilities in Kogi State. The present article narrows that gap by analyzing evidence from 110 commercial transport operators and 10 key informants. It contributes by placing infrastructure adequacy, socioeconomic outcomes and adoption barriers within a single empirical account rather than examining the economic or environmental dimension in isolation.

METHODOLOGY

The descriptive orientation was appropriate because the study sought to document the existing situation and users' experiences rather than to construct a predictive national adoption model. The mixed-method element was used to improve contextual interpretation: questionnaire responses provided a structured picture of the operators' views, while interviews provided stakeholder explanations of infrastructure conditions, operational challenges, and policy implementation.

Research Design and Study Context

The study employed a descriptive survey design within a mixed-method framework. The quantitative component used a structured questionnaire to measure perceptions of CNG infrastructure, socioeconomic outcomes and barriers to adoption. The qualitative component used interviews with stakeholders who possessed direct knowledge of CNG facilities, conversion services, transport operations, or policy implementation. The mixed-method design was intended to combine measurable response patterns with contextual explanations.

The study focused on Kogi State, with particular emphasis on Kogi Central Senatorial District. The accessible quantitative population comprised 110 commercial transport operators. Because this population was considered small and manageable, all 110 operators were included through total enumeration. Ten key informants—including facility operators, conversion-center operators, government-related stakeholders, and transport-union representatives—were purposively selected for interviews.

The questionnaire statements were organized around the study's three principal analytical domains: infrastructure and accessibility, socioeconomic gains, and barriers to adoption. This organization was intended to maintain a direct connection between the research questions and the empirical measures. Expert review focused on whether the items adequately represented the study constructs, whether the wording was clear, and whether the instrument was appropriate for commercial transport operators.

Instrumentation, Validity and Reliability

The questionnaire contained demographic items and statements covering infrastructure accessibility, socioeconomic benefits, and adoption barriers. Responses were recorded on a four-point Likert scale: Strongly Agree, Agree, Disagree and Strongly Disagree. The instrument was subjected to face and content validation by experts in Economics Education, Research Measurement and Evaluation, and Energy Policy. A pilot study was conducted in a neighboring area, and Cronbach's alpha was used as the reliability measure, with 0.70 stated as the minimum acceptable coefficient.

Data Collection and Analysis

Questionnaires were administered personally by the researcher, with research-assistant support where necessary. Respondents were informed of the purpose of the study and assured of confidentiality. Interviews were conducted with selected key informants and documented through notes and, where permission was granted, audio recording. Quantitative data were entered and cleaned before analysis in SPSS version 26. Descriptive statistics—frequencies, percentages, means and standard deviations—were used. Qualitative responses were analyzed thematically. The original analysis adopted a criterion mean of 2.50 for decision-making.

RESULTS

Infrastructure and Accessibility

The infrastructure results indicate a constrained access environment. Using the verified scale coding, respondents disagreed that refueling stations were easily accessible (M = 2.78, SD = 0.75) and strongly disagreed that waiting time was reasonable (M = 3.72, SD = 0.58). Respondents agreed that conversion centers were readily available (M = 1.78, SD = 0.58), but disagreed that existing infrastructure met current local demand (M = 2.77, SD = 0.88). The overall infrastructure mean of 2.76 therefore indicates that infrastructure remains inadequate relative to user needs.

Taken together, these results suggest that the strongest perceived motivation for CNG adoption is economic rather than technological. Operators appear to value the technology primarily because of its implications for recurring fuel expenditure and business predictability. The environmental and employment dimensions are also important, but the magnitude of agreement on fuel-cost reduction indicates that household and operator-level economics are likely to remain central to sustained adoption. (Table 1)

Table 1: The Impact of Operators on CNG

Indicator	Mean	SD	Interpretation
Refueling stations are easily accessible in my locality	2.78	0.75	Disagree
Waiting time at CNG stations is reasonable	3.72	0.58	Strongly Disagree
Conversion centers are readily available	1.78	0.58	Agree
Existing infrastructure meets current local demand	2.77	0.88	Disagree
Grand mean	2.76	—	Disagree

Socioeconomic Gains

The socioeconomic results are comparatively consistent across the manuscript. Respondents strongly endorsed reduced fuel costs, better business planning, environmental benefits, and employment creation. The strongest reported benefit was reduced fuel expenditure (M = 1.33, SD = 0.53). The frequency distributions reinforce this pattern: 99.1% of respondents either strongly agreed or agreed that CNG had significantly reduced fuel costs; 97.3% agreed or strongly agreed that CNG improved business planning; 99.1% agreed or strongly agreed that CNG was environmentally safer; and 99.1% of valid responses agreed or strongly agreed that CNG had created employment opportunities.

