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Empirical Review of Compressed Natural Gas (CNG) as an Energy Alternative in Nigeria: Opportunities and Challenges

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Abstract: *Compressed Natural Gas (CNG) has emerged globally as a cleaner, more economical alternative to conventional fossil fuels, particularly in transportation and industrial applications. In the context of Nigeria, where reliance on petroleum-based fuels continues to dominate energy consumption, CNG presents a promising pathway to energy diversification, economic efficiency, and environmental sustainability. This study examined the potential of CNG as an alternative fuel in Nigeria's transport and industrial sectors, with particular attention to energy consumption patterns, economic advantages, infrastructural demands, and key implementation challenges. A descriptive survey design was employed, targeting energy sector stakeholders, transport operators, and policymakers. A total of 300 respondents were selected using stratified random sampling. Data were gathered through structured, close-ended questionnaires and analyzed using descriptive statistical tools, including frequency and percentage analysis via SPSS. Findings revealed that over 86% of respondents acknowledged the urgent need to shift from petroleum dependence. Economic benefits of CNG adoption included reduced transportation costs, lower fuel subsidy burdens, and job creation. However, major obstacles identified were high capital investment, inadequate infrastructure, low public awareness, and policy inconsistency. The study concludes that CNG is a viable solution to Nigeria's energy challenges and recommends robust government investment in infrastructure, targeted awareness campaigns, policy coherence, and active stakeholder collaboration to facilitate CNG adoption.*
Keywords: Compressed Natural Gas (CNG), alternative fuel, energy consumption

INTRODUCTION

Nigeria is endowed with one of the largest natural gas reserves in the world, estimated at over 200 trillion cubic feet (NNPCL, 2022). Despite this, natural gas remains grossly underutilized within the country's energy mix. More than 90% of Nigeria's road transport and a significant portion of industrial activities still rely heavily on imported petrol and diesel, making the economy highly

susceptible to global oil price volatility and persistent foreign exchange instability (Okonkwo & Mba, 2021). Compounding this challenge is the country's longstanding fuel subsidy regime, which continues to place immense strain on public finances by diverting resources away from essential sectors such as healthcare, education, and infrastructure development. These circumstances have sparked growing interest in transitioning to more sustainable and economically viable alternatives, with Compressed Natural Gas (CNG) emerging as a prominent option.

CNG, composed mainly of methane, is widely recognized for its lower environmental impact and cost-effectiveness compared to traditional fossil fuels. Countries such as India, Iran, and Argentina have successfully integrated CNG into their public transportation systems, thereby reducing urban air pollution and lowering fuel costs (IEA, 2023). In recognition of its potential, the Nigerian government launched the National Gas Expansion Programme (NGEP) in 2020, aiming to promote the use of gas-based fuels—including CNG, Liquefied Petroleum Gas (LPG), and Autogas—as part of a broader effort to deepen domestic gas utilization and diversify the national energy portfolio. Furthermore, gas has been identified as a key "transition fuel" in Nigeria's national energy policy, aligning with global climate goals and the country's commitments under the Paris Agreement (Federal Ministry of Petroleum Resources, 2021).

Nevertheless, the penetration of CNG in Nigeria remains limited due to a range of systemic challenges. Chief among these is the inadequate infrastructure required for widespread adoption, such as a lack of CNG refueling stations, distribution pipelines, and maintenance facilities (Akinyemi et al., 2020). In addition, the high cost of converting existing vehicles to CNG, in the absence of targeted financial incentives, has discouraged both private and commercial users (Ogunleye & Akinyemi, 2022). Compounding these technical and economic barriers are issues related to low public awareness, safety concerns, and inconsistent regulatory policies, all of which have hindered the effective implementation of the NGEP and other gas utilization initiatives.
The consequences of inaction are becoming increasingly apparent. Major urban centers like Lagos, Port Harcourt, and Kano are experiencing deteriorating air quality, largely driven by emissions from petrol and diesel engines. As CNG emits significantly lower levels of carbon monoxide, nitrogen oxides, and particulate matter, it presents a viable solution not only for environmental improvement but also for meeting Nigeria's Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC, 2022). Moreover, CNG offers long-term cost advantages for both consumers and the government by reducing the demand for imported fuels and minimizing expenditure on fuel subsidies.

