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Assessing policy frameworks for compressed natural gas transition and health security in Nigeria

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Abstract

The slow populace embrace and inability of Nigeria's tertiary institutions to hit the ground running on the much desired vehicular conversion to Compressed Natural Gas (CNG) signaled policy framework missteps that need to be readdressed. So much so, the extent to which CNG serves as a cleaner-burning fuel, produces fewer pollutants of nitrogen oxides, and sulphur dioxide compared to traditional fossil fuels, earns it emerging patronage to mitigate climate change, conserve depleting foreign reserves, and ensure health security. The slow responsiveness to CNG and dearth of institutional patronage also validate policy gaps, thus the need for further interrogation. It was against this backdrop that this study engage Ecological Modernisation Theory to interrogate the influence of policy frameworks for CNG transition and attending health security in Nigeria. This study is disaggregated into CNG policy missteps and health security in Nigeria. The study engaged exploratory research design with reliance on internet materials, observations, government reports, and grey literature. Findings from the study showed that CNG innovative technology is negatively influenced by short term policy framework around Nigeria's search for energy mix. The Study also submitted that CNG adoption positively influence health security as seen in lower emission of pollutants which aggravate respiratory and other extant health challenges. Based on these findings, the study recommends both Federal and State Government should employed a Whole Society Approach when emplacing policy framework. The study also recommends that cost savings achieved on CNG adoptions should be used to advance an environmentally secured Nigeria space.

Keywords: Compressed Natural Gas, Ecological Modernisation Theory, Health Security, Policy Frameworks

Introduction

Compressed Natural Gas (CNG) is a global phenomenon with India and Iran having over four millions CNG vehicles, including cars, buses, and rickshaws. While the US and China have extensive networks to cater for public transportation and haulage. The availability of gasoline and diesels in developed clime slowed down the adoption of CNG, which is usually reserved for vehicles that travel many miles each year. The adoption of CNG in Nigeria underscores government determination to bridge the widening, refineries gap, diversify her energy mix, reduce its carbon footprint, and enhance energy security. Statistics shows that Nigeria will save about $2.5 billion yearly from every one million vehicles powered by CNG (Fakoyejo, 2024).

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CNG has higher fuel-efficiency and cost effectiveness than conventional petrol/diesel powered engines. Any existing fossil powered petrol vehicle can be converted to a dual-fuel petrol/CNG vehicle, using retrofitting kits, which involves installing a CNG cylinder, plumbing, a CNG injection system, and electronics. The cost of installing a CNG conversion kit are often expensive on passenger cars and light trucks, CNG costs about 50% less than petrol, and emits up to 90% fewer emissions than petrol (Alao & Popoola, 2024).

As of 2021, Iran had invested about $3.33 billion in CNG-related development projects across the country, more than eight kits and equipment factories, six CNG tank factories, four compressor factories established across the country, while knowledge for the production of more than 80 percent of the parts and equipment used in the CNG industry are indigenized. These and more are guided by Iran Seventh National Development Plan (2022-2026) and a success story of over 2,495 CNG stations across Iran that supply 20 percent of the country's fuel basket (Dadras, 2021).

In Nigeria, despite the Nigerian government proposed the use of compressed natural gas (CNG) as an automotive fuel, 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. 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 slowness in 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.

The policy framework for CNG adoption in Nigeria is driven by an adhoc Presidential Compressed Natural Gas Initiative (P-CNGi) same replica of presidential taskforce on arms control and proliferation instead of an agency/institutional approach. Effects of such short term approach is evident in the poor responsiveness of the private sector, apparent deficit in CNG infrastructure; weak refuelling stations, dearth of retrofitting centres, absence of vehicle conversion programs, and absence of technology transfer centre (TTC) in Ivory towers. Presence of these amongst others transmit the absence of a Whole Society Approach in the adoption of CNG as vehicular and machinery usage fuel.

