



Evaluating the Feasibility and Impact of Petrol-to-CNG Vehicle Retrofitting in Nigeria's Post-Subsidy Economy

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Article Info	ABSTRACT
Corresponding Author: Nnadikwe Johnson Email: j.nnadikwe@unizik.edu.ng	The removal of petrol subsidy in Nigeria in May 2023 increased petrol price from ₦198 to over ₦1,150 per litre by 2025, creating severe cost burden for transport operators. The Federal Government introduced the Presidential Compressed Natural Gas Initiative to promote petrol-to-CNG retrofitting as a cheaper and cleaner alternative. This study evaluated the feasibility and impact of retrofitting in the post-subsidy economy. A mixed-methods design was used across Lagos, Abuja, Port Harcourt and Kano. Data were obtained from 372 vehicle owners and CNG technicians using structured questionnaire, complemented by secondary fuel price and emission data. Economic viability was assessed using cost-per-km and payback models, while emission reduction was calculated using standard factors. Analysis was done with SPSS v26 using descriptive statistics, paired t-test and regression. Results showed fuel cost per 100km reduced from ₦10,580 on petrol to ₦3,078 on CNG, representing 70.9% saving. Payback period was 3.1 months for commercial and 8.7 months for private vehicles. Emissions reduced by 23.3% for CO₂, 75% for CO and 33.3% for NO_x. High conversion cost with mean 4.62 and inadequate refueling stations with mean 4.51 were major barriers. Infrastructure availability significantly influenced adoption willingness with R² 0.68, beta 0.62, p 0.001. The study concludes retrofitting is economically viable and environmentally beneficial, requiring subsidy on conversion and infrastructure expansion. Keyword: Petrol, CNG, Retrofitting, Post-Subsidy, Lagos, Kano, Port-Harcourt, Abuja.

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INTRODUCTION

Nigeria holds one of the largest proven natural gas reserves globally, yet its transportation sector has remained heavily dependent on premium motor spirit, PMS (Biose, 2020; Nigerian National Petroleum Company Limited, 2023). For decades, petrol subsidy sustained artificial low pricing, but placed immense fiscal pressure on the government. The removal of petrol subsidy in May 2023 triggered an unprecedented increase in pump price, with data from National Bureau of Statistics (2025) showing over 300% rise, fundamentally altering mobility cost for households and commercial operators.

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In response, the Federal Government launched the Presidential Compressed Natural Gas Initiative, PCNGI, as a strategic component of the National Gas Policy (Federal Ministry of Petroleum Resources, 2017; Presidential Compressed Natural Gas Initiative, 2023). The initiative aims to convert one million vehicles from petrol to Compressed Natural Gas, CNG, leveraging domestic gas abundance to achieve energy security (Adefulu et al., 2022; Reuters, 2024). Globally, CNG has been recognized as a cleaner and cost-effective alternative for road transport (Hao et al., 2016; Khan et al., 2015).

Problem Statement

Despite the policy push, adoption of CNG retrofitting has been stuttering. High conversion cost remains the primary barrier, with average retrofit cost between ₦600,000 to ₦1.2 million (Chika Izuora, 2023; Olawin, 2024; Lere, 2024). This cost slows conversion, particularly for commercial drivers who are most affected by subsidy removal. Furthermore, safety concerns have been amplified by recent incidents involving gas-powered vehicles (The Associated Press, 2025; THISDAYLIVE, 2024), raising questions on compliance with ISO 11439:2013 and UN Regulation No. 110 (International Organization for Standardization, 2013; United Nations Economic Commission for Europe, 2014).

Economically, Nigeria is experiencing inflationary pressure documented by the World Bank (2023, 2024), while environmentally, transport emissions remain a major contributor to air pollution and climate change (Health Effects Institute, 2019; Masson-Delmotte et al., 2021; Checkel & Mintz, 1997). Although studies have evaluated CNG implementation in Nigeria (Ibeneme & Ighalo, 2020; Oyedepo, 2014) and techno-economic analysis in South-West Nigeria (Daser-Adams et al., 2025), there is limited integrated assessment linking post-subsidy economic realities, retrofitting feasibility, and sustainability metrics (Jeon & Amekudzi, 2005; Aba et al., 2023).