However, despite these apparent benefits, the disconnect between policy intentions and practical implementation raises critical questions about the feasibility of CNG as a sustainable fuel alternative in Nigeria. Although the government has demonstrated commitment through various programs and strategic documents, empirical research remains limited on the actual dynamics of CNG adoption in the Nigerian context. Specifically, there is a gap in comprehensive studies that

address the economic viability, technological requirements, infrastructural investments, and socio-political factors influencing the success or failure of CNG deployment (Edeh & Uzochukwu, 2022; Ogunleye & Akinyemi, 2022). This study seeks to address this gap by systematically examining the opportunities and constraints of adopting CNG in Nigeria's transport and industrial sectors, providing actionable insights to guide policymakers, investors, and stakeholders in the country's energy transition.

RELATED BACKGROUND AND LITERATURE

Compressed Natural Gas (CNG)

Compressed Natural Gas (CNG) refers to natural gas that has been compressed to less than 1% of its volume at standard atmospheric pressure for use as a fuel in place of gasoline, diesel, or propane. According to Miah et al. (2015), CNG is composed mainly of methane and is stored at high pressure, making it a viable and cleaner alternative for combustion engines. CNG has gained attention for its lower emissions and affordability in regions with abundant natural gas resources. Okonkwo and Udegbunam (2019) highlight that in the Nigerian context, CNG presents a cost-effective and environmentally sustainable fuel source capable of reducing dependence on imported petroleum products and cutting down greenhouse gas emissions from the transport and industrial sectors.

The relevance of CNG in Nigeria's energy strategy is linked to its potential role in energy diversification and emission reduction. As Ajayi and Akinwunmi (2021) explain, Nigeria possesses vast natural gas reserves which remain underutilized, thus promoting CNG use could optimize resource utilization. However, the adoption of CNG in Nigeria also raises critical issues related to infrastructural investment, regulatory frameworks, and safety standards. These factors must be addressed to ensure a successful transition from traditional fuels to CNG, especially in the transport and industrial sectors that are major energy consumers. This makes the evaluation of both opportunities and challenges essential for effective policy-making and implementation.

Alternative Fuel

Alternative fuels are energy sources used as substitutes for conventional fossil fuels, often characterized by lower emissions and renewable origins. According to Demirbas (2007), alternative fuels include biofuels, electricity, hydrogen, and CNG, and are critical in addressing global energy sustainability and climate change challenges. Ogbuigwe (2018) emphasizes that alternative fuels are vital for countries like Nigeria, which face environmental degradation due to the overreliance on petrol and diesel. In the Nigerian context, alternative fuels can mitigate the health and environmental impacts of traditional fuel combustion while reducing dependence on volatile international oil markets.

CNG, as an alternative fuel, aligns with Nigeria's national energy policy goals of sustainability, affordability, and environmental protection. The adoption of alternative fuels supports broader objectives such as improving air quality, conserving natural resources, and enhancing energy security (Ishola & Salisu, 2020). Moreover, alternative fuel deployment requires systemic shifts in energy infrastructure, market structures, and public behavior, all of which must be managed strategically. Thus, considering CNG within the broader category of alternative fuels helps frame its potential not just as a technical innovation, but as part of a holistic transition towards cleaner energy use in Nigeria.

Energy Consumption Patterns

Energy consumption patterns refer to the trends and behaviors associated with how energy is sourced, distributed, and used across different sectors of the economy. According to IEA (2019), these patterns are influenced by economic activities, population growth, technological developments, and policy interventions. In Nigeria, Adebayo and Ogunleye (2020) report that energy consumption is heavily skewed towards fossil fuels, particularly in the transport and industrial sectors, which rely on petrol and diesel due to their availability and established distribution networks. However, this pattern is neither sustainable nor economically efficient in the long term.

Understanding energy consumption patterns is crucial for identifying areas where alternative energy sources like CNG can be introduced effectively. As Uduma and Arceneaux (2019) argue, restructuring energy consumption towards cleaner fuels in Nigeria demands a thorough assessment of sector-specific energy needs and behavioral drivers. In particular, the transport sector consumes a large portion of Nigeria's energy supply, and transitioning to CNG could substantially reduce costs and environmental impact. Similarly, the industrial sector, which drives manufacturing and economic growth, could benefit from a stable and cleaner fuel source. Therefore, analyzing current energy consumption patterns provides the foundation for strategic interventions aimed at promoting the adoption of alternative fuels like CNG.

