

The Use of Natural Gas in Operating Fuel Vehicles as an Alternative Technology in Tanzania

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Abstract: *This paper presents the implementation of natural gas vehicles (NGVs) in Tanzania's road transportation sector. The peculiarity of this analysis is the evaluation of the technical and economic performance of the converted gasoline and diesel engines to use compressed natural gas (CNG) as the cleanest-burning hydrocarbon. A few years back, Tanzania has discovered plenty of natural gas investments which are anticipated to uplift the socio-economic development of the country. The realization provides the possible chances opportunities to government to shift gear from oil to natural gas, foreign, domestic establishments and the local community. This paper, is intended to deliver the outline of the natural gas situation in Tanzania. It analyses the history of natural gas in Tanzania, gas supply as alternative to vehicle fuel in transportation sector in regards to pricing and environment opportunities, likewise assesses the accomplishments and challenges facing the users of natural gas products in the socio-economic development. To conclude, Natural Gas Vehicles (NGVs) technologies have remained positively employed in road transportation division, presenting substantial fuel savings and dropping dependence on imported fuel from outside countries. This study covers a way for Tanzania to promote Natural Gas Vehicles growth. Many drivers are encouraged to opt converting their vehicles for NG operation.*

Keywords: Natural gas, Technology, Fuel Vehicles

Abbreviation

CNG Compressed Natural Gas

NGV Natural Gas Vehicle

ECU Electronic Control Unit

LNG Liquid Natural Gas

NG Natural Gas

1. Background

Natural gas is an additional energy resource in various countries in the world today, it is measured as unpolluted and extremely resourceful and low carbon energy cause (Bishoge et al., 2018). Natural Gas is a National resource for the profit of the current and ongoing generation of Tanzania (URT, 2013).

Tanzania has been exploring for oil and gas for about more than 60 years now. Initially, natural gas was discovered on the Songo Songo Island in Lindi Region in the 1970s, followed by a second discovery at the Mnazi Bay (Mtwara Region) in the 1980s. Since its discovery, the Songo Songo natural gas came to be commercialized in 2004 and that of the Mnazi Bay in 2006 (URT, 2013).

Despite the National Natural Gas Policy which recognizes compressed natural gas to be used as an alternative to fuel in vehicles, the placement for the adaptation of the vehicle is currently only undertaken in Dar es Salaam, where there is a linkage of pipelines for compressed natural gas. However, the place undergoes a low transformation level, the existing filling stations were built to satisfy mainly the corporate needs of big fleet operators city bus companies, long-distance transportation since only very high and stable demand for natural gas can guarantee the profitability of investment in natural gas refueling infrastructure. (Gerutu & Greyson, 2023).

The general objective of this study was to investigate the use of natural gas in operating fuel vehicles as an alternative technology in Tanzania. Further, the study aims to help the public understand the importance of using natural gas as an alternative for fuel in reducing cost of using fuel as well as protecting the environment for sustainable use.

To supplement the investigation two key questions were considered. First, is the natural gas available to use in vehicle transportation in Tanzania? Secondly, to what extent is the Compressed Natural Gas used by motorists in Dar es Salaam for transport?

2. Literature Review

This section covers the **literature review** which narrate with the alternative technology of using natural gas instead of fuel in fuel used vehicles.

According to fuel vehicle users, the use of fuel is rather expensive than using natural gas. The Tanzania government is encouraged to switch the costs around US \$800 per convention, and plans on converting its fuel vehicles from petrol or diesel to natural gas. Using petrol one would spend at least US \$16 on fuel and cannot compare that to someone using natural gas who just spends US \$8 and make the same business. Users of fuel vehicles had also complain on high fuel price (Ramadhani et al., 2023).

Apart from the expenses of using fuel, petrol and diesel for running vehicles, a reduction in emissions of carbon dioxide

is a concern of all countries in the world including Tanzania. Currently, green house is the global concern. Over the past few years the world claimed that 23% of the carbon dioxide emission in the environment was contributed by the transportation using diesel and petrol. Recently the human health on difficult breathing is addressed by the problem arising from high congestion of the fuel vehicles.

