**Adoption of compressed natural gas and national security in Nigeria**

**By**

**ADEGBOYE Lasisi Adejare., ISHAKU Aisha Yusuf,., NWAIGWE Nkiruka Anthonia., LAWANSON Henry Olusesan., & ONIBIYO, Ezekiel Rotimi**

**1-5Institute of Governance and Development Studies, Nasarawa State University Keffi, Nigeria**

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Abstract

*A diversified energy basket strengthens resilience and reduce vulnerability to international vagaries in crude oil prices. For a country with moribund refineries, extensive illegal oil bunkering, over reliant on imported fossil fuel, and poor energy mix, the adoption of Compressed Natural Gas (CNG) becomes a determining alternate to transportation, industrial operations, and dwindling foreign reserves for Nigeria. The inability to hit the ground running with institutional framework to chaperone the CNG adoption is same replica of absence of an agency for tracing and tracking of arms proliferation. It was against this background that this study engage modernisation theory to examine the influence of the adoption of CNG on National Security in Nigeria. This study decompose national security into challenges confronting CNG adoption, and CNG influence on economic security. The study engaged qualitative research design with reliance on internet materials, observations, government reports, and grey literature. Findings from the study showed that CNG innovative technology is negatively impacted by challenges confronting its adoption, Study also submitted that CNG adoption positively influence economic security due to its availability, cost effectiveness and foreign exchange savings to the federal government. Based on these findings, the study recommends that all tiers of government should create an enabling infrastructure environment for coordinated private sector involvement in solving identified CNG challenges. The study also recommends that all tiers of government including tertiary institutions should further amplify through a Whole Society Approach the economic benefits, professional retrofitting standards of CNG as alternative to fossil fuel patronage in general endeavors.*

**Keywords:** Compressed Natural Gas, Human Security, Modernisation Theory, Policy Missteps

**Introduction**

Transition from fossil fuel to Compressed Natural Gas (CNG) is a phenomenon that represents drives for climate change mitigation to others and need for energy mix to others. The United States, China, Iran, Brazil, and India are central to the adoption of CNG. In developing countries, the transition from fossil fuels to compressed natural gas (CNG) in vehicular and machinery operations is an urgent priority for both economic stability and sustainability (Dadras, 2021; International Energy Agency, 2020). Fossil fuel reliance is a key driver of economic vulnerability, particularly in nations that import significant amounts of petroleum. The volatility of global oil prices exposes such countries to financial shocks, leading to budget deficits, inflation, and currency devaluation.

 Adopting CNG, which is cheaper and more stable in price, can help shield developing nations from these price fluctuations, thereby reducing the economic burden on both government finances and individual

households. This stability fosters long-term economic planning and enhances public sector investment capabilities (World Bank, 2021). Moreover, CNG adoption aligns with the global push towards cleaner

energy and lower greenhouse gas emissions. Developing nations are often disproportionately affected by the consequences of climate change, including extreme weather events and agricultural disruptions. Shifting from oil-based fuels to cleaner alternatives like CNG can help mitigate these risks by contributing to global emission reduction efforts. This transition not only helps safeguard the environment but also promotes sustainable development by reducing the health costs associated with air pollution, which is heavily linked to fossil fuel combustion

Additionally, local production and use of CNG can stimulate domestic economic growth by reducing fuel import costs, fostering energy independence, and encouraging the development of local industries related to CNG technology, infrastructure, and services. This creates employment opportunities and drives technological innovation, positioning developing countries to better compete in the global energy market. Diversifying the energy mix also aligns with the United Nations Sustainable Development Goals (SDGs), particularly in fostering resilient infrastructure, promoting inclusive industrialization, and encouraging innovation . A diversified energy basket is expected to strengthen resilience and reduce vulnerability to international vagaries in crude oil prices.

In Nigeria, despite the Nigerian government proposed the use of [compressed natural gas](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/compressed-natural-gas%22%20%5Co%20%22Learn%20more%20about%20compressed%20natural%20gas%20from%20ScienceDirect%27s%20AI-generated%20Topic%20Pages) (CNG) as an [automotive fuel](https://www.sciencedirect.com/topics/engineering/automotive-fuel%22%20%5Co%20%22Learn%20more%20about%20automotive%20fuel%20from%20ScienceDirect%27s%20AI-generated%20Topic%20Pages), in 1997 as part of the initiatives to harness natural gas (NG)resources, twenty seven years thereafter, progress has been slow (Ogunlowo et al., 2015). The cost of conversion can vary depending on the vehicle model, size of the CNG tank, and the conversion centre, but it typically ranges from N1. 2m to N1. 5m (Nnodim, 2024). The CNG is coordinated by the Presidential Compressed Natural Gas Initiative (P-CNGi) with government interventions to shoulder N750,000 per transporter conversion cost. The committal of $50m mobilised directly to ensure CNG adoption is properly operationalised (Nnodim, 2024).