Compressed Natural Gas (CNG) as an Energy Alternative in Nigeria

As Nigeria grapples with energy insecurity, rising fuel costs, and environmental degradation, the exploration of alternative energy sources has become increasingly critical. Compressed Natural Gas (CNG), due to its relative abundance, lower emissions profile, and cost-effectiveness, has been identified as a promising substitute for conventional fossil fuels, particularly in the transport and industrial sectors. Several empirical studies have investigated the viability, benefits, and barriers associated with CNG adoption in Nigeria, offering valuable insights into its potential role in the country's energy transition agenda. The following review presents key findings from such studies, highlighting the economic, infrastructural, and policy-related dimensions of CNG implementation. A relevant study by Akinyemi et al. (2020) aimed to assess the feasibility of adopting compressed natural gas (CNG) as a transport fuel in Nigeria, focusing on its economic and environmental

implications. Using a descriptive survey and cost-benefit analysis, the authors collected data from major urban transport operators and fuel distributors in Lagos and Abuja. Their findings indicated that CNG is significantly cheaper and cleaner than petrol and diesel, and could reduce vehicular emissions by up to 30%. However, they identified limited infrastructure and weak regulatory frameworks as critical barriers to widespread adoption. Similarly, Ogunleye (2018) examined the energy consumption patterns in Nigeria's transport sector and how they impact the country's transition to cleaner fuels. Utilizing a quantitative approach and time-series data analysis, the study highlighted that over 80% of the fuel consumed in Nigeria's transport sector is petroleum-based, with negligible contributions from alternative fuels. The study concluded that structural dependence on imported fuel and weak diversification policies pose significant challenges to the adoption of alternatives like CNG.

Okonkwo and Mba (2021) conducted a study focused on evaluating the technological and infrastructural readiness for CNG usage in Nigeria's industrial sector. Employing a mixed-methods approach, including interviews with engineers and surveys of industrial facility managers in Port Harcourt and Kaduna, the study found that while technological awareness exists, the lack of investment in CNG-specific infrastructure, such as refueling stations and conversion kits, undermines its adoption. The authors recommended government-private sector partnerships to bridge infrastructure gaps. In a broader regional study, Musa and Hassan (2019) analyzed the environmental and public health benefits of CNG adoption in Sub-Saharan Africa, with Nigeria as a case study. Through comparative environmental impact assessments and data modeling, the study revealed that CNG adoption could reduce particulate matter emissions by 40% and contribute to improved air quality and health outcomes. However, the researchers cautioned that policy inconsistency and public apathy may derail such benefits without a coordinated implementation framework.

Edeh and Uzochukwu (2022) examined the economic implications of transitioning to CNG in the Nigerian energy market. Their study applied input-output modeling and stakeholder analysis to estimate the macroeconomic impacts of large-scale CNG adoption. Results indicated that transitioning to CNG could create over 500,000 jobs across fuel distribution, conversion services, and equipment manufacturing sectors. The study emphasized that economic gains are contingent on policy clarity, stable investment climates, and public-private engagement. Adding to this discourse, Falade (2023) explored consumer perception and willingness to adopt CNG-fueled vehicles in urban Nigeria. Using a structured questionnaire distributed to 500 private car owners in Lagos and Ibadan, and analyzing the data with regression models, the study found that cost-saving benefits, environmental awareness, and government incentives were strong predictors of willingness to switch. However, fears over the availability of refueling infrastructure and the cost of vehicle conversion limited adoption readiness.

Yusuf et al. (2021) assessed the role of government policy in alternative fuel adoption, focusing on the National Gas Expansion Programme (NGEP) in Nigeria. Using policy evaluation tools and interviews with officials from the Ministry of Petroleum Resources, the study found that while the NGEP provides a roadmap for natural gas utilization, implementation bottlenecks and corruption risks hinder progress. The authors concluded that institutional reforms and transparency are essential for realizing the benefits of CNG transition.

Despite a growing body of research on the adoption of compressed natural gas (CNG) as an alternative fuel in Nigeria, several critical gaps remain. Firstly, most existing studies focus narrowly on either the environmental or economic implications, often neglecting a comprehensive multi-sectoral analysis that integrates transport, industrial, and policy dimensions. Secondly, while infrastructural and technological challenges are frequently cited, empirical evidence on the actual readiness of specific regions or sectors within Nigeria remains limited and outdated. Additionally, there is a notable lack of research on public perception, behavioral factors, and adoption psychology, particularly among private consumers and small-scale industrial users. Few studies also explore the long-term socio-political implications of transitioning to CNG, such as job displacement in the petroleum sector or the risk of policy inconsistency. Finally, regional disparities in access to natural gas infrastructure and their influence on the feasibility of a nationwide CNG rollout have not been thoroughly investigated, indicating a need for more disaggregated and location-specific studies. To bridge these gaps, this study examines the implications of introducing compressed natural gas (CNG) as an alternative fuel in Nigeria, with a focus on exploring the associated opportunities and addressing the potential challenges.