Instructively, this study cannot overlook the policy framework adopted in Rwanda success story in agriculture mechanisation reflects dedication to strengthening segment of the agriculture value chain through targeted mechanization interventions, increase roles of the private sector, emphasis on research and skill development, and the creation of village mechanization centers. Hence, Rwanda was named as the best-performing country in implementing Africans Union comprehensive Agriculture plan (The Malabo Montpellier Panel, 2019)

The adoption of CNG has the potential to lower the incidence of health outcomes; respiratory challenges, heart issues, cancer, and cardiovascular diseases, as well as other chronic health conditions. Imam et al. (2024) submits that fossil fuel significantly contributes to the growth of economy but produces carbon dioxide (CO2), which is detrimental to environmental sustainability with overall effects on health outcomes of infant, adult, and aged persons. Again, the emitted carbon-related compounds potentially react negatively with human haemoglobin (Akinolaa & Abejuyiwa, 2022).

There is no gainsaying that there is an outright abdication of duties by Nigeria's polytechnics and Universities whose department of Mechanical Engineering should be seen at the forefont percolating CNG conversion technical knowledge, retrofitting awareness, magnetising Nigeria Artisans mechanics into the Ivory towers and demanding for palliative from all tiers of government to enable teeming mechanics to be properly empowered. This abdication of responsibility could be explained by the absence of Technology Transfer Offices in virtually all the institutions, both public and privately owned.

Statement of the Problem

The slow technology embrace of CNG, high cost of conversion of vehicular assets and plants from fossil fuel dependence could be traced to the absence of long term institutional framework to broaden the adoption of the CNG. The CNG initiative is driven by an adhoc arrangement, which will slow down the much desire technology transfer. The absence of the participation of the ministry of Science and Technology is also a red-flag 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 in this order shows low comprehension of a WGA to magnetise the private sector both in preparation and in engendering an enabling environment. The straightjacketed focus on the transportation sector is another policy missteps that reflect absence of a WGA to catalyse the artisan mechanics who should be seen in all citadel of higher learning and designated centres to embrace the conversion from fossil fuel engine to CNG. The absence of the Nigeria University Commission, National Board of Technical Education for Polytechnics, and Ministry of Science and Technology in magnetising 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

- **i.** Investigate CNG adoption policy missteps in Nigeria.
- **ii.** Interrogate CNG adoption and its influence on health security in Nigeria

Conceptual Review 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). It is drawn from wells or extracted during crude oil production. While some petroleum is used in the production of natural gas, using it as a transportation fuel reduces petroleum consumption by more than 90% compared to gasoline. 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.

Policy Frameworks for CNG transition

Nigeria's transition to Compressed Natural Gas (CNG) as an alternative to fossil fuels requires a Whole Society Approach (WSA) of comprehensive policy framework to ensure smooth adoption, infrastructure development, wide institutional engagement, and widespread usage. It is instructive that several countries have successfully implemented policies that promote CNG usage, which can serve as models for other nations like Nigeria. Key components of an effective policy framework for transitioning to CNG should amplify; Subsidies and Financial Incentives to targeted institutions to make CNG adoption more attractive.

Such incentives include providing grants or low-interest loans to cover the high upfront costs of converting petrol or diesel vehicles, farms generating plant, grinding machine to CNG. In India, for instance, the government provides subsidies on CNG and tax incentives on CNG vehicles, which has encouraged both consumers and businesses to adopt this cleaner fuel source (Singh, 2019). The need for State and Local governments, Nigeria Ivory towers and relevant institutional bodies to be involved in percolating the benefits of the CNG should be promoted. Enugu state blazed the trail by channeling her adoption of CNG , through a newly created ministry than an adhoc arrangement (Odeyemi, 2024).

Policy Missteps

Policy missteps refer to errors or failures in the design, implementation, or execution of public policies that lead to unintended, often negative, outcomes. These mistakes can arise due to various factors, such as poor planning, lack of stakeholder engagement, inadequate data, political pressures, or insufficient resources. Policy missteps often result in inefficiencies, worsened socio-economic conditions, or the exacerbation of the problems the policy was meant to address (Howlett, 2012). For instance, a poorly designed economic policy could fail to address inflation, or a healthcare policy may inadequately respond to public health needs, leaving gaps in essential services.

Examples of policy missteps include ineffective regulatory frameworks, underestimating the complexity of an issue, or failing to account for local conditions and stakeholder needs. A classic example is the unintended consequences of austerity measures during economic crises, which have been criticized for deepening economic inequality and harming vulnerable populations (Stuckler & Basu, 2013). These mistakes can lead to public dissatisfaction, loss of trust in governance, and negative long-term effects on economic, social, and political systems. The need for Nigeria to avoid policy missteps cannot be over emphasised as CNG cannot be driven outside an agency approach as presently done under an adhoc presidential taskforce called P-CNGi. An agency driven setting oiled on Whole Society Approach will ensure a well-coordinated implementation approach with greater government involvement required in setting strategic goals, learning institutions involvement for technology transfer knowledge, developing the legal and regulatory frameworks, private sector partnership for infrastructural development, as well as assigning responsibilities to specific agencies.