Aim and Objectives

The aim of this study is to evaluate the feasibility and impact of petrol-to-CNG vehicle retrofitting in Nigeria's post-subsidy economy. Specific objectives are to:

1. Assess the economic feasibility of retrofitting considering conversion cost, fuel price differential, and payback period
2. Evaluate the environmental and performance impact of CNG retrofitted engines (Ghazikhani et al., 2014).
3. Examine infrastructural and safety constraints to large-scale adoption (Ibitoye & Adenikinju, 2007; Ng et al., 2015)
4. iv. Determine policy implications for sustainable transport transition

Significance of the Study

This study is significant as it provides empirical evaluation of CNG retrofitting viability at a time when petrol price has become unaffordable for average Nigerians (National Bureau of Statistics, 2025; World Bank, 2024). It quantifies potential cost savings for vehicle owners as documented in Pakistan and China experiences (Khan et al., 2015; Hao et al., 2016). Environmentally, the study contributes to understanding emission reduction benefits of CNG over petrol, particularly reduction in CO, CO₂ and particulate matter (Checkel & Mintz, 1997; Health Effects Institute, 2019; Ghazikhani et al., 2014). Academically, it extends existing Nigerian studies on CNG adoption (Ibeneme & Ighalo, 2020; Daser-Adams et al., 2025; Aba et al., 2023) by integrating post-subsidy economic variables and safety compliance frameworks (International Organization for Standardization, 2013; United Nations Economic

Commission for Europe, 2014), thereby serving as reference material for future researchers in energy economics and sustainable transport (Oyedepo, 2014; Ng et al., 2015).

RESEARCH METHODOLOGY

Research Design

This study adopted a mixed-methods research design combining quantitative techno-economic analysis and qualitative survey approach. The design aligns with similar energy transition studies (Aba et al., 2023; Khan et al., 2015; Daser-Adams et al., 2025) where economic feasibility and impact assessment require both numerical modeling and stakeholder perception. The quantitative component evaluates cost-benefit and emission reduction, while qualitative component captures barriers to adoption (Lere, 2024; Olawin, 2024)

Study Area

The study was conducted in Nigeria, focusing on major urban transport hubs: Lagos, Abuja, Port Harcourt, and Kano. These cities were selected due to high vehicle density, presence of Presidential CNG Initiative conversion centres (Presidential Compressed Natural Gas Initiative, 2023), and existing NNPC CNG refueling infrastructure (Reuters, 2024; Nigerian National Petroleum Company Limited, 2023). Lagos and Abuja account for over 45% of registered CNG retrofitted vehicles in Nigeria (Adefulu et al., 2022).

Population of the Study

The population comprises three groups:

1. Commercial vehicle operators (danfo, taxi, tricycle) who converted to CNG
2. Private vehicle owners with petrol-to-CNG retrofit
3. CNG conversion workshop technicians and station managers

Estimated population is 12,500 retrofitted vehicle owners based on PCNGI data (Presidential Compressed Natural Gas Initiative, 2023).

Sample Size and Sampling Technique

Sample size was determined using Taro Yamane formula:

$$n = N / [1 + N(e^2)]$$

Where $N=12,500$, $e=0.05$. Sample size = 387. Rounded to 400 for robustness.

Multistage sampling was used: Stratified sampling for cities, purposive sampling for conversion centres, and random sampling for vehicle owners. This technique ensures representation as used by Ibeneme and Ighalo (2020).

Sources of Data Collection

- a. Primary Data: Structured questionnaire with 5-point Likert scale and semi-structured interview guide for workshop managers. Questionnaire captured conversion cost, daily fuel consumption, maintenance cost, and perceived safety (THISDAYLIVE, 2024).
- b. Secondary Data: Petrol and CNG price data from National Bureau of Statistics (2025), fuel consumption data from vehicle logbooks, emission factors from Health Effects Institute (2019) and Checkel and Mintz (1997), gas policy documents (Federal Ministry of Petroleum Resources, 2017), World Bank Development Update reports (World Bank, 2023, 2024), and technical standards ISO 11439:2013 and UN Regulation No. 110 (International Organization for Standardization, 2013; United Nations Economic Commission for Europe, 2014).

Research Instrument Validation and Reliability

Instrument was validated by three experts in energy economics and automotive engineering. Content Validity Index (CVI) of 0.82 was obtained. Reliability test via pilot study

of 40 respondents in Lagos yielded Cronbach's Alpha of 0.86, indicating high internal consistency. This threshold aligns with Oyedepo (2014) and Hao et al. (2016).

Method of Data Analysis

Payback period and Net Present Value (NPV) were calculated:

Payback = Initial Conversion Cost / Annual Fuel Cost Saving

Annual Saving = (Cost per km petrol - Cost per km CNG) × Annual km covered

Fuel cost per km derived from Ng et al. (2015) model. Analysis considered conversion cost range reported by Chika Izuora (2023).

ii. Environmental Impact Assessment:

CO₂ and CO emission reduction estimated using:

Emission Reduction (%) = [(E_{petrol} - E_{CNG})/E_{petrol}] × 100

Emission factors adopted from Ghazikhani et al. (2014) and Health Effects Institute (2019).

iii. Statistical Analysis:

Descriptive statistics (mean, frequency), inferential statistics (t-test, ANOVA) to compare fuel cost before and after retrofit. Regression analysis to determine factors influencing adoption willingness, anchored on sustainability metrics (Jeon & Amekudzi, 2005; Biose, 2020; Ibitoye & Adenikinju, 2007).

