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Liquified petroleum gas as an alternative to transportation fuels in Nigeria

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Abstract

Internationally, the issue of climate change and its adversative influences on the peoples' population together with the environment has required substantial study on the sustainable utilization of natural resources. This paper investigates the possible utilization of liquified petroleum gas as an alternative for transportation fuels in Nigeria. Natural gas is regarded as clean burning and safe fuel that can save its users money at the pump apart from the benefit can be drive from its utilization on the environment and aid in decreasing the country's over reliance on petroleum as it is naturally occurring combination of gaseous hydrocarbon; nongaseous non hydrocarbons; gaseous non hydrocarbons obtained from underground reservoir rocks either as associated gas (with crude oil) or non-associated gas (on its own). Presently, Natural gas is considered as the efficient energy sources for the globe as well as the future due to its ecologically friendly nature when compared with the other categories of fossils fuels. Nigeria is classified as the number 7th among the major countries that are endowed with natural gas in the globe while it is number one in the continent of Africa as it possessed a natural gas deposit of about 88 trillion cubic feet. Therefore, the main objective of this paper is to offer some useful insight on the predictions of liquefied gaseous use in Nigeria as an alternative to the present transportation fuels more especially in the form of liquified natural gas and liquified petroleum gas, as a plan to achieve diversification in fuel within the context of the Nigerian economy in order to reduce the present pressure on the other petroleum products and precisely Premium Motor Spirit (PMS) and Automotive Gas Oil (AGO).

Keywords: Liquified Petroleum Gas, Transportation Fuels, Liquified Natural Gas, Premium Motor Spirit, Automotive Gas Oil and Dual-Purpose Kerosene

1. Introduction

The consumption of energy has been on a constant rise due to the urbanization and the worldwide demand for energy has increased because of universal population growth and the faster transportation development. The transportation sector is the major user of global oil as 60 percent of the produced oil is consumed by the transport sector and consequently, it is the principal greenhouse gas emitter as it accounts for around 20 percent of the emitted CO_2 (IEA, 2014) [8]. Presently, majority if not all of the cars used premium motor spirit or diesel for fuel but this fossil fuel source is inadequate and distributed uneven. Again, conventional fuels are regarded as the major environmental pollution emitters. However, the environmental influence of gas is measured as not that hazardous; therefore, this brings the need for the adoptions of substitutes sources such as liquified natural gas and compressed natural gas as fuel (Okon, 2018) [18].

Securing energy; climate change and the increasing universal demand for energy are increasingly attracting the attention of the general public and in order to lessen the dependency on crude oil with growing sustainability in transportation, many nations have strategized to substitute conventional fuels for transportation with alternative ones in the near future (Achtnicht, *et al.*, 2012) [1]. There is a greater possibility that natural gas can substitute both petrol and diesel in the personal, passengers and heavy cars. For instance, Adegoriola and Suleiman (2020) [2] opined that driving a car that used compressed natural gas against the one that used premium motor spirit is cost savings considering the case of car driver that travelled for a distance of 100 km daily for one month and they disclosed that the driver will be saving a total amount of N1,143 daily and at the end of the month it will be N34, 290. This is the clear indication that the amount of money spends by the car owner in changing his car from using premium motor spirit to compressed natural gas is recovered in the first 6-months of usage and realizing a total of N211,402 at the end of

