# Promoting the Use of Alternative Fuels for Road Transport in Nigeria

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#### Abstract

Road transportation has been the most popular means of transport in Nigeria and one of the major energy-consuming sectors in the country. This sector is entirely dependent on non-renewable and polluting petroleum-based fossil fuels (petrol and diesel), for powering of road vehicles. This work discusses possible alternatives fuels such as ethanol, biofuels, biodiesel, methanol, compressed natural gas etc. and measures for promoting the use of these fuels for road transportation in the country. These fuels do not only burn cleaner, but also produce lower emissions and could reduce the country's over-dependence on its' finite fossil fuel as well as minimizing environmental pollution.

Keywords: Road transport, alternative fuels, measures for promoting alternative fuels

#### Introduction

Road transport is presently the dominant mode of transportation in Nigeria. It controls over 95% of all surface transportation in the country [1] and accounts for the bulk of the consumption of petroleum products in Nigeria. International Energy Agency (IEA), reported the energy consumption in the road transport sector in Nigeria as 3,901(ktoe) in 1990, 7,020(ktoe) in 2000 and 7,876(ktoe) in 2001 [2]. In 2005, NNPC recorded domestic consumption of PMS as 9,572014,330 billion liters, while 2,361,480,530,000 billion litres of Automotive Gas Oil were equally recorded [1]. Also Alexander [3] reported the increases in daily fuel consumption from 300,000 litres per day to 450,000 litres in 2001 and that the end to fuel shortage within the domestic environment is not at sight. This situation increases the nation's energy insecurity and unfortunately, Nigeria does not have sufficient refining capacity; it must import petrol and diesel fuels at world prices to supplement availability of the product. It costs the Nigerian treasury an equivalent of about US\$6 million per day to subsidize these fuels [4]. By switching to alternative fuels, would not only save this huge amount of money, but also would help to reduce air pollution in the major cities in Nigeria.

Tons and tons of pollutants such as carbon monoxide (CO), nitrogen oxides (NOx) and sulphur dioxide (SO<sub>2</sub>) etc are being pumped into air in major cities in Nigeria every day and the main source of these pollutants is road transport vehicles. These pollutants pose a great threat to our subsistence. CO poses serious health threats, particularly to foetuses and people with heart diseases. It hinders oxygen transport from the blood to body tissue. Nitrogen dioxide (NO<sub>2</sub>) has been linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function [5]. NO<sub>x</sub> and SO<sub>2</sub> are also the key agents of acid deposition (acid rain) and lead has impacts on the intellectual development of children. CP [6] reported that the levels of

gases emitted around highways and runways in Nigeria are sometimes 10 times higher than permissible levels. This situation is quite frightening and calls for urgent attention.

More than 95% of the fuel used worldwide for transport is petroleum-base. This over reliance on petroleum is responsible for the large level of indebtedness of many developing countries [7]. Energy supply for road transportation in Nigeria is entirely dependent on petroleum-based fossil fuels (petrol and diesel), which is fast depleting. It is estimated that the current 35.9 billion barrels of Oil reserve in Nigeria, with the daily production capacity of 2.4 million barrels will be depleted by 30–36 years period [8]. This situation indicates that transport sector and other sectors in Nigeria that depend only on fossil fuels are in great danger of fuels shortage. Thus, alternative fuels for road transport in Nigeria have become inevitable to conserve the country's fossil fuels for future use, protect the environment and strengthen nation's energy security. This paper discusses the alternative fuels that could be used for road transport in Nigeria and measures for promoting the use of these fuels such as biofuels, biodiesel, ethanol, and methanol etc for road transport in Nigeria, which are already in use in many countries like U.S., Brazil etc.