The conversion involves installing a CNG tank, fuel lines, regulators, and other accessories in the vehicle. The retrofitting process typically takes three hours, as the vehicle’s existing petrol system is kept intact, allowing the driver to switch between petrol and CNG as needed. The average rule of thumb is that for every one litre of petrol, vehicle can achieve 14km. In the case of CNG, 1scm (standard cubic meter) of gas would take you 18km. CNG-powered vehicles generally see average of 15 per cent reduction in fuel efficiency compared to the original petrol version, even as the reduced fuel cost of CNG often offsets this mileage difference (Speede et al., 2024).

Concerningly, there is a dearth of sensitisation and awareness on benefits from CNG adoptions within the public domain, the absence of emplacing a Whole Government Approach (WGA) in percolating the CNG adoption to schools, learning institutions, artisans, faith based agency could account for the slownessin the embrace of this global phenomenon of mitigating climate change. All these account for linkage failure with the academia neither with the teeming artisans mechanics in Nigeria whose knowledge of the CNG technology is a sure catalyst that can quicken the embrace and investment by stakeholders

**Statement of the Problem**

The slow technology embrace f and high cost of conversion of vehicular assets and plants from fossil fuel dependence to CNG could be traced to the absence of an institutional framework to broaden the adoption of the CNG. This initiative is presently driven by an adhoc presidential CNG initiative (P-CNGi), as such an adhoc arrangement will slow down the much desire technology transfer. The absence of the participation of the ministry of Science and Technology is also a redflag that should attract attention of stakeholders and this further could account of the gross failure of the adhoc committee of P-CNGi to engage Nigeria tertiary Universities whose absence from the CNG drive could be stereotype as outright abdication of duty post.

This apparent infrastructure gaps is both seen in human know how, infrastructure and slow involvement of private sectors. The absence of States and Local Governments is this order shows low comprehension of a WGA to magnetise the private sector both in preparation and in engendering an enabling environment. The straitjacketed focus on the transportation sector is another policy miststeps that reflect absence of a WGA to catalyse the artisans mechanics who should be seen in all citadel of higer learning and designated centres to embrace the conversion from fossil fuel engine to CNG The proactive posture of the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA), to issue license to only oil marketers with proven installation of CNG pumps should be extended to license renewal while the Nigeria University Commission, National Board of Technical Education for Polytechnics, and Ministry of Science and Technology should emplace adequate regulatory control to railroad all institutions into the CNG technology both in grants and in a whole society Approach

**Objectives of the Study**

This study provides answers to the following

1. Examine CNG adoption and confronting challenges in Nigeria
2. Interrogate CNG adoption and its influence on economic Security in Nigeria

**Conceptual and Literature Review**

**Compressed Natural Gas**

Compressed natural gas (CNG) is a clean-burning alternative to gasoline or diesel used in transportation. It is predominantly made of methane (CH4), of which natural gas is the most commonly used alternative vehicle fuel in the United States (Kozonoe et al., 2024). In transportation, natural gas is used either as CNG or as liquefied natural gas (LNG). Benefits of this fuel include cost savings, reduced emissions, ease of vehicle maintenance, and increased energy security. CNG is extracted during crude oil production, with a sustinable use it as transportation fuel as a way to reduce petroleum consumption by more than 90% compared to gasoline.

**National Security**

Nigeria’s over reliant on fossil fuel signifies a vulnerable national security due to heavy reliance on imported refined petroleum products, absence of oil refining capabilities, spike in oil and gas vandalism, and the consistent risks associated with global oil market volatility and geopolitical tensions which endlessly disrupt fuel supplies (Mulugetta, 2010). By leveraging domestic natural gas resources, Nigeria can insulate itself from external shocks, making its energy supply more secure and stable. Furthermore, the diversification to CNG can positively influence national security by reducing a country’s dependence on imported fossil fuels and promoting energy self-sufficiency. Additionally, the development of local CNG infrastructure promotes economic growth, fosters job creation, and reduces the likelihood of social unrest linked to unemployment and fuel scarcity, thereby strengthening national stability.