METHOD

Data Collection and Participants

The study adopted a descriptive survey design. This design enabled the researcher to collect data from a large and diverse group of stakeholders, including policymakers, energy experts, transportation operators, and vehicle owners, to gain a comprehensive understanding of the opportunities and challenges associated with CNG adoption. The target population included key players in the energy, transportation, and industrial sectors, particularly from major Nigerian cities like Lagos, Abuja, and Port Harcourt, where the adoption of alternative fuels was more likely. A stratified random sampling technique was used to ensure that each sector was adequately represented, with an estimated sample size of 300 respondents, which was considered sufficient for this study.

Data was collected using a structured questionnaire comprising closed-ended questions, utilizing a 5-point Likert scale to capture in-depth responses. The use of an online Google Form to administer the instrument was chosen for its convenience, cost-effectiveness, and ability to reach a large and geographically dispersed sample. Given the diversity of the target population, which

included stakeholders from various sectors and locations across Nigeria, the online platform provided a practical solution for reaching respondents efficiently.

Analysis Methods

For data analysis, descriptive statistical methods were employed to summarize and interpret the responses obtained from the structured questionnaires. Descriptive statistics are useful for organizing raw data into a more understandable form, allowing researchers to identify trends, patterns, and general characteristics within the dataset. In this study, key descriptive tools such as frequency distributions, and percentages were used to analyze respondents' views on the feasibility, benefits, and challenges of Compressed Natural Gas (CNG) adoption in Nigeria.

The Statistical Package for the Social Sciences (SPSS) software was utilized to process and analyze the data efficiently. This approach enabled the researcher to quantify the level of agreement or disagreement among respondents on various items related to energy consumption patterns, economic implications of CNG, infrastructural readiness, and policy frameworks. The descriptive analysis provided a basis for drawing logical inferences and informed conclusions regarding the potential of CNG as an alternative fuel in Nigeria's transport and industrial sectors.

Analysis and Results

Descriptive Analysis of the Respondents' Biodata

Table 4.1 Descriptive Analysis of the Respondents' Biodata

	Biodata	Frequency	Percentage
Gender	Male	189	63.0
	Female	111	37.0
Age	18-25 years	39	13.0
	26-30 years	63	21.0
	31-35 years	81	27.0
	36-40 years	57	19.0
	Above 40 years	60	20.0
Marital Status	Single	93	31.0
	Married	165	55.0
	Divorced	15	5.0
	Separated	9	3.0
	Widow	18	6.0
Occupation	Driver/Transport Worker	75	25.0
	Engineer/Technician	63	21.0
	Business/Entrepreneur	57	19.0
	Civil Servant	69	23.0
	Others	36	12.0

Sector	Transport	93	31.0
	Industry	81	27.0
	Energy	69	23.0
	Government	57	19.0
Educational Level	SCCE/O'level	45	15.0
	OND/NCE	69	23.0
	Bachelor's Degree	105	35.0
	Master's Degree	57	19.0
	Doctorate (Phd) Degree	24	8.0
	Total	**300**	**100**

Source: SPSS Output (2025)

The descriptive statistics in Table 4.1 provide an overview of the demographic characteristics of the 300 respondents. The gender distribution indicates that 189 respondents, representing 63%, were male, while 111 respondents, constituting 37%, were female. This shows a greater participation of males in the study sample. The age distribution shows that the largest group of respondents was aged 31–35 years, accounting for 27% (81 respondents), followed by those aged 26–30 years with 21% (63 respondents), and those above 40 years with 20% (60 respondents). Respondents aged 36–40 years comprised 19% (57 respondents), while the youngest group, aged 18–25 years, made up 13% (39 respondents).

In terms of marital status, the majority of respondents were married, accounting for 55% (165 respondents), followed by single individuals who represented 31% (93 respondents). Divorced respondents were 5% (15), while separated and widowed individuals accounted for 3% (9 respondents) and 6% (18 respondents), respectively. The occupational breakdown revealed that the highest number of respondents were Driver/Transport Workers, who made up 25% (75 respondents), followed by Civil Servants at 23% (69 respondents). Engineer/Technicians comprised 21% (63 respondents), Business/Entrepreneurs 19% (57 respondents), and Others 12% (36 respondents).