The barrier results reveal a potential contradiction at the heart of the transition. Operators can perceive CNG as economically beneficial while simultaneously being unable or unwilling to convert because of the initial investment required. This distinction between operating cost and entry cost is important for policy. Although CNG may offer lower operating costs after conversion, the upfront conversion cost can remain a significant financial barrier to adoption. (Table 2)

Table 2: The Impact of Conversion Cost on CNG

Indicator	Mean	SD	Interpretation
CNG has significantly reduced fuel costs	1.33	0.53	Strongly Agree
CNG usage has improved business planning	1.65	0.57	Strongly Agree
CNG is safer for the environment than petrol/diesel	1.56	0.55	Strongly Agree
CNG adoption has created new job opportunities	1.69	0.48	Strongly Agree
Grand mean	1.56	—	Strongly Agree

Barriers to Adoption

Conversion cost emerged as the most prominent barrier in the source study. The frequency data show that 99.1% of respondents agreed or strongly agreed that conversion cost was too high for the average user. Similarly, 99.1% agreed or strongly agreed that they were concerned about cylinder safety and maintenance, while 88.2% agreed or strongly agreed that frequent CNG scarcity discouraged use. The information item produced a more mixed distribution: 56.9% agreed or strongly agreed that they lacked enough information on safe CNG operation, while 43.1% disagreed or strongly disagreed. (Table 3)

Table 3: The Impacts of Various Factors on CNG

Barrier	Mean	SD	Interpretation
Vehicle conversion cost is too high	1.15	0.38	Strongly Agree
Inadequate information on safe CNG operation	2.33	0.85	Agree
Concern about CNG cylinder safety/maintenance	1.46	0.52	Strongly Agree
Frequent scarcity of CNG discourages use	1.55	0.82	Strongly Agree
Grand mean	1.62	—	Strongly Agree

DISCUSSION

Infrastructure as a Condition for Diffusion

The study suggests that the benefits of CNG cannot be separated from the availability of complementary infrastructure. Where refueling and conversion services are convenient, the perceived complexity of the innovation is reduced; where access is uncertain, the same technology becomes more difficult to adopt. This is consistent with DOI theory, particularly the dimensions of complexity and compatibility. The source study similarly links infrastructure limitations to slower diffusion and argues for additional refueling and conversion facilities.

The infrastructure finding also has a policy implication beyond the simple number of stations. Infrastructure quality should be evaluated in terms of geographic coverage, reliability, waiting time, conversion capacity, maintenance support, safety certification and supply continuity. A nominal increase in station numbers will not necessarily generate adoption if users continue to experience long queues, uncertain supply or limited technical support.

The findings should also be interpreted in relation to the scale and frequency of commercial transport operations. Unlike occasional private motorists, commercial operators consume fuel repeatedly and therefore have greater potential to recover conversion expenditure through cumulative operating savings. This suggests that targeted financing for commercial operators may produce relatively rapid adoption responses if supply reliability is adequate. However, the study does not calculate payback periods, net present values or actual per-kilometre cost differences; those would require verified fuel-consumption and price data.

Economic Benefits and Operator Welfare

The strong perception of fuel-cost savings is the clearest economic finding. For commercial transport operators, fuel expenditure is a recurring operating cost, so even modest savings can accumulate rapidly. The result is consistent with the broader literature reviewed in the source study, including Daser and Adams, which presents CNG as a potentially more affordable and stable alternative to petrol and diesel, and Ibeneme and Ighalo, which links gas-sector investment with employment and industrial activity[6,7].

The responses also indicate perceived benefits beyond fuel expenditure.

The results also highlight the importance of trust. Safety concerns can become an adoption barrier even when technical standards exist, particularly where users are uncertain about the quality of conversion work or the integrity of cylinders. Effective certification, visible compliance information and periodic inspection can therefore function as demand-side interventions because they reduce uncertainty. In the same way, reliable supply can increase confidence that the investment in conversion will remain useful over the life of the vehicle.

Conversion Cost, Safety and Supply Reliability

The dominance of conversion cost among the reported barriers is economically intuitive. CNG adoption requires an upfront investment before fuel savings can be realized. For operators with limited access to credit, the present cost may outweigh a stream of future savings. This creates a classic adoption problem: a technology can have positive long-run returns while remaining unattractive to liquidity-constrained users.

Safety and supply concerns reinforce this problem. CNG systems require appropriate cylinders, installation procedures, inspections, and maintenance. If users cannot readily identify certified conversion centers and technicians, perceived risk may remain high even where technical standards are adequate. Similarly, irregular supply reduces the expected convenience of switching. The source study therefore recommends financial incentives, technician training, stronger regulation, public education, and improved gas distribution.

CONTRIBUTION TO KNOWLEDGE

The study contributes to the literature in three ways. First, it provides localized empirical evidence from Kogi State, complementing national-level discussions of Nigeria's CNG transition. Second, it brings infrastructure conditions, socioeconomic benefits, and adoption barriers together within one analytical framework. Third, by interpreting the findings through Diffusion of Innovation theory, it demonstrates that the perceived economic advantage of CNG is insufficient on its own; adoption also depends on compatibility, complexity, accessibility, and confidence in the supporting infrastructure.