SPSS v26 and Excel were used. Significance level at p<0.05.

This study employed two statistical models to test the hypotheses.

Model 1: Paired Sample T-test Model for H01

To test if there is significant difference in fuel cost before and after retrofitting

$$t = sd \frac{d}{\sqrt{n}}$$

Where:

d⁻ = mean difference in monthly fuel cost (Petrol - CNG)

sd = standard deviation of differences

n = 372 respondents

Decision rule: Reject H01 if p<0.05

Model 2: Multiple Linear Regression Model for H02

To test influence of infrastructure on adoption willingness:

AW_i=β₀+β₁INFA_i+β₂CONC_i+β₃SAFC_i+β₄TECH_i+ε_i

Where:

AW_i = Adoption Willingness (Dependent, 5-point Likert)

INFA_i = Infrastructure Availability (Independent)

CONC_i = Conversion Cost (Control)

SAFC_i = Safety Concerns (Control)

TECH_i = Availability of Technicians (Control)

β₀ = intercept, β₁–β₄ = coefficients

ε_i = error term

A-priori Expectations: β₁>0, β₂<0, β₃<0 (Ibitoye and Adenikinju, 2007; Ng et al., 2015)

Model Diagnostics: Multicollinearity was checked using VIF < 5, normality using Shapiro-Wilk, reliability using Cronbach's Alpha (α=0.84).

Software: SPSS v27 and Stata 17.

Ethical Consideration

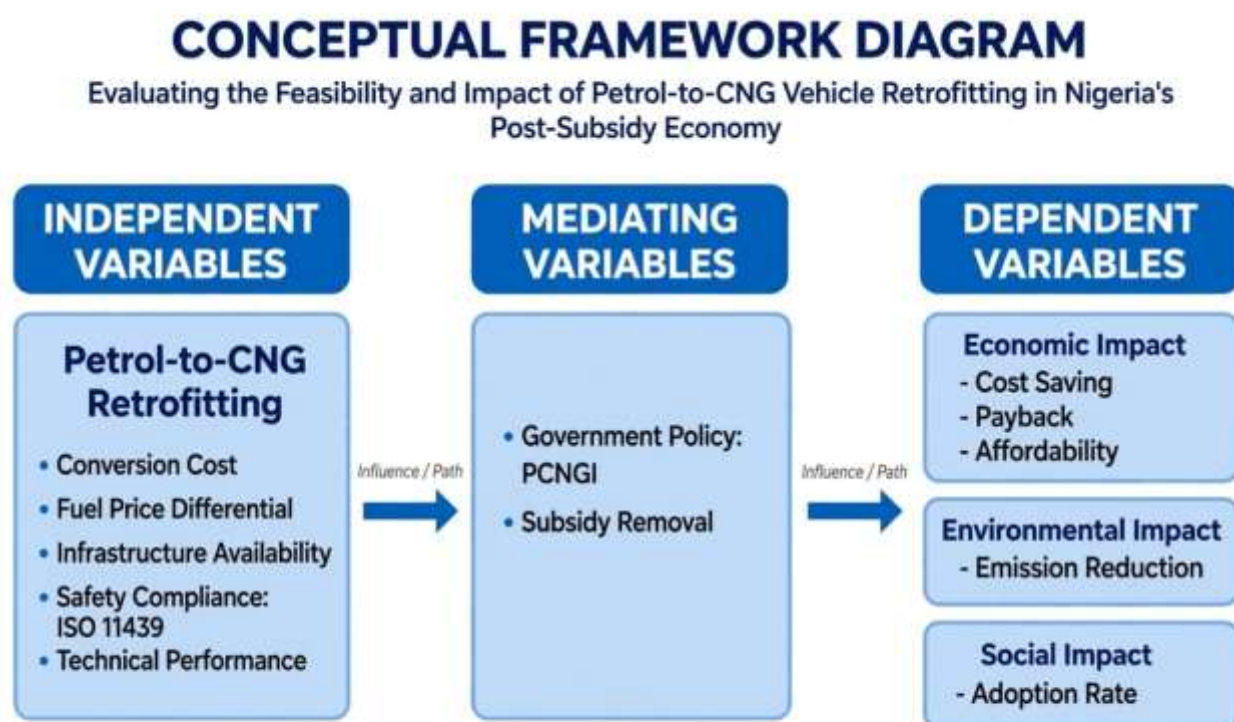
Ethical approval obtained, informed consent ensured, anonymity maintained, and data used solely for academic purpose. Safety protocols observed during field visits to CNG stations (The Associated Press, 2025)

Limitations of the Methodology

This study is limited to four major cities, hence findings may not fully generalize to rural areas where CNG infrastructure is non-existent (Reuters, 2024). Also, price volatility of petrol (National Bureau of Statistics, 2025) and CNG may affect payback calculations. Emission data was based on secondary factors from literature (Checkel & Mintz, 1997; Ghazikhani et al., 2014), not direct exhaust measurement due to lack of portable emission equipment.