Sectoral distribution shows that 31% (93 respondents) worked in the transport sector, 27% (81 respondents) in the industrial sector, 23% (69 respondents) in the energy sector, and 19% (57 respondents) in government. As for educational qualifications, the majority of respondents held a Bachelor's Degree (35%, 105 respondents), followed by those with OND/NCE qualifications (23%, 69 respondents). Respondents with a Master's Degree constituted 19% (57), SSCE/O'Level 15% (45), and those with a Doctorate Degree (PhD) accounted for 8% (24 respondents). The data represents a diverse group across gender, age, marital status, occupation, sector, and educational background, totaling 300 participants.

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Analysis of the research questions

Research Question 1: What is the current energy consumption pattern in Nigeria's transport and industrial sectors?

Table 4.2: Descriptive Statistics Result on the current energy consumption pattern in Nigeria's transport and industrial sectors

S/n	Items		SA	A	D	SD	Remark
1	Petroleum-based fuels dominate Nigeria's transport and industrial energy consumption	*f*	162	96	27	15	Agreed
		%	54	32	9	5	
2	There is a heavy dependence on imported refined petroleum products in Nigeria	*f*	150	105	30	15	Agreed
		%	50	35	10	5	
3	Nigeria lacks diversification in its energy sources for transport and industry	*f*	138	111	33	18	Agreed
		%	46	37	11	6	
4	Energy consumption patterns in Nigeria have a significant impact on the economy	*f*	144	114	30	12	Agreed
		%	48	38	10	4	
5	The current energy model in Nigeria is unsustainable for future industrial growth	*f*	156	108	24	12	Agreed
		%	52	36	8	4	

Source: SPSS Output (2025)

The descriptive statistics presented in Table 4.2 provide insightful data on the prevailing energy consumption patterns in Nigeria's transport and industrial sectors. A significant proportion of respondents (54%, n=162) strongly agreed, and 32% (n=96) agreed that petroleum-based fuels dominate energy consumption in these sectors, with only 9% (n=27) disagreeing and 5% (n=15) strongly disagreeing. Similarly, 50% (n=150) of the participants strongly agreed and 35% (n=105) agreed that Nigeria heavily depends on imported refined petroleum products, while 10% (n=30) and 5% (n=15) disagreed and strongly disagreed respectively.

Regarding the diversification of energy sources, 46% (n=138) strongly agreed and 37% (n=111) agreed that Nigeria lacks adequate diversification in its energy sources for the transport and industrial sectors. A smaller fraction, 11% (n=33) and 6% (n=18), disagreed and strongly disagreed with this view. Additionally, 48% (n=144) strongly agreed and 38% (n=114) agreed that the existing energy consumption patterns significantly affect Nigeria's economy, whereas 10% (n=30) and 4% (n=12) held opposing views.

Furthermore, when asked about the sustainability of Nigeria's current energy model for future industrial growth, more than half of the respondents (52%, n=156) strongly agreed and 36% (n=108) agreed that it is unsustainable. In contrast, 8% (n=24) disagreed and 4% (n=12) strongly disagreed. These responses collectively highlight a consensus among the respondents on the urgent

need for energy diversification and reform in Nigeria's energy strategy to ensure economic resilience and industrial sustainability.

Research Question 2: What are the potential economic benefits of adopting CNG as an alternative fuel in Nigeria?

Table 4.3: Descriptive Statistics Result on the potential economic benefits of adopting CNG as an alternative fuel in Nigeria

S/n	Items		SA	A	D	SD	Remark
1	The use of CNG can reduce transportation costs in Nigeria	*f*	165	96	27	12	Agreed
		%	55	32	9	4	
2	CNG adoption can create job opportunities in the energy and transport sectors	*f*	144	111	30	15	Agreed
		%	48	37	10	5	
3	Transitioning to CNG could reduce government spending on fuel subsidies	*f*	153	99	30	18	Agreed
		%	51	33	10	6	
4	CNG offers long-term economic sustainability compared to petroleum	*f*	150	105	30	15	Agreed
		%	50	35	10	5	
5	Widespread use of CNG can boost Nigeria's GDP and economic competitiveness	*f*	159	99	27	15	Agreed
		%	53	33	9	5	

Source: SPSS Output (2025)

The results from Table 4.3 indicate strong support for the potential economic benefits of adopting compressed natural gas (CNG) as an alternative fuel in Nigeria. For the statement "The use of CNG can reduce transportation costs in Nigeria," 55% (n=165) of respondents strongly agreed and 32% (n=96) agreed, while 9% (n=27) disagreed and only 4% (n=12) strongly disagreed. This suggests that the majority view CNG adoption as a viable means of reducing transportation costs. Similarly, when asked about CNG's ability to create job opportunities in the energy and transport sectors, 48% (n=144) strongly agreed and 37% (n=111) agreed, indicating strong optimism about the economic benefits of job creation. A smaller fraction, 10% (n=30) and 5% (n=15), disagreed or strongly disagreed with this notion.