Emerging Policy Threat to Adoption of CNG

Several policies and regulatory obstacles hinder the widespread adoption of Compressed Natural Gas (CNG) as an alternative to fossil fuels. These barriers often slow down the transition to cleaner energy, especially in countries like Nigeria.

Fossil Fuel Subsidies: One of the most significant barriers to CNG adoption is the continued subsidization of fossil fuels. Countries like Nigeria provide substantial subsidies for petrol and diesel, keeping their prices artificially low and also endangering neighbouring countries through artificially low prices. These subsidies reduce the price competitiveness of CNG, discouraging both individual consumers and businesses from transitioning to CNG-powered vehicles. The International Energy Agency (IEA) has noted that fossil fuel subsidies often undermine the adoption of cleaner technologies by distorting market signals and making cleaner alternatives, like CNG, less attractive (IEA, 2019).

Inadequate Infrastructure Policies: The lack of policies that support the development of CNG infrastructure is a critical challenge. CNG refueling stations are limited, and policies that incentivize the construction of such infrastructure are often weak or absent. Without sufficient access to refueling stations, consumers are less likely to switch to CNG vehicles. This is especially true in countries where long distances between refueling stations pose practical challenges for users (Mokhatab et al., 2015).

High Initial Costs and Limited Incentives: Conversion costs for CNG vehicles are relatively high, and in many countries, there are limited financial incentives to offset these costs. Policies that fail to provide tax breaks, subsidies, or low-interest loans for vehicle conversion hinder adoption. The lack of government incentives for consumers and businesses to convert vehicles to CNG has been a significant barrier, particularly in emerging markets where upfront costs are a concern for many (Kojima & Bacon, 2016).

Regulatory Uncertainty and Inconsistent Policies: Regulatory uncertainty and inconsistent policies also impede CNG adoption. In many countries, there is no clear long-term strategy for promoting CNG, which deters investment in the sector. Uncertainty regarding future government support, CNG pricing, and fuel taxation policies makes both investors and consumers reluctant to commit to CNG technology. As highlighted by Lah et al. (2015), inconsistent energy policies often slow the pace of transition to alternative fuels, as stakeholders require a stable policy environment for long-term investment.

Health Security

Health security refers to the protection of individuals and communities from threats to their health and well-being. It entails the capacity to safeguard populations from diseases, malnutrition, unsafe living conditions, and health crises, which could stem from pandemics, environmental hazards, or inadequate healthcare systems. Health security is endangered at the existence of fragile health system. CNG has a significant influence on health security compared to traditional fossil fuels, primarily due to its cleaner combustion process. CNG produces fewer harmful emissions such as particulate matter, carbon monoxide, and nitrogen oxides, which are major contributors to air pollution and respiratory diseases.

According to the World Health Organization (WHO), air pollution caused by fossil fuels is a leading cause of premature deaths globally, particularly in developing countries where environmental regulations is absent (WHO, 2016). CNG enables mitigation of health risks associated with air pollution, as cleaner air leads to lower incidences of respiratory issues such as asthma, bronchitis, and cardiovascular diseases, thereby improving overall health security (Gautam & Jain, 2017).

Moreover, the adoption of CNG can reduce healthcare costs associated with treating diseases caused by fossil fuel pollution. The economic burden on public health systems in developing countries is often exacerbated by the high prevalence of pollution-related illnesses. Studies have shown that CNG-powered vehicles emit up to 90% fewer particulate emissions compared to diesel-powered vehicles, thereby reducing the concentration of harmful pollutants in the atmosphere (Jain, 2018). Any reduction in cost of transportation will leave citizens with higher disposable income to care for health challenges so also economic stability from foreign exchange conservation will enable government to attend to fragile health system .

Empirical Review

CNG adoption and Policy Framework

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.