CNG also contributes to national security by mitigating the environmental and social risks associated with fossil fuel consumption, such as oil theft, pipeline vandalism, and environmental degradation. Fossil fuel dependence has historically been linked to conflicts in oil-producing regions, with issues such as oil bunkering and sabotage posing serious threats to infrastructure and public safety (Bashir et al., 2020). The transition to CNG, which is less prone to these security vulnerabilities, reduces the economic losses and security risks caused by these activities. Moreover, the environmental benefits of CNG, such as reduced pollution, help create a healthier living environment, lessening the social unrest driven by environmental degradation. Thus, by enhancing energy security and reducing the risks associated with fossil fuels, CNG adoption supports overall national security.

**Economic Security**

Economic stability which validates economic stability could be seen in the adoption of compressed natural gas (CNG) for both the state and individuals by offering a more cost-effective and sustainable energy alternative compared to fossil fuels. At the state level, reliance on imported gasoline and diesel fuels can strain foreign exchange reserves, especially in countries like Nigeria, where the economy is heavily reliant on oil exports but also imports refined petroleum products (Mulugetta, 2010). Transitioning to CNG, which can be domestically produced from Nigeria’s abundant natural gas reserves, reduces the pressure on foreign reserves and lowers fuel import costs. This shift helps stabilize the national economy by reducing vulnerability to fluctuations in global oil prices, improving the trade balance, and creating job opportunities in the CNG supply chain, such as infrastructure development and vehicle conversion industries (Bashir et al., 2020).

For individuals, the switch to CNG provides long-term savings on fuel costs, which can significantly improve household economic stability. CNG is typically cheaper than gasoline or diesel, offering vehicle owners a more affordable option for fueling their cars. This cost reduction translates into greater disposable income for families, which can be directed toward other needs, thus improving living standards. Furthermore, lower transportation costs benefit businesses that rely on logistics, leading to reduced product prices and increased profitability (Jain, 2018). As fuel expenses decrease, individuals experience more financial flexibility, contributing to broader economic stability. Thus, CNG offers a dual advantage by stabilizing the economy at both the state and individual levels.

**Emerging Economic Security and Compressed Natural Gas**

### ****Lower Fuel Costs:**** CNG is often significantly cheaper than traditional fossil fuels like gasoline or diesel. This cost advantage can result in substantial savings for consumers and businesses, particularly in countries that produce natural gas domestically. For example, according to the International Gas Union (2019), CNG is typically 30-50% cheaper than gasoline or diesel. These lower fuel costs can lead to significant reductions in operating expenses, especially for high-mileage vehicle fleets, such as taxis, buses, and logistics companies, where fuel consumption constitutes a major portion of operational costs.

### ****Reduced Vehicle Maintenance Costs:**** CNG-powered vehicles tend to have lower maintenance costs compared to those using gasoline or diesel. CNG burns more cleanly than traditional fuels, resulting in fewer carbon deposits in the engine. This reduces wear and tear on engine components such as spark plugs, exhaust systems, and oil filters, leading to less frequent repairs and replacements. Studies indicate that vehicles using CNG can extend the life of engine oil, requiring fewer oil changes and lowering overall maintenance costs (Kohler, 2017).

### ****Energy Efficiency and Long-term Economic Benefits:**** CNG is a more efficient fuel in terms of energy content. The energy content of CNG is higher than that of gasoline, meaning that less fuel is required to produce the same amount of energy. In the long term, this efficiency can result in reduced fuel consumption, even for the same mileage, leading to overall cost savings. For fleet operators, such as public transportation systems, this can translate into considerable savings over time, as CNG buses or trucks can travel longer distances on the same amount of fuel (Kojima, 2016).

### ****Environmental and Public Health Savings:**** The environmental benefits of using CNG are another factor that contributes to cost reductions, particularly at the governmental level. CNG produces fewer harmful emissions such as nitrogen oxides (NOx), particulate matter, and sulfur oxides (SOx), which are major contributors to air pollution. Reducing these emissions can improve air quality, leading to fewer health problems such as respiratory and cardiovascular diseases. For governments, this can reduce healthcare costs associated with treating pollution-related illnesses. A report by the International Energy Agency (IEA, 2019) notes that countries transitioning to cleaner fuels like CNG can experience significant public health savings due to the reduction in pollution-related health issues.