A natural gas vehicle (NGV) is an alternative to fuel vehicle that uses compressed natural gas (CNG) or liquefied natural gas (LNG) as a cleaner alternative to other fossil fuels. Most natural gas vehicles use the same type of combustion engine as gasoline and diesel vehicles (Ramadhani et al., 2023).

Not only Tanzania, but all parts of the world are also facing the demand for (CNG) resulted from its lower cost when compared to petrol and diesel. Fuel prices continue rising yearly owing to changes in prices of fuel in the market globally and its value in the local currency. But the cost of CNG has been constant for the past 11 years, thus being seen as an economical substitute (URT, 2013; Gerutu & Greyson, 2023).

Awareness to the society

The government of Tanzanian is the main actor in providing information to vehicle owners on the intent of transforming them to become natural gas users from fuel. Also, the government could design a potential website where potential buyers and importers of vehicles could find a list of approved conversion centers that can help with engine transformations. Experts from recognized management bodies could provide awareness about the appropriate usage of natural gas cars (Gerutu & Greyson, 2023; Bishoge et al., 2018).

Cost of transforming a fuel engine to natural gas engine

According to Gerutu and Greyson (2023), the compressed natural gas CNG is the possible substitute fuel in Tanzania road division owed to its overflowing and environmental welfares. The challenges facing the CNG market is service shortage, due to few manageable filling stations. And this comes to be difficult for the consumers. Dealers know the necessity and plan to increase number of filling stations in the country. Currently the Petroleum Development Corporation has licensed 20 companies to build natural gas filling stations and nine more are expected by 2025.

The installation of compressed natural gas (CNG) systems in the cars

It is anticipated that number of vehicles with Compressed Natural Gas powertrain arrangements will keep growing in the coming years. The reasons for the use of alternative technology with Compressed Natural Gas as fuel are that Compressed Natural Gas can be made from dissimilar bottoms including an eFuel options. For vehicles in Dar es Salaam for example, there might be an option of using CNG at the same time the vehicle can still have an alternative of using fuel. Dar es Salam is the first to install the CNG because it is deliberated as a major milestone for TAQA Arabia since they joined hands with JCG oil and Tanzania government in early November 2023.

Once the gas is finished, the vehicle can be controlled to use the fuel instead. The mechanisms can be used flexibly for mono-fuel and or bi-fuel uses (Ramadhani et al., 2023).

The Dar es Salaam Institute of Technology (DIT) in Tanzania was the first institute to work on the implementation of converting petrol vehicles to NGVs. The Institute started its implementation in 2008 where the first car was successfully transformed to CNG. However. The Dangote Company Limited situated in Mtwara region also started implementing the transformation of diesel-powered vehicles to CNG (World Bank Report, 2012).

Several factors influencing the adoption and incorporation of CNG into vehicles have been identified by various researchers. Gerutu & Greyson (2023), described the various reasons given by numerous governments around the world which encouraged them to use natural gas technology instead of fuel that reduced greenhouse gas emissions. The researchers added that Asian pacific countries and Thailand realized road pollution mitigating measures by using two stages, which intricate establishment of natural gas pipeline in the greater Bangkok, and the conversion of public buses to use NG while increasing in the city more filling stations as well. The other stage involved encouraging the use of NG throughout the country by supplying CNG and liquefied NG in the areas with and without NG pipelines gatherer.

The Concept of Technology Transfer

In Tanzania, an innovative uprising to decrease carbon dioxide impression is ongoing. The government is progressing out a plan to terminate the use of fuel for its vehicles. This is a measure of a higher national initiative to decrease carbon footprint and implement a more environmentally pleasant system of using Compressed Natural gas. These vehicles are expected to lower costs and significant technical competences if compared to regular internal ignition engine vehicles.

The CNG arrangement that is typically fixed in a vehicle involves CNG cylinder which stores the pressurized gas. The technique and design of this cylinder consists of four types, whereby type one design and technique has no liner. The second and the third are both lined with carbon fibers whereas the fourth fiber is wholly wrapped by an aluminum liner. The function of the liner material is to regulate the temperature inside the cylinder and to affect the CNG to the defined limit. Steel fiber tanks or carbon fiber tanks can be used but steel tanks do not retain heat compared to carbon fiber tanks. Steel tanks might reduce capacity of CNG because during hot condition their molecules might expand.