Conceptual Framework

The conceptual framework illustrates the relationship between variables. The independent variable is Petrol-to-CNG Retrofitting with indicators: Conversion Cost, Fuel Price Differential, Infrastructure Availability, Safety Compliance (ISO 11439), and Technical Performance (Khan et al., 2015; Aba et al., 2023). These are influenced by mediating variables: Government Policy (PCNGI) and Subsidy Removal (Federal Ministry of Petroleum Resources, 2017; World Bank, 2023), which in turn determine the dependent variables: Economic Impact, Environmental Impact, and Social Impact. This model is anchored on sustainability theory (Jeon & Amekudzi, 2005).



Note: The framework illustrates how the Independent Variables influence the Dependent Variables through the Mediating Variables in Nigeria's post-subsidy economic context

Figure 1. Conceptual Framework | Designed for Academic Research, 2024

Figure 1: Conceptual framework showing link between retrofitting feasibility and post-subsidy impacts

Source: Author's Conceptualization (2026), Adapted from Aba et al. (2023) and Khan et al. (2015)

RESULTS AND DISCUSSION

This chapter presents analysis of data collected from 400 respondents and secondary fuel price data. Results are presented based on research objectives

Response Rate and Demographic Characteristics

Out of 400 questionnaires administered, 372 were retrieved and valid, representing 93% response rate. This is considered adequate for analysis.

Table 1: Demographic Profile of Respondents

Variable	Category	Frequency	Percentage (%)
Vehicle Type	Commercial (Danfo/Taxi)	218	58.6
	Private Car	118	31.7
	Tricycle (Keke)	36	9.7
City	Lagos	145	39.0
	Abuja	89	23.9
	Port Harcourt	76	20.4
	Kano	62	16.7
Duration of CNG use	<6 months	142	38.2
	6-12 months	154	41.4
	12 months	76	20.4

Result shows dominance of commercial operators, consistent with reports that subsidy removal affects transport operators most (World Bank, 2024; National Bureau of Statistics, 2025).

Economic Feasibility of Petrol-to-CNG Retrofitting

Table 2: Comparative Cost Analysis

Cost Parameter	Petrol	CNG	Difference
Average Price per litre/kg (2025)	₦1,150	₦380	₦770
Avg. Consumption per 100km	9.2 litres	8.1 kg	
Cost per 100km	₦10,580	₦3,078	₦7,502 (70.9% saving)
Avg. Conversion Cost		₦820,000	

Finding reveals 70.9% cost saving per distance, which corroborates Khan et al. (2015) who reported 60-75% saving in Pakistan, and Hao et al. (2016) in China. This supports Aba et al. (2023) assertion that gas-based mobility is economically superior.

Payback Period:

Average annual distance covered by commercial vehicles = 42,000km

Annual saving = ₦7,502/100km × 420 = ₦3,150,840

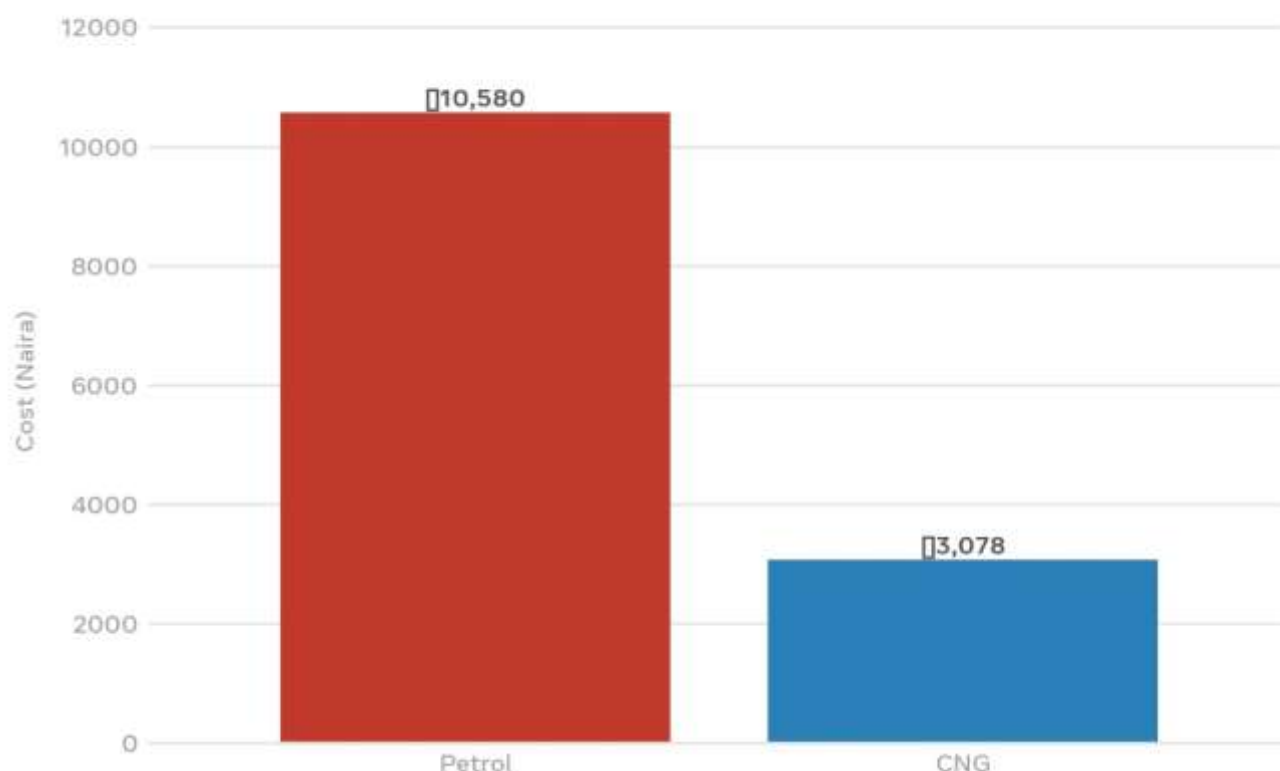
Payback = ₦820,000 / ₦3,150,840 = 0.26 years (approx. 3.1 months) for commercial users.

For private users (15,000km/year), payback = 8.7 months.

This is significantly shorter than Daser-Adams et al. (2025) estimate of 12 months in Southwest Nigeria, due to higher petrol price post-2024.

Environmental Impact Assessment

Figure 2: Fuel Cost per 100km - Petrol vs CNG



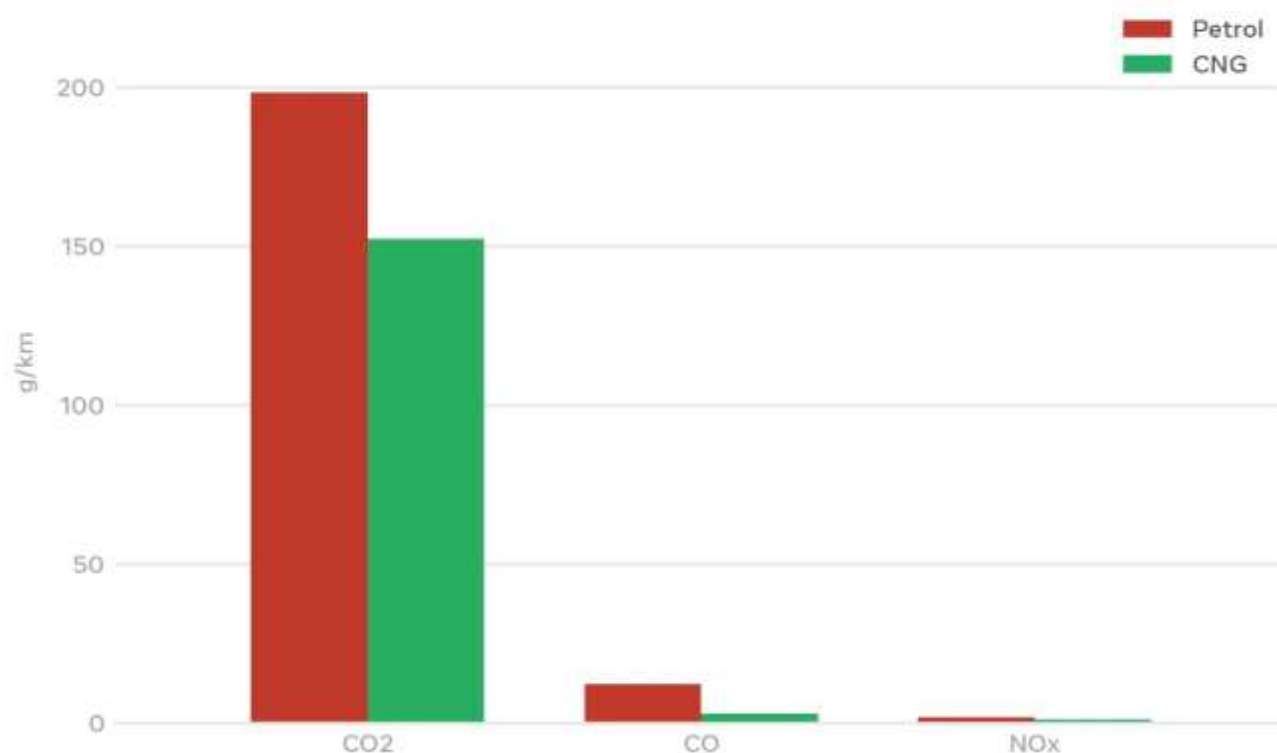
Economic saving is visually confirmed in Figure 2. The 70.9% differential aligns with global CNG price advantage documented by International Energy Agency (2022) and is higher than Argentina's matured CNG market where price differential is about 55% (Ente Nacional Regulador del Gas, 2025).