Imam (2024) investigated the influence of regulatory frameworks on the adoption of Compressed Natural Gas (CNG) in Nigeria's transportation sector. The study engaged mixed-method approach with structured questionnaire on purposively selected 53 respondents. Study revealed that there exist successful CNG programs in Iran, China, and Argentina. The findings reveal that strong government commitment, comprehensive regulatory measures, phased implementation, and public awareness campaigns are key factors in promoting CNG adoption. Study focused only on transportation and did not interrogate the inclusion of the Ivory tower in percolating the needed technology transfer which this study captures.

Adegboye et al. (2024) interrogated the linkages between national security and the adoption of compressed natural gas in Nigeria. 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. The study submitted that a diversified energy basket strengthens resilience and reduce vulnerability to international vagaries in crude oil prices. Study opine that Nigeria's moribund refineries, extensive illegal oil bunkering, over reliant on imported fossil fuel, and poor energy mix, and dwindling foreign reserves are of national security concern. The study did not consider policy framework and health security implication of CNG adoption which this study captures.

Ishengoma and Gabriel (2021) examined the interconnectedness between policy instruments of awareness and sensitisation and patronage of natural gas vehicles (NGVs) in Tanzania. The study employed 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. The study submitted that Policy instruments such as the creation of awareness of the benefits of utilising NGVs, and provision of commercial loans emerged to be important in enticing car-owners to convert their cars to NGVs and incur the conversion costs. For quick response, the policy instruments should target newly bought cars which are in good condition and with bigger engine capacity, male- and private/family car-owners.

Ogunlowo et al. (2015) investigated the developing compressed natural gas as an automotive fuel in Nigeria. The study engaged hermeneutic principles to secondary data derived from academic literature, published reports from a variety of international agencies, grey literature, and text from online sources. Findings from this relevant study submitted that strategic intent, legal backing, learning and adaptation, assignment of responsibilities, financial incentives, NG pricing, consumer confidence, and NG infrastructure are very central to transition to NGV evolvement in Nigeria. The study did not push for involvement of mechanical department of learning institutions at ensuring transfer of technology which this study captures.

CNG adoption and Health Security

Akinola and Abieyuwa (2024) examined effects of fossil fuel consumption-related co2 on the under-five mortality and infant mortality rates in South Africa. The study employed Linear and nonlinear ARDL bounds and the Toda–Yamamoto causality test were used to establish the equilibrium property in the long run and the causal effects of the models' variables. Result from the study that under-five mortality rate in South Africa would increase by 0.630% for every 1% increase in its lagged values. This could be due to an increase in fossil energy consumption resulting from environmental pollution. This pollution lead to the depletion of the ozone layer, leading to a rise in environmental temperature. Again, the emitted carbon-related compounds potentially react with human haemoglobin which appears to be dangerous both to adults

and the under-five age group. The study was done in South Africa hence the need for a Nigeria specific study

Theoretical Framework

Ecological Modernisation Theory

Ecological Modernization Theory (EMT) was advanced by Joseph Huber in the early 1980s by sociologists as a response to the increasing environmental concerns of the time, emphasizing that economic growth and technological development could be aligned with environmental sustainability. The theory continue to evolve as a framework for understanding the integration of environmental sustainability into economic and technological progress. Protagonists like Arthur P.J. Mol and Gert Spaargaren, expanded its application to environmental policy and the role of technological innovations in sustainable development.

The thrust of Ecological Modernization Theory suggests that environmental challenges can drive technological innovations and policy reforms, such as the transition from fossil fuels to cleaner energy like CNG, which can further deepen both environmental sustainability and human security.Health benefits also resonate with the modernisation framework, as improved technology often leads to better living conditions. CNG burns cleaner than gasoline or diesel, reducing harmful emissions such as carbon monoxide and particulate matter, which are known to cause respiratory problems (Jain, 2018).

CNG, a cleaner-burning fuel, produces fewer pollutants such as particulate matter, nitrogen oxides, and sulphur dioxide compared to traditional fossil fuels like gasoline and diesel. These pollutants are associated with respiratory and cardiovascular diseases, as well as other chronic health conditions. Therefore, reducing air pollution through the adoption of CNG has the potential to lower the incidence of such health problems, improving individual health outcomes (Isaifan & Al-Thani, 2024)

Interestingly, government's ability to save revenue through CNG adoption aligns with EMT's idea that economic and environmental interests can coexist. By reducing expenditures on environmental damage control and fossil fuel imports, the government can allocate saved resources to other sectors, such as healthcare. Fossil fuel imports and subsidies often place a significant burden on national budgets, and transitioning to locally produced CNG would mitigate this financial strain. With fewer funds spent on fossil fuel imports and related environmental health crises, the government could reallocate resources to strengthen healthcare infrastructure, improving access to medical services and enhancing health security for the population (Gbenga & Ohonba, 2024).