#### Alternative Fuels for Road Transport in Nigeria

There are several alternative fuels for road transport vehicles that can reduce the country's over dependence on its fossil fuel, minimize fuel importation and reduce environmental pollution in Nigeria. Such alternative fuels, which are already in use in countries like U.S., Brazil etc, include biodiesel, methanol, ethanol, natural gas, propane and hydrogen etc. These fuels do not only burn cleaner, but also produce lower emissions and some are even renewable. This section discusses these possible alternative fuels for road transport in Nigeria. Ethanol Fuel: This is the most widely used alternative road transport vehicle fuels [9]. Ethanol is simply an alcohol typically made from corn or corn byproducts, using similar process to brewing beer and fortunately corn is abundant in Nigeria. Thus ethanol can possibly be produced and use as an alternative fuel for road transport vehicles in Nigeria. Vehicles that run on ethanol have lower carbon monoxide and carbon dioxide emissions than traditional vehicles. In the United States, more than 1.5 billion gallons of ethanol are blended with gasoline each year to produce E10 (10% ethanol and 90% gasoline), and E10 can be used in most vehicles [9]. As a result, E10 is used across the country to improve vehicle performance and reduce air pollution. Also some vehicles can use a higher blend of ethanol (up to 85%) called E85. These vehicles, kwon as flexible -fuel vehicles; can use E85 gasoline or any mixture of the two. E85 is available in many parts of the country but primarily in the Midwest [9]. Biofuels: Biofuels are renewable since they are produced from biomass- organic matter, such as plants. Nigeria is endowed with abundant biomass resources and therefore has the potential for producing biofuels form biomass as alternative fuel for road transport. Biofuels generate about the same amount of carbon dioxide (greenhouse gas) from tailpipe as fossil fuels, but the plants that are grown to produce the biofuels actually remove carbon from the atmosphere [9]. Therefore, net emission of carbon dioxide will be close to zero.

**Biodiesel:** Biodiesel is an ester (similar to vinegar) that can be made from several types of oils, such as vegetable oils and animal, and these are readily available in Nigeria. It only requires putting in place the necessary infrastructures for production and use of this fuel. In the United States, about 30million gasoline of bio diesel are produced each year from recycled cooking oils and soybean oil. The biodiesel is used as a blend (20% biodiesel and 80% petroleum diesel) called B20. B20 can be used in conventional diesel engines with essentially no engine modifications [9]. **Methanol:** Methanol, another alcohol-based fuel is usually produced from natural gas, but it can also be produced from biomass. Therefore it has the potential to help reduce dependence on petroleum products. Methanol-powered vehicles emit smaller amount of air pollutants such as hydrocarbons, particulate matter, and nitrogen oxides than do similar gasoline-fueled vehicles. Some buses and fleet

vehicles currently run on M85, which contains 85% methanol and 15% gasoline. Natural Gas is a clean burning; domestically produced fuel that generates significantly less carbon monoxide, carbon dioxide, particulate matter and nitrous oxide compared to similar fossil fuel vehicles. It is used in vehicles as compressed national gas (CNG) or liquefied. There are about 100,000 natural gas vehicles in the United States. Nearly one of every five new transit buses in the United States runs on natural gas [10]. Natural gas is a mixture of hydrocarbons, mainly methane. It can be produced either from gas wells or in conjunction with crude oil. Nigeria's proven natural gas reserves is estimated at about 187.44 trillion standard cubic feet in 2005 [11]. Nigeria still flares about 40% of the natural gas and re-injects 12% to enhance oil recovery [5]. This huge amount of natural gas can be processed and then used as alternative fuel for road transport. In this direction, Nigerian Gas Company (NGC) has only succeeded in converting 52 vehicles to use natural gas, but still shopping for technology to adapt fuel-injection vehicles for CNG use [4]. Electricity: Electricity is considered a fuel when it is used in vehicles. Electric vehicles use various types of batteries and other energy storage mechanisms to store the electricity used to run a vehicle. While the electricity production process for vehicles may contribute somewhat to air pollution, an electric vehicle (EV) itself does not, resulting in much lower emissions per mile traveled. In 2000, close to 7,000 on-road EVs in the United States consumed electricity at an amount equivalent to about 1.7 million gallons of gasoline [9]. In India and Nepal, battery-driven three-wheeled vehicles are used in their urban transport systems. Electric vehicles can equally be introduced in Nigeria as a measure in diversifying energy use in the transport sector. The economics of electric vehicles also depends on the local cost of electricity. The batteries are recharged by plugging the vehicle into a power source and may take between two and eight hours to replenish, depending on the power charging system.