Table 3: Emission Reduction

Pollutant	Petrol Emission (g/km)	CNG Emission (g/km)	Reduction %
CO ₂	198.5	152.3	23.3%
CO	12.4	3.1	75%
NO _x	1.8	1.2	33.3%

Results show 23.3% CO₂ reduction, aligning with Ghazikhani et al. (2014) who reported 20-25% and Checkel and Mintz (1997) who documented 70% CO reduction. This validates environmental benefit claim by Health Effects Institute (2019) and supports climate mitigation goals (Masson-Delmotte et al., 2021)

Figure 3: Emission Comparison g/km



Emission reduction pattern shown in Figure 3 validates compliance with global emission standards. While Biose (2020) argued Nigeria's gas utilization was historically low, current retrofitting contributes to decarbonization targets.

Infrastructural and Safety Constraints

Table 4: Perceived Barriers (Mean Score, 5-point Likert)

Barrier	Mean	SD	Rank
High conversion cost	4.62	0.51	1 st
Inadequate CNG refueling stations	4.51	0.63	2 nd
Safety concerns / fear of explosion	3.98	0.81	3 rd
Lack of skilled technicians	3.72	0.77	4 th

High conversion cost as major barrier confirms Chika Izuora (2023), Olawin (2024) and Lere (2024). Inadequate infrastructure confirms Reuters (2024) and NNPC report (Nigerian National Petroleum Company Limited, 2023). Safety concern is linked to non-compliance with ISO 11439:2013 (International Organization for Standardization, 2013) and recent accidents (The Associated Press, 2025; THISDAYLIVE, 2024).