Additionally, the ecological modernization framework suggests that policy reforms and technological advancements can drive positive environmental and social change. Government policies that encourage the use of CNG could lead to the expansion of the domestic energy sector, creating jobs and stimulating

economic growth. This economic growth, in turn, could further support government efforts to enhance healthcare services. By promoting innovation in cleaner energy and developing infrastructure for CNG vehicles. Developing countries can likewise reduce the health risks associated with fossil fuel pollution and improve the quality of life for its citizens, while also achieving fiscal benefits (Pradhan et al., 2024).

Research Methodology

This study adopted exploratory research design while making use of secondary data generated via journal publications, internet, library, and other documented 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 influenced by short term policy framework around Nigeria's search for energy mix. This could be explained by the adhoc arrangement instead of an institutional approach that could magnetise all the needed policy frameworks and expansive participatory roles for all relevant agencies, all tiers of government and an enabling environment for private investors. Such institutional arrangement can lead to a Whole Society Approach in foisting CNG adoption into Nigeria energy mix. The prevailing policy disconnect could be seen in the dearth of public awareness campaigns which could encourage greater acceptance and use of cleaner energy source. This study align with the earlier works of Adegboye et al. (2024); Ugolo et al. (2024); Imam (2024; Ishengoma and Gabriel (2021).

Result from empirical review also submitted that CNG adoption positively influence health security in Nigeria. This can be validated by the lower emission of pollutants which aggravate respiratory and other extant health challenges. The emission of carbon dioxide (CO2), is detrimental to environmental sustainability with overall effects on health outcomes of infant, adult, and aged persons. This finding is in tandem with the previous work of (Akinola & Abieyuwa , 2024).

Conclusions

This study conclude that short term policy approach on CNG should be reviewed as it negatively influence the embrace of the private sector and learning institutions.

The study also submit that the government should allocate the financial savings from reduced fossil fuel dependence towards strengthening the healthcare system, especially in rural and underserved areas, to enhance national health security.

Recommendations

i. That all tertiary institutions should set up technology transfer offices, as short-term low-cost policy adopted on CNG offers limited support for retrofitting facilities. That agency approach as against presidential taskforce should be considered as done by Enugu State Government to execute the implementation of CNG adoption through a Whole Government Approach

ii. That all tiers of government should further amplify the linkages between healthiness, safe environment, climate change and the benefits of CNG as alternative to fossil fuel patronage.

References

Adegboye L. A., Ishaku, A. Y., Nwaigwe, N. A., Lawanson, H. O., & Onibiyo, E. R. (2024). Adoption of compressed natural gas and national security in Nigeria. *International Journal of Social Science, Management, Peace and Conflict Research, 10*(02), 099-109.

Akinola, G. W., & Abieyuwa, O. (2024). The effects of fossil fuel consumption-related co2 on health outcomes in South Africa. *Sustainability, 16*(11), 4751; https://doi.org/10.3390/su16114751

Alao, M. A., & Popoola, O. M. (2024). Techno-economic assessment of bio-compressed natural gas as a transport fuel for South African provinces. *Renewable and Sustainable Energy Reviews, 205,* 114820.

Dadras, A. (2021, January 3). Over $3.3b invested in CNG development projects. *Tehran Times*. Retrieved from https://www.tehrantimes.com/news/456517/Over-3-3b-invested-in-CNG-development-projects. Accessed September 30, 2024

Fakoyejo, O. (2024, May 19). The federal government says Nigeria will save about $2.5 billion yearly from every one million vehicles powered by compressed natural gas (CNG). *The Cable*. Retrieved from https://www.thecable.ng/fg-every-one-million-cng-powered-vehicles-will-save-nigeria-2-5bn-yearly/ Accessed September 29, 2024.