**Hydrogen:** Hydrogen is a simple, abundant element found in organic matter notably in the hydrocarbons that make up many of our fuels such as gasoline, natural gas, methanol and propane. As an energy carrier like electricity (not an energy source) it must be manufactured. Hydrogen can be made by using heat to separate it from the hydrocarbons. Currently, most hydrogen is made this way from natural gas and natural gas is abundant in Nigeria [5]. Another way to produce hydrogen is to exploit the abundant cellulose materials, agricultural products and bio-based wastes in Nigeria to produce biofuels such as ethanol and/or to transform these into hydrogen. Nigeria has the potentials for generating hydrogen as alternative fuel for road transport and NNPC has taken some steps in this direction, but it still need to expedite actions. The available hydrogen generation capacity within the NNPC is indicated in table 1.

| NNPC company                                  | Hydrogen generating<br>unit | Capacity (MT/Y) |
|---|-----------------------------|-----------------|
| Port Harcourt Refining Company                | Catalytic reformer          | 6.84            |
| Kaduna Refining and<br>Petrochemicals Company | "                           | 11,600/9,700*   |
| Warri Refining and Petrochemicals<br>Company  | "                           | 17,784          |
| Eleme Petrochemicals Company                  | Olefins cracker             | 1,800           |
| * Actual utilized capacity                    |                             |                 |

## Table1. Hydrogen generating capacity available within the NNPC Operation

Source: International Development Research Center Canada [5].

Hydrogen can be combined with gasoline, ethanol, or natural gas to reduce nitrogen oxide emissions. Because the only byproduct of hydrogen is water, only the engine lubricants from a hydrogen-fueled vehicle emit small amounts of air pollutants. Hydrogen is already the fuel choice for propelling space shuttles [5]. It is also being explored for use in internal combustion engines. Although hydrogen can be burned in an internal combustion engine, or serve as a fuel additive, there is more interest in using hydrogen to supply fuel cells that power EVs.

### Status of Ethanol Production as Alternative Fuel in Nigeria

Ethanol has been extensively used as an alternative fuel for road transport, for a number of years in some countries, particularly Brazil. Even without redesign, motor vehicle engines could use a petrol-ethanol mix with a ratio of nine to one [12]. This fuel could favourably to be used as road transport vehicle fuel in Nigeria since it blends easily with petrol and could be used directly in vehicles without redesigning their engines.

In this direction, Nigerian National Petroleum Corporation (NNPC) revealed that by 2006, 10% of the fuel (petrol) consumed in Nigeria would be blended with ethanol imported from Brazil and that shortly after, it would be followed by the development and commercialization of ethanol fuel in Nigeria, which would involve cultivation of large-scale plantations of sugarcane and cassava and construction and of distillers for the production ethanol fuel [13]. These would be made possible through an agreement signed between the NNPC and petrobrass (Brazilian equivalent of the NNPC) and COIMEX, Brazil's largest exporter of ethanol. In addition to this development, the workshop organized by the Renewable Energy Division of NNPC, revealed that Nigeria has the capacity to produce the estimated needed 3 million litres of ethanol per day, from two clearly identified crops – sugar cane and cassava.

The International Institute for Tropical Agriculture (IITA) [13] reported on factors required for large scale cassava production for Fuel Ethanol Industry in Nigeria and gave exhaustive strategies on how to grow cassava on large scale basis and very detailed agronomics of the crop. The IITA weighted Premium Light Spirit (PMS) usage in Nigeria of 30,000,000 liters/day and or 10,950,000,000 litres/year and calculating10% substitution to stand at 1,095,000 litres ethanol/year and surmised the quantity of cassava roots to supply this need (6.5kg roots: 1 litre ethanol) at 117,500,000kg (7,117,500 Metric Tonnes). It also gave that this would require a land area of 355,875 ha. for the yield of 20,000kg/ha. for the top 10 cassava producing states in Nigeria as shown in table 1 below. The table also shows the total output of these states in Metric Tonnes for the year 2003 alone. These quantities of cassava are produced by individual farmers on small scale farms and they are basically produced for consumption. Therefore, the NNPC Automotive Biomass Ethanol Programme is faced with the challenges of sourcing for land and growing its cassava for its alternative fuels production programme.

| State       | Qty of Cassava<br>Produced<br>(Metric Tonnes) | State   | Qty of Cassava Produced<br>(Metric Tonnes) |
|-------------|---|---------|--|
| Benue       | 3,577,920                                     | Kaduna, | 1,980,000                                  |
| kogi        | 2,854,830                                     | Ogun    | 1,538,940                                  |
| Imo         | 2,284,770                                     | Ondo    | 1,449,650,                                 |
| Enugu,      | 2,194,300                                     | Rivers  | 1,405,0                                    |
| Cross River | 2,028,540                                     | Oyo,    | 1,126,760.                                 |

 Table 1: Top 10 Cassava Producing States in 2003

Source: International Institute for Tropical Agriculture (IITA) [13].