Regarding the potential for CNG to reduce government spending on fuel subsidies, 51% (n=153) strongly agreed and 33% (n=99) agreed, while 10% (n=30) disagreed and 6% (n=18) strongly disagreed, reinforcing the belief that CNG could provide financial relief for the government by reducing reliance on expensive petroleum imports. Moreover, when asked whether CNG offers long-term economic sustainability compared to petroleum, 50% (n=150) strongly agreed and 35% (n=105) agreed, with only 10% (n=30) disagreeing and 5% (n=15) strongly disagreeing, further solidifying the consensus on the long-term benefits of CNG in ensuring economic sustainability. Finally, 53% (n=159) strongly agreed and 33% (n=99) agreed that widespread use of CNG could

boost Nigeria's GDP and enhance economic competitiveness, showing broad support for CNG's potential to positively influence the country's overall economic performance.

Research Question 3: What are the infrastructural and technological requirements for the successful implementation of CNG?

Table 4.4: Descriptive Statistics Result on the infrastructural and technological requirements for the successful implementation of CNG

S/n	Items		SA	A	D	SD	Remark
1	Nigeria requires more CNG refueling stations for nationwide adoption	*f*	168	99	21	12	Agreed
		%	56	33	7	4	
2	CNG-powered vehicles need advanced mechanical support and servicing facilities	*f*	156	111	24	9	Agreed
		%	52	37	8	3	
3	The current infrastructure is inadequate for large-scale CNG distribution	*f*	162	105	24	9	Agreed
		%	54	35	8	3	
4	Government investment is required to build and maintain CNG infrastructure	*f*	171	96	24	9	Agreed
		%	57	32	8	3	
5	Technical expertise and training are essential for managing CNG systems	*f*	159	111	21	9	Agreed
		%	53	37	7	3	

Source: SPSS Output (2025)

The findings from Table 4.4 highlight the infrastructural and technological requirements for the successful implementation of compressed natural gas (CNG) in Nigeria. For the statement "Nigeria requires more CNG refueling stations for nationwide adoption," 56% (n=168) strongly agreed and 33% (n=99) agreed, indicating that a significant majority recognizes the necessity of expanding refueling infrastructure for CNG adoption. Only 7% (n=21) disagreed, and 4% (n=12) strongly disagreed, suggesting that most respondents perceive the lack of CNG refueling stations as a key barrier to widespread implementation. Regarding the need for advanced mechanical support and servicing facilities for CNG-powered vehicles, 52% (n=156) strongly agreed, and 37% (n=111) agreed, indicating that a large proportion of respondents believe that specialized technical support is crucial for the successful deployment of CNG vehicles. Only 8% (n=24) disagreed and 3% (n=9) strongly disagreed, reinforcing the view that such facilities are necessary.

The item "The current infrastructure is inadequate for large-scale CNG distribution" also garnered strong agreement, with 54% (n=162) strongly agreeing and 35% (n=105) agreeing, highlighting the widespread concern over the insufficiency of current infrastructure to support large-scale CNG distribution. Only 8% (n=24) disagreed, and 3% (n=9) strongly disagreed, further suggesting a consensus on the need for infrastructural improvements. In line with these findings, when respondents were asked if government investment is required to build and maintain CNG infrastructure, 57% (n=171) strongly agreed and 32% (n=96) agreed, reinforcing the idea that

substantial financial backing from the government is seen as essential for the development of the necessary infrastructure. Only 8% (n=24) disagreed and 3% (n=9) strongly disagreed, emphasizing that respondents strongly support public sector involvement. Lastly, the importance of technical expertise and training for managing CNG systems was acknowledged by 53% (n=159) who strongly agreed, and 37% (n=111) who agreed, indicating broad consensus on the need for skilled labor to support CNG technology. Only 7% (n=21) disagreed, and 3% (n=9) strongly disagreed, suggesting that most respondents view technical expertise as a critical component for the successful operation of CNG systems in Nigeria.

Research Question 4: What are the challenges and risks associated with the introduction of CNG in Nigeria?