every year would be possible. Again, there will be significant decrease in roughness and difficulties that are associated with fuel importation into the nation when driving cars that consume compressed natural gas or liquified natural gas. The fossil fuel-based energy natural gas which is a hydrocarbon gas is mixture of methane, carbon dioxide and nitrogen. The natural gas commonly initiates in the field of crude oil or the underground coal bed and it is regularly used in cooking, heating and electricity generation. The vehicles that used natural gas utilized it in two different forms which consist of Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG). For instance, the Compressed form of natural gas has the capacity to store with the pressure of about 20-32MPa because it is lighter than air (Hai, 1993) [10]. The brawny tank is highly essential storage which requires extra space in the vehicle the lighter and easy to release properties of natural gas makes it safer than the vehicle's petrol and diesel and more importunately, the vehicles that are utilized compressed natural gas are usually engaged for light duty vehicles (Zhang, 2015) [26]. But in terms of the density of energy, liquefied natural gas has twice capacity than the compressed natural gas which is supply in a specifically designed tanks with cool temperature of about 165 and less pressures of about 70-150 psi. It is generally consumed by the heavy-duty cars and due to the liquefied natural gas' greater density of energy, the refueling become relatively less expensive as it requires less electric power in a hundred times when compared with the compressed natural gas. Utilization of natural gas has some associated benefits and these benefits ranges from quality of air improvement; improving the security of energy; reducing operational costs and noises in the town. Therefore, it is universally known to be the greatest alternative to petrol and diesel for vehicles. Even though natural gas is a non-renewable energy consumption, but numerous technologies that are capable of creating bio-natural gas have been equally developed and these comprises of bio-methane; biogas; bio-synthetic gas (Michiel, 2010) [14]. Again, in terms of emitting pollution that affect the equality of the environment, natural gas is considered as the freshest fossil fuel and on the basis of well to wheel analysis, natural gas releases 25 percent CO_2 than petrol that is utilized in producing the same volume of heat and this is because natural gas has less CO_2 emissions per energy ratio. Additionally, natural gas releases lesser amount of gases such as SO_2, NO_2 and particulate matter when compare with the extra hydrocarbon fuels (Michiel, 2010) [14]. On the analysis of complete life cycle, natural gas can provide reduction in the emissions of greenhouse gasses for 20 to 30% when compared with the conventional petrol and diesel and again, the conventional emissions of air pollution from is also lesser than that those of the petrol and the diesel Peter (2012) [23].

But the pump price of natural gas could be affected by the petroleum pump price per litre. History has shown that the pump price of natural gas per litre was found to be more stable than that of petrol and in the recent time the pump price per litre of natural gas has become lesser than that of petrol and this make it possible in the reduction of operating costs (Michiel, 2010) [14]. Zhang (2015) [26] supported this position by saying that the cost of consuming natural gas is 20 percent to 60 percent lesser than petrol and 20 percent to 40 percent lesser than diesel. Again, the retail pump price of natural gas per litre usually is lesser than petrol which is adjustable among several nations.

Often all these, Nigeria is presently exporting 18.6 million tons per annum of Liquified Natural Gas (IGU, 2017) while Liquified Petroleum Gas utilization by the public for domestic purposes which include cooking is increasing. Numerous advantages occur for enhancing these statistics and also growing the usage of additional fractions of natural gas. For instance, the country might have remained protected from the dropping GDP due to the present regime of low-price in the sales of crude oil if paths for the LPG consumption are discovered as substitute to household kerosene for cooking. Moreover, in Nigeria, the instability in PMS retailing is frequently felt more in the automobile business and has remained the source of some arguments between government and the labour union (Ubani and Ikpaisong, 2018) [25]. This problem can be tackled if substitutes like Compressed Natural Gas (CNG) and Liquified Natural Gas were discovered. It is against this background that we attempt to shed more light on the benefits of LPG to the Nigerian automobile industry as it will result in lessen the costs of fuel for the general public, decreasing the level of CO_2 emissions and most importantly eliminating the premium motor spirit's subsidy requirement.

2. Literature Review

Due to the outcome of restrictive crude oil reserve and the demand for the country's petroleum sector deregulation necessitate the need for the search outside petrol and diesel as fuels for vehicle and the practicability of natural gas adoption for vehicles' fuels have been shown. The adoption of natural gas as vehicles' fuel possess some benefit over the petrol and diesel and these include less toxicity of effluents; high octane number; engine parts negative effects (Adegoriola and Suleiman, 2020) [2].

Demirbas (2006) [7] indicates four consecutive substitute fuels that can be easily employed in conventional CI engines which include the dimethyl ether; Fischer-Tropsch; Vegetable oil and Vegetable oil as both the fischer-tropsch and dimethyl-ether can be produced from natural gas and therefore not restricted by feedstock accessibility. But diesel engine has some benefits in terms of efficiency level been greater than that of Otto cycle engine and the major components of petrol are aromatics; olefins; napthenes and paraffins. Therefore, the main substitute fuels are liquefied petroleum gas; alcohol; compressed natural gas; Petrol type cars operated with electricity. Adom *et al.* (2012) [3] in their study for the conditional requirement of electricity consumption in Ghana indicate that per capita real income, efficiency of industries, changes in the structure of the economy and the extent of urbanization are regarded as the important determinants of demand for electricity in the case of Ghanaian economy and there is scanty of empirical studies on the demand for natural gas and specifically LPG. Mensah (2014) [12, 13] examined the long-run and the short-run drivers of LPG demand in the case of Ghanaian economy and exposed 10 years future trends projections with the help of ARDL and partial adjustment model procedures and their outcomes revealed that price; imcome and urbanization are the major demand determinants while predictions from all the 3 scenarios indicates that LPG demand will attain a least amount of 5.9 million metric tons in the year 2022 implying that there is serious suggestions regarding the side of demand and the supply management. Kafood (2014) opined that natural gas has remained considered as the greatest hopeful substitute for other fossil fuels due to its purity and richness. In the current periods, natural gas has gained acceptance in a series of industries plus