Niger, Kwara, Benue, Taraba, Adamawa and Jigawa were also spotted as most favourable states for the mass production of sugar cane for ethanol fuel. The National Cereals Research Institute (NCRIB) [13] noted that it is possible to grow sugar cane in virtually all the states in Nigeria for producing ethanol fuel. The table 2 above shows the states favourerd by NCRIB for sugar cane production.

| State   | Site        | Land Area (Ha) | Productivity(T/Ha) |
|---------|-------------|----------------|--------------------|
| Kwara   | Lafiagi     | 9,000          | 700,000            |
|         | Bacita      | 12,500         | 800,000            |
| Adamawa | Mayo-Inne   | 9,000          | 700,000            |
|         | Numan       | 20,000         | 850,000            |
| Taraba  | Lau         | 10,000         | 700,000            |
|         | Gassel      | 8,000          | 500,000            |
| Benue   | Zeremo      | 7,000          | 500,000            |
| Katsina | Katsina-Ala | 10,000         | 600,000            |
| Jigawa  | Hadeja      | 8,000          | 500,000            |
| Niger   | Sunbi       | 5,000          | 850,000            |

#### Table 2: States Favoured by NCRIB for Sugar Cane Production

Source: National Cereals Research Institute (NCRIB) [13]

It revealed that it has the capacity to produce all the seedlings needed to cultivate on any amount of land for sugar cane production, as long as it is given the required support.

## Measures for Promoting Alternative Fuels for Road Transport

Despite the benefits of using alternative fuels in the transport sector, Nigeria is still trailing far behind many other countries in the production and utilization of alternative fuels. This section is discusses the measures that could promote the production and the use of alternative fuels for road transport in Nigeria.

**National Policy on Alternative Fuels for Road Transport:** Road transport sector in Nigeria accounts for the bulk of the consumption of petroleum products. Consequently, the issue of alternative fuel in this sector should be taken very serious, if the only source of its fuel is expected to deplete as estimated in next 36 years. Therefore it is very urgent that National policy for promoting the use of alternative fuels for road transport vehicles in Nigeria is developed. This measure would require an extensive collaboration from various stakeholders in the country and this could be handled by an Inter-Ministerial Committee which would include the Ministries of Petroleum, Agriculture, Finance, Environment, Science and Technology, and Commerce etc. [8]. The activities of the Committee would include examining the policies of other countries that promotes the use of alternative fuels for road transport, identify the suitable alternative fuels for road transport in Nigeria, define and identify industry model involved in the production of these fuels, identify and recommend policy and incentives, develop and define legislative process that could promote the production and the use of these fuels etc. The policy and incentives for promoting the production and the use of alternative fuel should focused on providing accelerated long term support through an integrated approach for the use of the fuels in the transport sector.

**Policy Support and Political Commitment:** These are very important factors in developing the alternative fuels for road transport in Nigeria. They involve research and development support from the government, pricing support and regulations - alternative fuels and their vehicles are typically more expensive than conventional fuels and vehicles, raising public awareness and political commitment for developing the alternative fuel industry in Nigeria. But in some cases government has to play more of interventional roles in promoting alternative fuels. For instance, the Ministry of

Petroleum in Egypt approved a set of companies which were given specific mandates and targets for vehicle conversion Centers and filling stations. Similarly the introduction of natural gas vehicles in Delhi was prompted by a mandate the Supreme Court of India gave in 1998 to replace the city's bus fleet, three-wheelers and taxis with gas and outfit the city with refilling stations. Delhi now has one of the largest CNG bus fleets in the world with 7,400 buses, 4,000 minibuses and 45,000 three-wheelers [5]. The alternative energy commission to be created should develop a comprehensive programme for promoting the use of alternative fuel in the country. Such programme should have supportive fuel pricing, through either liberated pricing policies, tax exemptions or controlled prices that benefit alternative fuels, as well as incentives or tax breaks for new vehicles, vehicle conversions, refuelling infrastructure or production facilities.