Expand Refueling and Conversion Networks

Infrastructure expansion should prioritize locations with high commercial-transport activity and should be coordinated with reliable gas supply. Station planning should consider distance, expected demand, storage capacity, operating hours, and maintenance support. Conversion centers should be developed alongside refueling facilities so that prospective users can complete the transition without traveling long distances for technical services.

Reduce the Upfront Cost of Conversion

The evidence supports targeted financing mechanisms for vehicle conversion. Low-interest credit, structured repayment through transport associations, targeted grants for priority commercial fleets, and partnerships with financial institutions could reduce the initial liquidity constraint. Such programs should be transparent and linked to certified conversion centers so that financial support does not encourage unsafe installations.

Strengthen Safety and Technical Standards

Certification of conversion technicians, periodic cylinder inspection, clear installation standards and effective enforcement are essential for maintaining public confidence. Safety communication should explain both the benefits and the responsibilities associated with CNG use rather than relying on promotional messages alone.

Improve Information and Monitoring

Government agencies and industry operators should publish clear information on station locations, operating status, safety requirements, conversion costs and maintenance procedures. A monitoring framework should track conversion numbers, station utilization, supply interruptions, safety incidents, fuel-cost savings and user satisfaction. These indicators would provide evidence for adjusting the program over time.

POLICY IMPLICATIONS

First, infrastructure policy should move from isolated project announcements toward integrated network planning. Refueling stations, mother and daughter stations, conversion centers, and maintenance facilities should be planned as an integrated system. Second, conversion finance should target commercial operators and small businesses through grants, subsidized kits, low-interest credit or other carefully designed mechanisms that reduce the upfront barrier without creating permanent dependence on subsidies. The policy environment is also moving toward conversion finance and wider CNG access; in 2026, the federal initiative announced structured consumer-credit arrangements for conversion and continued deployment of refueling infrastructure[3].

Third, technical capacity should be treated as a core component of the CNG infrastructure system. Training and certification programs for conversion technicians, maintenance personnel, and safety inspectors can reduce operational risk and improve public confidence. Fourth, government agencies and industry stakeholders should intensify public education around the economic, environmental, and safety characteristics of CNG. Fifth, reliable supply should be treated as an adoption policy in its own right: users are unlikely to invest in conversion if they cannot reasonably predict where and when they can refuel.

Finally, stronger monitoring and evaluation are needed. CNG programs should track station availability, utilization rates, conversion volumes, fuel-price savings, employment, safety incidents, supply reliability, and user satisfaction. Such indicators would allow policymakers to identify whether investment is translating into actual adoption and socioeconomic gains.

Future research should build on the present descriptive evidence by collecting verified operational data from CNG and conventional-fuel vehicles. A comparative design could estimate fuel cost per kilometer, maintenance expenditure, vehicle downtime, and conversion payback periods. Longitudinal research could also examine whether perceived benefits and adoption barriers change as infrastructure expands. Such studies would provide stronger evidence for evaluating the effectiveness of Nigeria's transport-energy transition.

CONCLUSION

This study assessed CNG facilities in Kogi State and examined the socioeconomic gains and adoption constraints reported by commercial transport operators. The evidence points to a clear asymmetry: perceived benefits are strong, but the conditions needed to realize those benefits at scale remain incomplete. Respondents reported lower fuel expenditure, improved business planning, environmental advantages, and employment opportunities. At the same time, high conversion costs, safety concerns, irregular supply, and information gaps continue to constrain adoption.

The study therefore concludes that CNG can play a meaningful role in Nigeria's transport-energy transition, but infrastructure and institutional capacity must expand alongside user demand. The most effective policy approach is not to promote CNG adoption in isolation, but to build the ecosystem that makes adoption practical: accessible refueling, affordable conversion, reliable supply, certified technical services, effective regulation and credible public information.

The article's principal contribution is its location-specific evidence from Kogi State. It shows how national energy-transition objectives can encounter local implementation constraints and demonstrates the importance of examining adoption through both economic and infrastructure lenses. Future research should extend the analysis to larger and more diverse samples and apply inferential methods—including logistic regression, structural equation modeling, or panel approaches—to identify the determinants and causal pathways of CNG adoption.

STUDY LIMITATIONS

Three limitations should be considered when interpreting the findings. First, the quantitative sample comprised 110 commercial transport operators, so the results should not automatically be generalized to all households, private vehicle owners or businesses in Kogi State. Second, the analysis is predominantly descriptive and based on self-reported perceptions; it therefore cannot establish causal effects or independently verify reported fuel savings and employment outcomes. Third, the study is cross-sectional and geographically focused on Kogi Central, limiting the generalizability of the findings beyond the study area. The study nevertheless provides useful location-specific evidence on the practical conditions surrounding CNG adoption.

DECLARATION

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