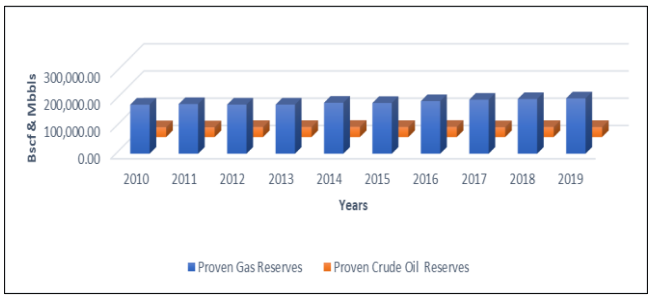
transportation industry where it has replaced diesel, petrol and extra fuels. Mainly due to its moderately less costs and the growing cognizance operations on polluting the air, some ratio of cars today run on CNG and their number continue to increase on a daily basis. Ogunlowo (2016) [17] opined that numerous factors have hindered the adoption of compressed natural gas as transportation fuel in Nigeria and among these factors include lack of focus, unfavorable structure of energy market, insufficient access to capital, inadequate public awareness campaign, insufficient vehicle standards enforcement organizations and the frail structure of transport market using the basis of the case study's perceptions, constant submissions of the partakers interviews of semi-structured and the Delphi survey result. Otene *et al*. (2016) [20] highlighted the capacities of changing flared gas from the Nigerian oil and gas industry to compressed natural gas which might possibly be the best choice for the 220 Lagos Bus Rapid Transit and achieve the aim of CO_2 emissions reduction. Additionally, the LEAP software was utilized in the model demand for energy and CO_2 emissions from the BRT-Lite via recent situation and the year 2030 predictions. The outcome from the model estimation revealed that compressed natural gas utilization by the Lagos BRT-Lite will reduce the emissions of CO_2 in the country's oil and gas industry. The other consumption choices for flaring gas from the industry include liquefied petroleum gas; power generation and liquefied natural gas. Ubani and Ikpaisong (2018) [25] discoursed that natural gas is clean in terms of burning, harmless fuel that can save some cash at the pump while promoting the quality of the environment and decreasing the country's addiction to petroleum because it occurred naturally as a mixture of gaseous hydrocarbon; non-gaseous non-hydrocarbons; gaseous non-hydrocarbons. It is originated from the underground reservoir of rocks in two sample either as non-associated gas (i.e. on its own) or as associated gas (i.e. associated with crude oil) and due its free environmental impact, natural gas is accepted as the world best source of energy when compared with the other fossi fuels. Dalaba *et al*. (2018) [5] engaged in cross-sectional study with objectives of characterizing the existing situation of liquified petroleum gas market and to exposed the prospects and the challenges regarding the expansion of liquified petroleum gas acceptance. Using 16 suppliers of liquified petroleum gas together with 592 households in the case of Kassena Nankana Districts of Ghana and revealed that 10 percent rural households have LPG stoves and there is cognizance of LPG and the limited access to fuel supply with the presence of single refilling station in the area. The major constraint to LPG acceptance is affordability and the acceptability is limited due to the extensive concerns about the LPG cooking safety. Synáka *et al*. (2019) [24] in their assessment for the liquefied petroleum gas as a substitute fuel, showed that liquefied petroleum gas is the combination of butane; propane and additional substances of less volume and it is found as by-product of existence that is manufactured through petroleum refining and the authors assessed liquefied petroleum gas from the economic; safety and emissions points of view. In their investigation for the purpose of utilizing gas as vehicle fuels in Nigeria, Adegoriola and Suleiman (2020) [2] showed that gas utilization as fuel has some advantage regarding efficiency and the environmental influence making its demand to exceed the existing other fossil fuels owing to its cleanliness; versatility; availability; accessibility and that its adoption in the short run has some associated challenges but in the long run it appears to be the best because it is economical and most importantly it is clean in terms of greenhouse gas emissions to the environment. On the deliberation of the influence of crude oil price and the rate of exchange on economic growth in the case of Nigeria for the sample period of 1982 to 2018, Musa *et al*. (2019) [15] utilized ARDL bound test for cointegration and the outcome revealed that there exist cointegration association among the series. The outcome further indicate that price of crude oil and the rate of exchange have positive and significant relationship with the growth of the economy within the sample period and the researchers conclude that the country's government should source for other means of generating revenue other than crude oil exports. Maijama'a and Musa (2020) [11] in their study for the environmental impact of crude oil price and urbanization using ARDL method for the 1981-2016 period revealed that there is strong cointegration relationship among the series and that crude oil price and foreign direct investment have positive and significant sign with environmental pollution in the long run and this suggest that earnings from crude oil exports and foreign capital inflows help in maintaining the quality of the environment. But urbanization was having positive and significant sign in both the long run and the short run periods meaning that environmental pollution was drive by urbanization.