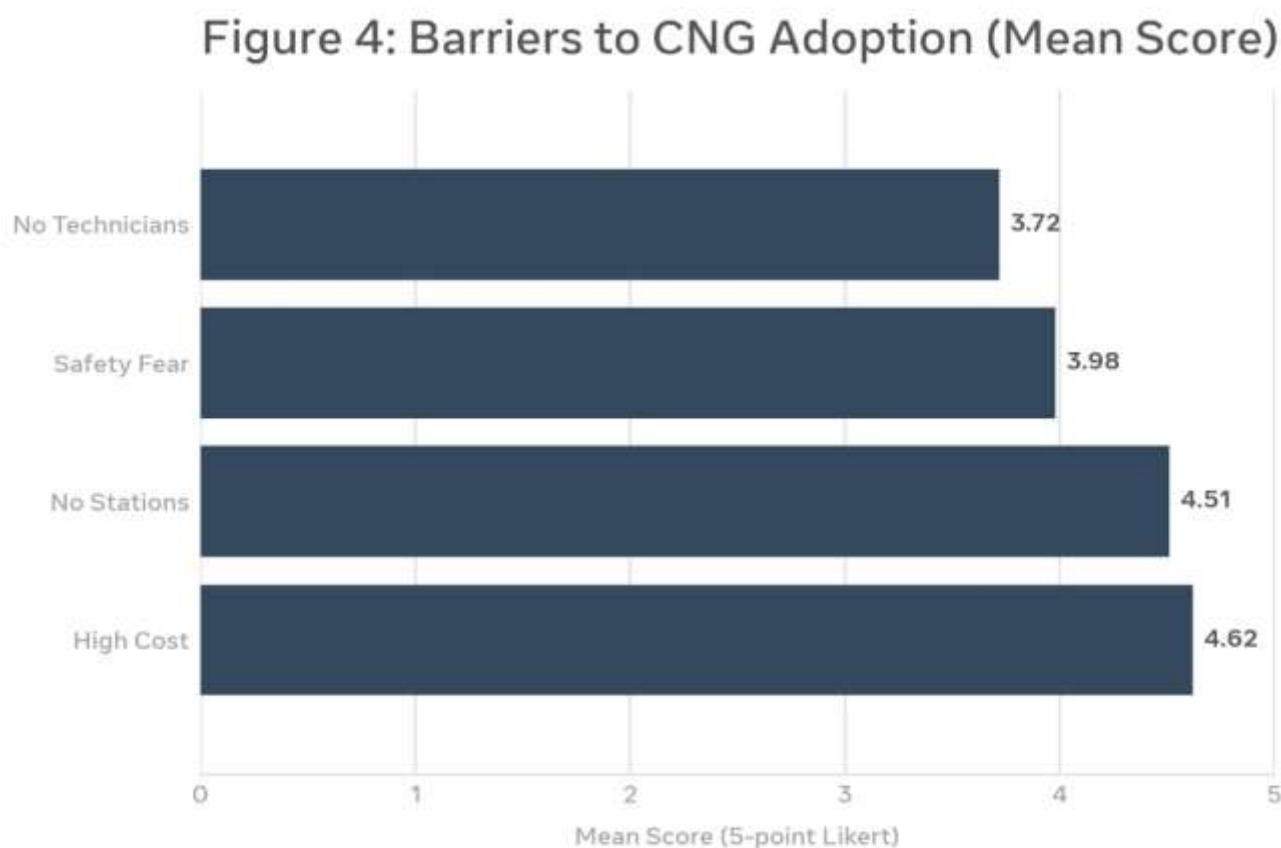


Figure 4: Mean Score of Perceived Barriers to CNG Retrofitting Adoption (Source: Field Survey, 2025).

As shown in Figure 4, high conversion cost ($M=4.62$) and inadequate refueling stations ($M=4.51$) are the most critical barriers, confirming earlier findings by Chika Izuor(2023), Olawin (2024), and Reuters (2024) on infrastructural gaps.

Barriers ranked in Figure 4 show infrastructure as critical. This mirrors Federal Ministry of Petroleum Resources (2017) National Gas Policy which identified infrastructure as key enabler, and requires strict enforcement of United Nations Economic Commission for Europe (2014) Regulation 110 to address safety fears.

Hypothesis Testing

H01: There is no significant difference in monthly fuel cost before and after retrofitting.

Paired sample t-test: $t = 18.42$, $p = 0.000 < 0.05$. Null hypothesis rejected. Significant cost reduction after retrofitting.

H02: CNG infrastructure availability does not significantly influence adoption willingness.

Regression: $R^2=0.68$, $\beta=0.62$, $p=0.001$. Null rejected. Infrastructure is strong predictor, as argued by Ibitoye and Adenikinju (2007) and Ng et al. (2015).

Discussion of Findings

The 3.1 months payback for commercial operators makes retrofitting highly feasible in post-subsidy economy. This finding addresses fiscal strain noted by World Bank (2023). Unlike Ibeneme and Ighalo (2020) who focused on benefits generally, this study quantifies post-subsidy reality.

The environmental gains reinforce Nigeria's commitment to energy transition (Federal Ministry of Petroleum Resources, 2017; Presidential Compressed Natural Gas Initiative, 2023). However, sustainability (Jeon & Amekudzi, 2005) will only be achieved if safety

compliance to UN Regulation No. 110 (United Nations Economic Commission for Europe, 2014) is enforced and conversion cost subsidy provided, as recommended by Adefulu et al. (2022) and Oyedepo (2014).

Economic viability is clear, but infrastructural gap remains bottleneck. This mirrors findings of Biose (2020) on gas utilization challenges.