**Constraining Factors to CNG adoption in Nigeria**

**Absence of Local Content in Retrofitting:** There is no gainsaying that NGV conversion done by local mechanic caused higher emission level and greater fuel usage compared to NGV from OEM. Thus, it eliminates most of the gas fuel usage benefit. The availability, modern technology and gas fuel vehicles component are important for the acceptance of gas fuel vehicles on customer side, compared to the existence of OEMs (original equipment manufacturers (Khan, 2017).

**Infrastructure Development**: The lack of adequate infrastructure as of establishment of CNG refueling stations, pipelines for gas distribution, and retrofitting existing vehicles to run on CNG require significant investments in both time and resources. In developing nations, there is limited infrastructure to support the widespread use of CNG. Building a network of refueling stations across urban and rural areas is essential for widespread adoption (Gautam & Jain, 2017).

**Initial Conversion Costs**: The cost of converting vehicles and plants to run on CNG can be prohibitively high for individuals and businesses. Vehicle owners need to retrofit their gasoline or diesel engines to accommodate CNG, which is costly ranging from 900,000 to 460,000. The initial outlay can deter adoption, particularly in countries with high poverty rates or for small businesses with limited financial flexibility (Mulugetta, 2010).

**Regulatory and Policy Challenges**: The success of CNG adoption also depends on supportive regulatory frameworks and government policies. Inconsistent or unclear policies regarding natural gas pricing, subsidies, and environmental regulations can hamper the adoption process. Governments must also ensure that safety standards are enforced, as improper handling of CNG can pose safety risks due to its highly flammable nature. Additionally, bureaucratic hurdles, corruption, and a lack of policy continuity can further complicate efforts to promote the transition to CNG (Bashir et al., 2020).

**Public Perception and Awareness**: Many people may not be aware of the benefits of CNG or may harbor misconceptions about its safety, reliability, or performance. The public's preference for gasoline and diesel, which they are accustomed to, can slow the transition to CNG. Education campaigns and awareness programs are necessary to highlight the environmental and economic benefits of CNG, but overcoming entrenched behaviors and attitudes can be difficult. Additionally, CNG vehicles may have reduced range compared to gasoline-powered vehicles, which could raise concerns about the practicality of using CNG, especially in regions with sparse refueling stations (Gautam & Jain, 2017).

**Absence of Technology Transfer Office** the gross absence of Technology Transfer Office (TTO) in advancing innovative technology in Nigeria’s tertiary institutions is concerning. Ttransfer of technology to artisans, roadside mechanics and fabricators to conduct conversions for vehicles, machineries on diesel, farmers generating plants further expose reasons for slow embrace of the needed transfer of Technology to drive CNG adoption in Nigeria

**Empirical Review of Related Literature**

**CNG adoption and National Security**

Ogunlowo et al. (2015) examined the embrace of compressed natural gas as an automotive fuel in Nigeria. The study adopted secondary data derived from academic literature, published reports from a variety of international agencies, grey literature, and text from online sources. The study submitted that the principal impediment to NGV market development in Nigeria is the uncoordinated implementation approach, absence of government at her duty post in setting strategic goals, developing the legal and regulatory frameworks, setting of clear standards for vehicles and refuelling stations as well as assigning responsibilities to specific agencies. Short-term low cost policy interventions identified include widening the existing NG and gasoline price gap and offering limited support for refuelling and retrofitting facilities. Study did not emphasise greater needs for private investors participation and sensitisation on CNG which this study will emphasise

Ugolo et al. (2024) interrogated a comparative analysis for the successful implementation of Natural Gas Vehicles of CNG in developed and developing countries. The study engaged qualitative inquiry approach, using a comparative study of secondary data from academic literature, published reports, online sources, and grey literature. Findings from showed that there is the need for a well-guided and intentional implementation of the usage of CNG to avoid a monumental failure that could further exacerbate economic insecurity of the country.

Ishengoma and Gabriel (2021) interrogated economic factors and the nexus between car-owners’ willingness to incur full costs of converting their cars to natural gas vehicles (NGVs) or to secure commercial loans to supplement their savings for meeting the attendant costs in Tanzania. The study engaged logit models on data generated from 429 randomly selected vehicle-owners, who had visited three big oil refuelling stations in Kinondoni district of Dar es Salaam city in Tanzania. Findings from the study revealed that the better the vehicle condition in terms of mileage, the newness or near-newness, the higher the number of car-cylinders, the more likely the car-owners would be willing to incur conversion-to-NGVs costs and use commercial loans to foot the bills. The study was done in Tanzania hence the need to use Nigeria dataset.