Also, the CNG cylinder might have a conversion kit which falls under two categories, these are the venturi and sequential kit. The venturi is furnished with neither sensors nor an electronic control unit (ECU), to make easier to be connected in any typical vehicle. Also, it makes the working of the venturi kit changeably as it cannot normalize the stream of CNG into the engine (Gerutu & Greyson, 2023).

Working Arrangement of the CNG components to petrol-fueled vehicles

Figure 1 shows the CNG mechanisms for retrofitting petrol-powered vehicles. Before the CNG cylinder through a receptacle to work under 200 bar pressure, the natural gas must be compressed into a cylinder. The high-pressure gas is transmitted to the pressure manager over the high-pressure pipe. The pressure manager decreases the pressure to a level that is friendly with the engine fuel instillation system.

Again, before the mixture moves in the ignition chamber for compression, CNG mixes with air in the intake multiple. Spark plug ignites the air-gas mixture to yield mechanical power. Once the exchange switch is pressed on to permit CNG to activate, the ECU opens and the CNG valve and pressure regulator allows CNG to move to the injector barrier via the gas filter and mean absolute pressure (MAP) sensor while blocking petrol nozzles. The oxygen sensor displays the oxygen in the consumer and transmits that information to the ECU, which controls the air-to-fuel ratio consequently.

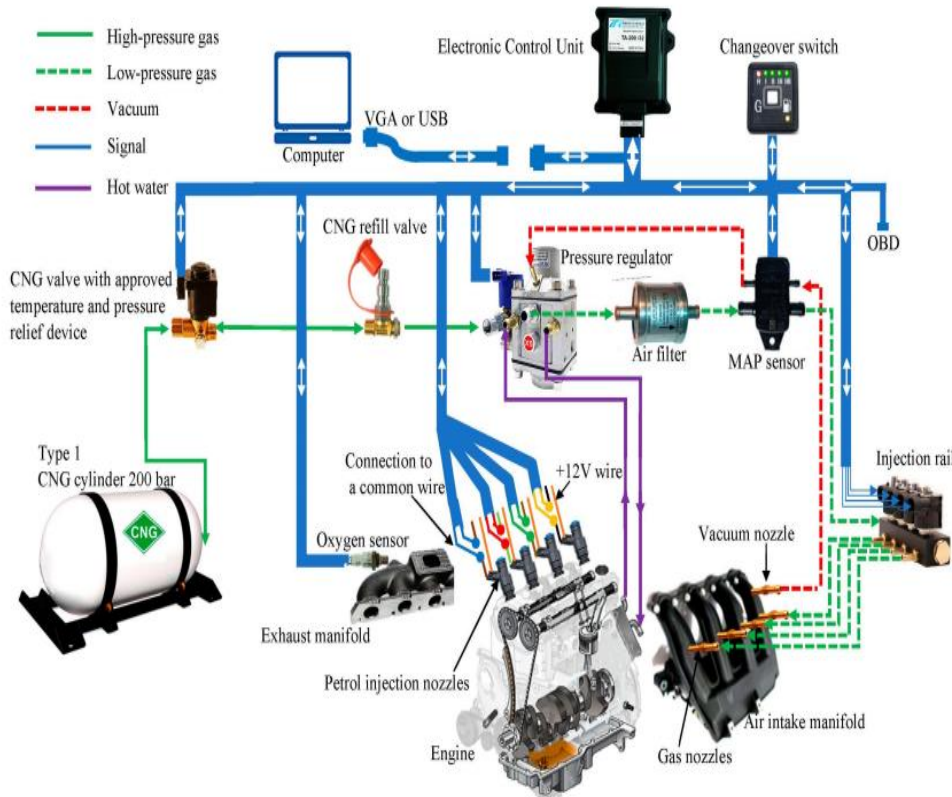


Figure 1: The arrangement of CNG components in petrol-fueled vehicles

Source: Adopted from (Gerutu & Greyson, 2023)

Figure 2 shows the retrofitting powered vehicle CNG components. The hassled gas is moved to the pressure regulator from the CNG cylinder. Here, in the combustion chamber, the gas is decreased to needed level. The low pressurized gas combines with the bulk air at the intake manifold where it is moved to the combustion chamber to be compressed. The existence of an air-gas assortment in the intake air of an engine affect a substantial reduction in feed mixture temperature, causing the air-gas mixture to fall inside the ignite throughout the compression stage (Gerutu & Greyson, 2023).