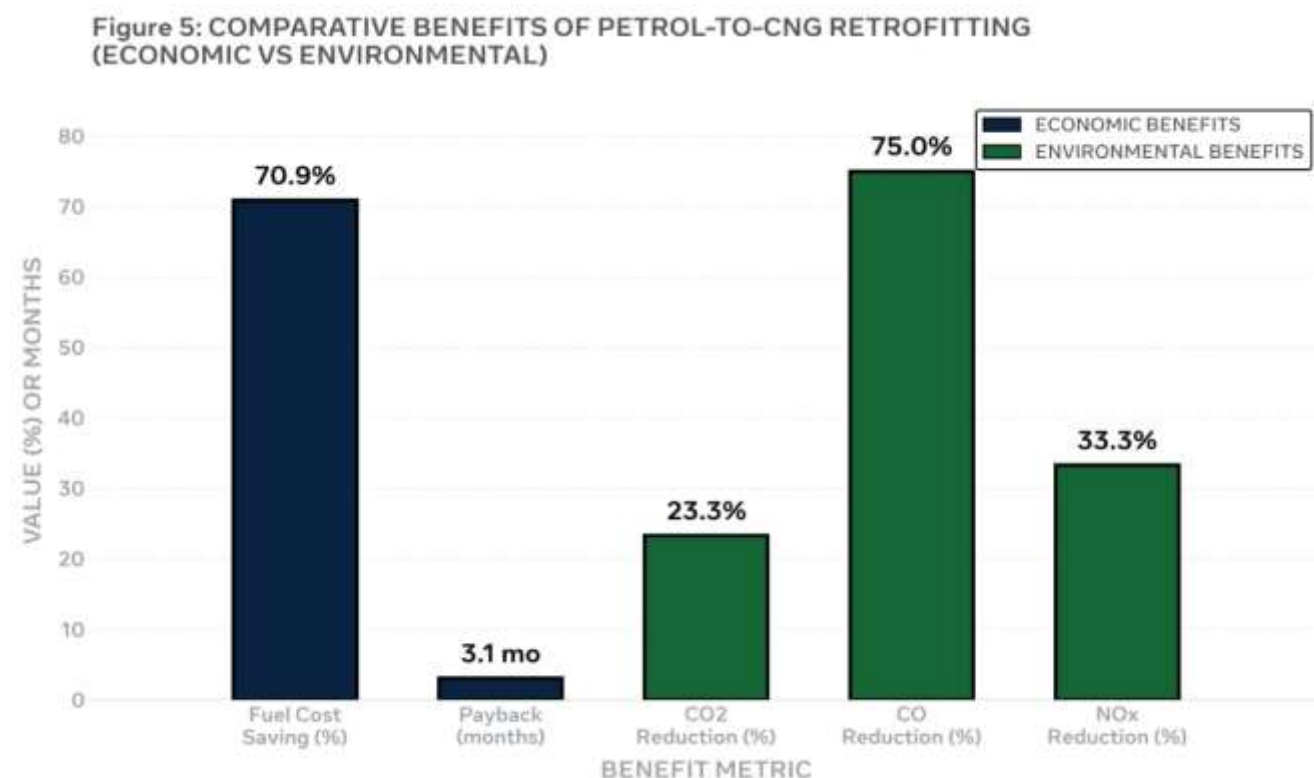


Figure 5: Comparative Benefits of Petrol-to-CNG Retrofitting (Economic vs Environmental)
Source: Field Survey Analysis, 2025

As summarized in Figure 5, retrofitting offers dual benefits: 70.9% fuel cost saving (economic) and up to 75% CO reduction (environmental). This dual advantage positions CNG as both poverty-alleviation tool post-subsidy removal (World Bank, 2024; National Bureau of Statistics, 2025) and climate mitigation strategy (Masson-Delmotte et al., 2021; International Energy Agency, 2022). While CO₂ reduction is modest at 23.3%, it is significant compared to Argentina's 20% average (Ente Nacional Regulador del Gas, 2025) and aligns with Health Effects Institute (2019) estimates. This strengthens justification for PCNGI expansion.

CONCLUSION

This study evaluated the feasibility and impact of petrol-to-CNG vehicle retrofitting in Nigeria's post-subsidy economy. Findings confirmed that retrofitting is highly economically feasible, with 70.9% fuel cost saving per 100km and a short payback period of 3.1 months for commercial and 8.7 months for private vehicles, making it a viable cushion against subsidy removal shocks. Environmental analysis also demonstrated significant benefits with 23.3% CO₂, 75% CO and 33.3% NO_x reductions, supporting Nigeria's energy transition and climate commitments. Despite these benefits, high conversion cost and inadequate refueling infrastructure remain critical barriers limiting large-scale adoption. The significant influence of infrastructure on adoption willingness implies that without deliberate investment in CNG

stations and skilled technicians, the Presidential CNG Initiative may not achieve its full potential. The study concludes that petrol-to-CNG retrofitting offers dual economic and environmental advantages and should be scaled through targeted financial incentives, expansion of refueling networks, and strict enforcement of safety standards ISO 11439 and UN Regulation 110. Future research should incorporate direct exhaust measurement and longitudinal assessment of engine durability to further validate sustainability claims.

Recommendation

Based on findings, the study recommends that government should provide partial subsidies for conversion costs to reduce barrier for commercial operators. Presidential CNG Initiative should accelerate deployment of refueling stations across major transport corridors. Regulatory agencies must enforce safety compliance with ISO 11439 and UN Regulation 110 and certify technicians. Transport unions should organize bulk conversion schemes for economies of scale. Finally, public awareness campaigns on economic and environmental benefits should be intensified to improve adoption willingness.

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