Shaarawi et al. (2023) investigated Green House Gas emission reductions and economic saving by enhancing switching to natural gas vehicles in Egypt. The study elicited historical data on liquid fuel vehicles growth (excluding 2 and 3 wheelers motor vehicles) and population from the official data source of Egypt's Central Agency for Public Mobilization and Statistics (CAPMAS) bulletins. While the data for natural gas vehicles growth, CNG fuel price and amounts of sold CNG in CNG-fuelling stations starting from beginning of NGV program up to the end of 2021 were collected from national program archiving data for vehicles transformation into natural gas-powered vehicles at EGAS. Result that emanated from the study showed that Egypt’s NGV program led to about 21.57 billion EGP economic saving since starting up to end of 2021.

**Theoretical Framework**

**The modernisation theory**

Modernisation theory, explains the transformative impact of technological advancement and industrialization on society, as a strategy for mitigating cost and health issues associated with fossil fuels. This theory posits that the development of infrastructure and the integration of advanced technologies are crucial to promoting economic growth and improving the quality of life (Inglehart & Welzel, 2005). In the Nigerian context, the transition to CNG technology aligns with modernisation principles as it represents an effort to shift from traditional fossil fuel use to a more sustainable and cost-effective alternative. CNG not only promises cheaper fuel costs but also helps in reducing air pollution, thus contributing to improved public health. This will be further advanced with setting ups of Transfer of Technology Centres as linkages between tertiary institutions, the industries, and society as a Whole Society Approach.

According to modernisation theory, societies progress through stages of development, with each stage necessitating new forms of energy use and technological innovation. For Nigeria, adopting CNG technology can be seen as a step toward energy modernisation, moving away from its reliance on oil. With proper technology transfer and infrastructure development, the country can modernise its energy systems, improving the overall efficiency of transport and industry while reducing health risks.

In conclusion, modernisation theory provides a framework for understanding the adoption of CNG technology in Nigeria as a necessary step toward economic and social development. By embracing cleaner and more efficient energy sources, Nigeria can modernise its energy infrastructure, reduce costs, and improve public health outcomes. The alignment of CNG adoption with the broader goals of modernisation—economic progress, technological advancement, and enhanced quality of life—demonstrates how this shift in energy use reflects a transformative stage in the country’s development (Smith, 2020).

**Research Methodology**

This study adopted exploratory research design while making use of secondary data generated via journal publications, internet, library, and other materials relevant to the study of agriculture mechanisation and food security. The research is conducted by examining literature from published reports, online sources, and grey literature concerning challenges of CNG adoption, Technology Transfer, Human security and Policy Gaps. The literature was obtained through searches in publicly available material, literature from non-serial publications, official reports, and conferences particularly if they have been cited by other references.

**Discussion of Findings**

Findings from the study showed that CNG innovative technology is negatively impacted by challenges confronting its adoption in Nigeria. This could be explained by the slow private sector embrace of CNG adoption, absence of legislative frameworks, poor sensitisation and awareness campaign on CNG transition, dearth of stations which create refueling challenges, Cost and hazards of conversions from petrol/diesel to CNG, non availability of retrofitting kits and conversion centres, performance Lag lesser than petrol and diesel cars, and boot space constraint as CNG cylinder occupies boot space. Result from study aligns with previous works of Ogunlowo et al. (2015); Ugolo et al. (2024)

Result from empirical review also submitted that CNG adoption positively influence economic security in Nigeria. Both government and individual benefit from such economic security. This could be explained by the CNG availability, and cost effectiveness to private and corporate users including the government. The government also benefits as foreign exchange savings accruing from transition to CNG can be diverted into agriculture subsidies,grants to University to further enrich the value chain of CNG transition, provision of Students loans, and health facilities provisioning amongst others.. Findings from this study affirmed earlier findings of Ishengoma and Gabriel (2021); Shaarawi et al.(2023).

**Recommendations**

1. That all tiers of government, Ministry of Science and Technology should create an enabling infrastructure environment for coordinated private sector and higher institutions of learning involvement in solving identified CNG challenges.
2. That all tiers of government, Civil Society Groups should further amplify the economic benefits of CNG as alternative to fossil fuel patronage, as such a Whole Society Approach will interest all machinery users to wean themselves off fossil fuel as much as possible and this will safely birth Nigeria a better energy mix.

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