The engine functions the same way as a gasoline engine. Natural gas is stored in a fuel tank or cylinder, typically at the back of the vehicle. The CNG fuel system transfers high pressure gas from the fuel tank through the fuel lines where a pressure regulator reduces the pressure to a kind comparable with the engine fuel injection system. Finally, the fuel is introduced into the intake manifold on combustion chamber, where it is mixed with air and then compressed and centered by the spark.

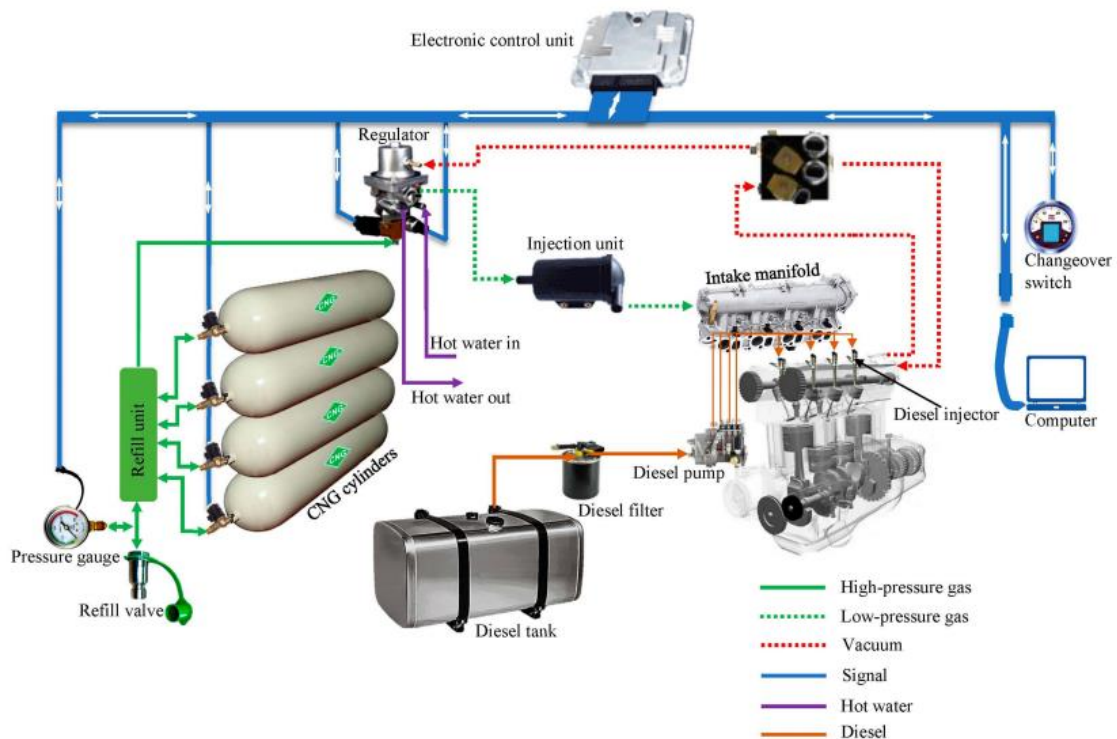


Figure 2: The arrangement of CNG components in petrol-fueled vehicles

Source: Adopted from (Gerutu & Greyson, 2023)

3. Methodology

This study employed a descriptive phenomenological qualitative research method. In this approach the empirical materials related to natural and compressed gas were reviewed for conducting this research (Hendren et al., 2023).

The phenomenological research design enabled to identify the experience of fuel vehicle users in Dar es Salaam, Tanzania about their change on using CNG instead of fuel. The descriptive phenomenology is concerned with revealing the essence or essential structure of any phenomenon under investigation, that is, those features that make it what it is rather than something else.