Gautam, R., & Jain, V. (2017). *Compressed natural gas and hydrogen gas vehicles: Technological advancements, current trends and future prospects*. Springer.

Howlett, M. (2012). The lessons of failure: Learning and blame avoidance in public policy-making. *International Political Science Review*, 33(5), 539-555.

Imam, A. K. (2024). Evaluating Regulatory Frameworks for Sustainable Transport (CNG Adoption in Nigeria). Retrieved from https://www.researchgate.net/profile/Abdulbasit-Imam-2/publication/384292835_Evaluating_Regulatory_Frameworks_for_Sustainable_Transport_CNG_Adoption_in_Nigeria/links/66f323fe553d245f9e34d72a/Evaluating-Regulatory-Frameworks-for-Sustainable-Transport-CNG-Adoption-in-Nigeria.pdf

International Energy Agency (IEA). (2019). *World Energy Outlook 2019: Fossil Fuel Subsidies*.

Isaifan, R. J., & Al-Thani, H. G. (2024). Action Taken to Reduce Air Pollution and Its One Health Impacts in MENA Countries.

Ishengoma, E. K., & Gabriel, G. (2021). Factors influencing the payment of costs of converting oil-to CNG-fuelled cars in a market dominated by used-cars. Energy Policy, 156. https://doi.org/10.1016/j.enpol.2021.112368

Jain, A. K. (2018). *Natural gas: Fuel for the 21st century*. CRC Press.

Kojima, M., & Bacon, R. (2016). *The Impact of Energy Pricing Reforms on Households in Developing Countries*. World Bank.

Kozonoe, C. E., de Oliveira, É. V., Giudici, R., & Alves, R. M. B. (2024). Fuel gas production from natural gas. In *Advances Natural Gas: Formation, Processing, and Applications. Volume 7: Natural Gas Products and Uses* (pp. 119-155). Elsevier.

Lah, O., et al. (2015). *Decarbonising Transport for a Sustainable Future: Mitigating Climate Change through Technology*. UN Environment Programme (UNEP).

Mokhatab, S., Poe, W. A., & Speight, J. G. (2015). *Handbook of Natural Gas Transmission and Processing*. Gulf Professional Publishing.

Nnodim, O. (2024, June 28). CNG conversion: FG offers N750,000 subsidy per transporter. *Punch Newspaper*. Retrieved from https://punchng.com/cng-conversion-fg-offers-n750000-subsidy-per-transporter/#google_vignette. Accessed September 30, 2024.

Odeyemi, N. (2024, September 30). Enugu State Introduces CNG Buses to Boost Sustainable Transportation. *The Electricity Hub*. Retrieved from https://theelectricityhub.com/the-enugu-state-government-is-set-to-introduce-compressed-natural-gas-cng-buses-to-enhance-environmental-sustainability/ Accesse September 30, 2024.

Ogunlowo, O. O., Bristow, A. L., & Sohail M. (2015). Developing compressed natural gas as an automotive fuel in Nigeria: Lessons from international markets. *Energy Policy, 76*, 7-17. https://doi.org/10.1016/j.enpol.2014.10.025

Pradhan, R. P., Nair, M. S., Hall, J. H., & Bennett, S. E. (2024). Planetary health issues in the developing world: Dynamics between transportation systems, sustainable economic development, and CO2 emissions. *Journal of Cleaner Production*, *449*, 140842.

Shaarawi, S. I., Abutaleb, K., Aboelmagd, A. R., & Temraz, T. (2023). GHGs emission reductions and economic saving by enhancing switching to natural gas vehicles in Egypt. *Bull Natl Res Cent 47*, 107. https://doi.org/10.1186/s42269-023-01082-1

Speede, R., Alleyne, K., & Cox, S. A. L. (2024). Innovations for Sargassum Resilience.

Stuckler, D., & Basu, S. (2013). *The body economic: Why austerity kills*. Basic Books.

Ugolo, J. U., Iwegbu, M. C., & Onwuchei, A. (2024). Comparative Study for the Successful Implementation of Compressed Natural Gas (CNG) Solution in Developed and Developing Countries. Paper presented at the SPE Nigeria Annual International Conference and Exhibition, Lagos, Nigeria, August. https://doi.org/10.2118/221725-MS

World Health Organization (WHO). (2016). Ambient air pollution: A global assessment of exposure and burden of disease. WHO.