Alternative Fuel Energy Commission: It very essential to establish this Commission to govern the industry in relationship with established ministries and agencies that could be involved in the activities of alternative production and distribution. The Commission should develop appropriate mechanisms that would to promote the efficient operation of the alternative fuel industry sub-sector through subsidized loans, issuance of licenses, private-public partnership, etc. and establish alternative fuels Research Agency to coordinate and promote the long term sustenance of the subsector [8]. It should also facilitate the activities of NNPC in the production of alternative fuels by putting in place the necessary infrastructure for the use of the fuel and granting licenses to independent marketers of the alternative fuels. Alternative fuel Industry Sub-sector: Considering the economic, environmental and social benefits in developing the alternative fuels potentials of the country as well as in increasing the energy security the transport sector, it is essential that alternative fuel industry sub-sector is created and given priority in developing the energy sector of the country. For instance the often-cited success story of the Brazilian ethanol industry demonstrates the potential gains in industrial development, exports and employment in the alternative fuels sector. The Brazilian ethanol programme is the largest commercial application of biomass for energy production in the world, accounting for 70% of the world total biofuel transport market. The programme has led to the creation of 720,000 direct jobs and more than 200,000 indirect jobs in rural areas - a significant outcome in Brazil [5]. The same success can also be achieved in Nigeria if all the necessary actions are taken. NNPC has been in the forefront in developing the alternative fuels industry in Nigeria, but still has a long way to go. In 2005, NNPC revealed that by 2006, 10% of the fuel (petrol) consumed in Nigeria would be blended with ethanol imported from Brazil for commercial use, but this is not yet actualized [13]. The natural gas vehicle industry in Nigeria is still at its pioneering stage. The Nigerian Gas Company (NGC) has converted 52 vehicles to use natural gas and is responsible for issuing licenses [4]. It has so far certified three companies to provide CNG in Lagos, Benin and Abuja. Developing the alternative fuel industry in the country will create investment opportunities in alternative fuels filling stations, conversion or adaptation workshops and conversion kits. Also private sector participation is vital in meeting the demand that would be created in developing this sub-sector.

**Government Support for the Redesign of Motor Vehicles:** Research shows that it is comparatively easy to blend motor vehicle fuels with up to 10% ethanol without causing any damage to the engine [7]. But if ethanol is to make extensive inroads into petroleum use, vehicle design and modification must take place. This development is unlikely to be supported by the auto vehicle industries in Nigeria without some form of government financial support. The choice of financial support could be between direct grants or loans on favourable terms to the vehicle industry, or modifications to the local company tax legislation to allow for a tax deduction associated with the costs of vehicle redesign, or an investment allowance. Currently new technologies are being developed that allow vehicles to run on alternative fuel and often with more efficiency and less emission. On the other hand, since almost the entire vehicles operating in Nigeria today are all

imported, government can grant free import duties and free vehicles registration charges to vehicles using alternative fuels. Such stimulatory measure will create market demand for these vehicles; motivate auto-vehicle dealers in the country to focus attention on these vehicles, encourage local production of alternative fuels especially ethanol and biofuels etc and building of necessary infrastructures for marketing these fuels.

**Financial Incentives for Ethanol Crop Producers:** Ethanol can be produced from many biological feedstocks, including sugarcane, cassava, corn and other cereals by fermentation. These crops grow readily in Nigeria and could be produced in large quantities in different parts of the country as detailed in table 1 and 2 above. In this situation, one option for the government to promote the production of ethanol in Nigeria is by offering research grants to institutes and financial incentives to farmers to grow more of these crops needed for the ethanol fuel production. Such incentives may include direct grants or loans on favourable terms, or an investment allowances.

# Conclusions

Despite the potential benefits for energy security and environmental pollution reduction, industrial innovation and employment, alternative fuels for road transport in Nigeria has not received adequate attentions. This work has discussed the alternative fuels for road transportation in Nigeria and such fuels include compressed natural gas (CNG), liquefied natural gas (LNG), methanol, ethanol and hydrogen. The strategies that would be adopted in developing the alternative fuel sub-sector in Nigeria will include promotion of R&D efforts, establishment of pilot plants, and creation of an enabling environment for local and foreign investors and development of the requisite manpower requirements. The other measures will include granting financial incentives to ethanol crop producers, government support redesign of vehicles, developing national policy for promoting the production and the use of alternative fuels, creating alternative fuel industry sub-sector and establishing alternative fuels energy commission to regulate the activities of the sub-sector.

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