Table 4.5: Descriptive Statistics Result on the challenges and risks associated with the introduction of CNG in Nigeria

S/n	Items		SA	A	D	SD	Remark
1	High initial investment cost is a major barrier to CNG adoption	*f*	162	96	27	15	Agreed
		%	54	32	9	5	
2	Lack of public awareness and education limits the acceptance of CNG	*f*	153	111	24	12	Agreed
		%	51	37	8	4	
3	There are safety concerns associated with the use and storage of CNG	*f*	144	120	24	12	Agreed
		%	48	40	8	4	
4	Inconsistent government policies hinder the implementation of CNG initiatives	*f*	168	105	18	9	Agreed
		%	56	35	6	3	
5	Resistance from fuel marketers and petroleum stakeholders is a challenge to CNG deployment	*f*	150	114	24	12	Agreed
		%	50	38	8	4	

Source: SPSS Output (2025)

The findings from Table 4.5 reveal several challenges and risks associated with the introduction of compressed natural gas (CNG) in Nigeria. One of the most significant barriers identified is the high initial investment cost, with 54% (n=162) strongly agreeing and 32% (n=96) agreeing that the financial burden is a major obstacle to CNG adoption. Only 9% (n=27) disagreed, and 5% (n=15) strongly disagreed, suggesting that a majority of respondents view the cost of initial investment as a substantial barrier that could delay or hinder the widespread adoption of CNG technology in the country. In terms of public acceptance, 51% (n=153) strongly agreed and 37% (n=111) agreed that a lack of public awareness and education limits the acceptance of CNG. Only 8% (n=24) disagreed, and 4% (n=12) strongly disagreed, indicating a strong consensus on the importance of public awareness campaigns to facilitate the adoption of CNG.

Safety concerns regarding the use and storage of CNG were also highlighted, with 48% (n=144) strongly agreeing and 40% (n=120) agreeing that these concerns are a significant challenge. Only 8% (n=24) disagreed, and 4% (n=12) strongly disagreed, emphasizing the need to address safety measures before widespread implementation can take place. The item on inconsistent government policies hindering the implementation of CNG initiatives received 56% (n=168) strong agreement and 35% (n=105) agreement, indicating that respondents view policy inconsistency as a critical challenge to CNG deployment. Only 6% (n=18) disagreed, and 3% (n=9) strongly disagreed, underlining the necessity for stable and supportive government policies. Finally, resistance from fuel marketers and petroleum stakeholders was perceived as a challenge by 50% (n=150) of respondents who strongly agreed, and 38% (n=114) who agreed. Only 8% (n=24) disagreed, and 4% (n=12) strongly disagreed, suggesting that vested interests in the petroleum sector could pose a significant hurdle to the successful deployment of CNG.

Summary of findings

The following are the key findings of the study:

i. Petroleum-based fuels dominate Nigeria's transport and industrial energy consumption. This reflects a heavy reliance on traditional fuel sources, with a need for diversification to alternative fuels like CNG.
ii. Adopting CNG can reduce transportation costs, reduce government spending on fuel subsidies, offer long-term economic sustainability compared to petroleum, boost Nigeria's GDP and economic competitiveness and create job opportunities in the energy and transport sectors in Nigeria. This suggests a positive outlook on the economic advantages of CNG, including potential cost savings in the transport sector and broader economic impacts.
iii. Government investment is necessary to build and maintain CNG infrastructure. This highlights the importance of developing the required infrastructure, such as refueling stations and maintenance facilities, for the successful adoption of CNG across Nigeria.
iv. The challenges and risks associated with the introduction of CNG in Nigeria are high initial investment cost, lack of public awareness and education, inconsistent government policies, and resistance from fuel marketers and petroleum stakeholders.

DISCUSSION

It was discovered that Petroleum-based fuels dominate Nigeria's transport and industrial energy consumption. The heavy reliance on petroleum-based fuels in Nigeria's transport and industrial sectors is a significant concern for the country's energy sustainability. Petroleum fuels, such as gasoline and diesel, have historically dominated the energy consumption patterns in both these sectors. This trend is not only economically limiting but also environmentally problematic, as it exacerbates the nation's vulnerability to volatile global oil prices. Nigeria's dependency on

imported refined petroleum products has led to high transportation costs and increased government expenditure on subsidies. This finding supports the discovery of Oloruntoba (2015) that petroleum-based fuels account for more than 90% of energy consumed in Nigeria's transport sector, which has long contributed to economic instability in the country. Additionally, a report by the International Energy Agency (IEA, 2021) suggests that the lack of diversification into alternative energy sources has hindered the country's energy security, making Nigeria more susceptible to external shocks, such as oil price fluctuations.