The researcher adapted some of the Colaizzi's descriptive phenomenological method steps as described in Beck (2023).

Description: The researcher familiarized with the situation by reading through the related materials on natural gases by other researchers. The researcher employed the paper desk research.

Identifying significant statements: On this step, various statements that were directly appropriate to the phenomenon under investigation were identified significantly.

Formulating meanings: The researcher identified meanings related to the phenomenon that emerged from an important key statement.

Clustering themes: The researcher gathered the recognized meanings into subjects that are corporate through all interpretations.

Developing an exhaustive description: The researcher then wrote a complete and comprehensive description of the phenomenon, combining all the themes produced at step 4.

Producing the fundamental structure: The researcher summarized the full description down to short, dense statement that internments just those features considered to be important to the organization of the phenomenon.

The last step is seeking verification of the fundamental structure: The researcher here returned the necessary structure account to all contributors.

4. Findings

The government plans are underway to set up CNG refilling stations in Dar es Salaam, morogoro and Dodoma. It first got compressed natural gas filling station at Dar es Salaam in Bagamoyo. Project carried out by TAQA Dalbit a joint venture between JCG Arab and iol and gas. The station expected to serve up to 800 vehicles a day. They consider Dar es Salaam as a major milestone for TAQA Arabia as they join hands with JCG oil and Tanzania government in November 2023.

Compressed Natural Gas (CNG) Filling Station and Conversion Center branded Master gas located at Pugu Road-Airport Area in Dar es Salaam, Tanzania. Bagamoyo had two filling stations, mkuranga and Goba. At Ubungo station they had high queue the reason behind they had only one filling station is now working and all people far and near have to get services from this station. Tanzania Petroleum Development Corporation (TPDC) has given the go-ahead to 20 companies to build CNG stations as part of a larger initiative to deliver cleaner and more affordable energy. The mother station will also have a workshop for converting

vehicles to CNG fuel, as so far only DIT place is concerned with this convention.

A CNG vehicle is a car powered by natural gas rather than gasoline or diesel fuel. These cars are not specially manufactured to use CNG. Instead, automakers modify existing gasoline-powered vehicles to operate on CNG, supporting of government strategies plans and increase the use of CNG as a cleaner alternative to fuel. Instead of oil, the Tanzania Government Procurement Services Agency (GPSA) will now purchase vehicles that run on compressed natural gas (CNG). Additionally, there are CNG hybrids that can run on both natural gas and gasoline. Due to this dual capability, these bi-fuel vehicles offer flexibility. This allows them to operate even in areas where a CNG refueling station is not available.

A powered CNG powered passenger vehicle is estimated to emit about 25% less CO_2 and is on average 50% cheaper than petrol cars. Natural gas is a more sustainable alternative energy source compared to petrol and diesel. Coming at a time when the cost of living is rising, motorists will be happy to know that this CNG station will provide a cheaper alternative for their daily vehicle use and that they can seamlessly convert their vehicles at our center.

5. Conclusion and Recommendations

The study found that, currently not many motorists are aware on the use of CNG in their vehicles; knowing the advantages on the use of CNG and how it is taking place might help in taking a decision to implement the CNG on vehicles.

Currently there are only three filling stations or points in the whole of Tanzania where customers can have their vehicles converted to using CNG, these are DIT, BQ company and Anric Gas Technology, thus for the purpose of reducing costs incurred by using fuel on vehicles and protecting the environment by using alternative appropriate technology, the number of stations are very low.

All converting stations from fuel usage to CNG are situated in Dar es Salaam, however they are not fulfilling the users' need for the natural gas.

It is therefore recommended that more efforts must be done to educate motorists on the need to convert their vehicles to use CNG.

Private sector needs to invest adequately in the technology of converting vehicles as well as building CNG filling stations. According to Global Gas Flaring Reduction (GGFR) program led by the World Bank, the advancement of economical CNG transportation might be a measure of the conceivable outcomes for the recovery of allied gas (Wold Bank, 2015).

It is further recommended that CNG convention centres should be built not only in Dar es Salaam but throughout the country.

Awareness of the benefits of using CNG to power vehicles is gaining momentum in Tanzania and thus service providers now find it hard to keep pace with ground demand.

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