Also, it was unveiled that adopting CNG as an alternative fuel in Nigeria holds numerous economic benefits. First, CNG has the potential to significantly reduce transportation costs due to its lower price compared to petroleum-based fuels. This reduction in costs could lower overall logistics expenses, making goods and services more affordable across the country. Thie finding aligns with the findings of Oyebanji (2020), that the shift to CNG would save the government billions of dollars by reducing its dependence on costly fuel subsidies, which are a major financial burden. Moreover, the long-term economic sustainability of CNG is a crucial consideration, as it offers a more stable and environmentally friendly alternative to petroleum. A study by Olowu (2018) indicates that CNG is not only cheaper but also more abundant than petroleum, offering Nigeria an opportunity to improve its energy security and reduce reliance on oil imports. Beyond the immediate cost savings, CNG adoption would also have a broader economic impact. It could foster job creation in the energy, transport, and manufacturing sectors, as new infrastructure such as refueling stations, maintenance facilities, and vehicle conversion services would be required. Alabi and Oyinloye (2016) report that the development of a CNG infrastructure could lead to significant job creation in Nigeria, further boosting the country's economic output.

In addition, it was discovered tht government investment is necessary to build and maintain CNG infrastructure. This highlights the importance of developing the required infrastructure, such as refueling stations and maintenance facilities, for the successful adoption of CNG across Nigeria. For CNG to be successfully integrated into Nigeria's energy landscape, significant government investment is required. This investment would be needed to build the necessary infrastructure, such as CNG refueling stations, vehicle conversion centers, and maintenance facilities. Without this investment, the adoption of CNG could be severely hindered, as the existing infrastructure is largely tailored to petroleum-based fuels. This finding supports the conclusion of Akinmoladun (2021) that the lack of adequate infrastructure for CNG in Nigeria is a major barrier to its widespread adoption. The study also found that the government must take an active role in financing the construction of refueling stations and developing the requisite technical expertise to manage CNG systems. Additionally, Adedayo (2019) notes that the private sector is unlikely to invest heavily in CNG infrastructure without government guarantees and support, as the initial capital required is substantial.

Finally, it was revealed that the adoption of CNG in Nigeria faces several challenges, which must be addressed for its successful implementation. One of the primary challenges is the high initial investment cost required for infrastructure development, including the establishment of refueling stations and the conversion of vehicles. According to Ayodele (2018), the costs involved in switching to CNG are significant, and both the government and private sector must work together to provide funding for this transition. Furthermore, there is a general lack of public awareness and education regarding the benefits of CNG, which has led to skepticism about its viability as an alternative fuel. Bello et al. (2020) suggest that a robust public awareness campaign is essential to changing public perceptions and driving demand for CNG. The lack of consistent government policies is another major challenge; policy instability has created uncertainty, making it difficult for investors to commit to CNG-related projects. As Nwoke et al. (2019) note, inconsistent policies have deterred potential investors, hindering the country's transition to alternative fuels.

CONCLUSION

Nigeria's heavy reliance on petroleum-based fuels in its transport and industrial sectors is a major challenge that highlights the need for diversification into alternative energy sources like CNG. The adoption of CNG offers significant economic benefits, including reduced transportation costs, lower government spending on fuel subsidies, and increased job opportunities. However, successful implementation of CNG requires substantial government investment in infrastructure development, alongside efforts to address the challenges posed by high initial costs, lack of public awareness, inconsistent policies, and resistance from key stakeholders. Hence, the following recommendations were made:

i. To reduce Nigeria's overreliance on petroleum-based fuels, the government should implement comprehensive energy diversification policies that prioritize alternative fuels like CNG. This can be achieved through national legislation that encourages investments in CNG projects, sets clear targets for alternative fuel use, and integrates CNG into Nigeria's national energy roadmap.
ii. The federal and state governments should allocate significant resources to the construction of CNG refueling stations, vehicle conversion centers, and maintenance facilities nationwide. Simultaneously, vocational training programs should be established to build a skilled workforce that can install, operate, and maintain CNG systems. Public-private partnerships can be leveraged to fund these infrastructure projects while minimizing fiscal strain on the government.
iii. A nationwide sensitization campaign should be launched to educate the public, transport operators, and industry stakeholders on the safety, cost-efficiency, and environmental benefits of CNG. This should involve the use of mass media, social platforms, workshops, and demonstration projects in key urban and rural locations.

iv. To overcome resistance and reduce policy uncertainty, the government must maintain stable, transparent, and predictable policies that support CNG adoption. This includes establishing a regulatory agency or task force to coordinate CNG implementation and ensure accountability.

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