3.0 Data and Empirical Presentation

All the data regarding the empirical presentations were sourced from the Nigerian National Petroleum Corporations 2019 annual statistical bulletin. The reason for choosing this organization is because it is the best and reliable for all the data concerning petroleum products.

3.1 Proven Crude Oil and Natural Gas Reserve

The first presentation centered on the 10 years proven crude oil and natural gas reserves from 2010 to 2019 and the reason for choosing the sample period is to conform with the data availability. From Figure 1 it is realized that the proven natural gas reserve is higher than that of the crude oil reserve. For instance, in the year 2010 the proven natural gas reserve was 180,331.17 Billion Standard Cubic Feet while that of the crude oil was just 36,375.26 Million Barrels. Again, in the year 2015 the natural gas reserve was 186,476.82 Billion Standard Cubic Feet and that of the crude oil was 37,062.06 Million Barrels and this is a clear indication that there is an increase in both the two reserves from the year 2010 to 2015. Similarly, the natural gas reserve increases to 193,354.99, 198,711.27, 200,902.20 and 203,449.26 Billion Standard Cubic Feet respectively in the year 2016, 2017, 2018 and 2019. But the reserve in crude oil was just fluctuating where it attained 37,453.00, 36,182.00, 36,971.91 and 36,890.00 Million Barrels in 2016, 2017, 2018 and 2019 respectively. The rest of the comparative analysis of the two products is documented in Figure 1 below.

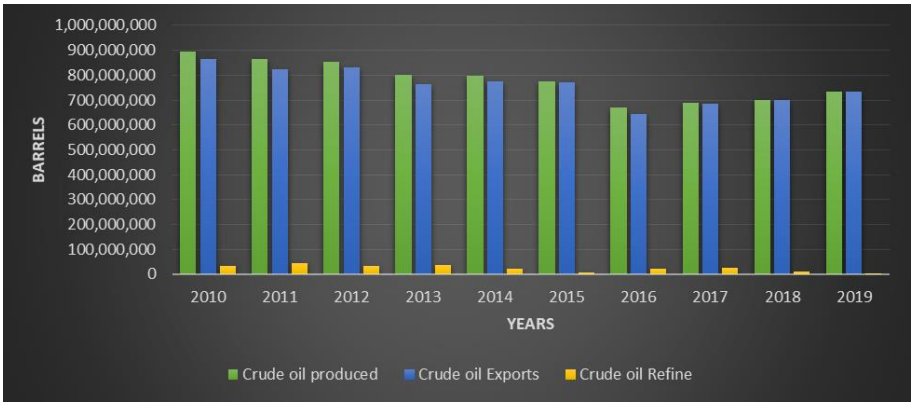


Source: Authors' Presentation using data from NNPC, 2019.

Fig 1: 10-Years Proven Crude Oil and Natural Gas Reserve

3.2 Crude oil produced, exports and refined

After the proven crude oil and natural gas reserves offered in the above section, this section presents the total capacity of the country in terms of crude oil produced, exports and refined as given in Figure 2. In the year 2010 the total crude oil production capacity was 896,043,406 Million Barrels; the export was 864,702,101 Million Barrels and the total refined was 34,700,973 Million Barrels. But from the year 2015, 2016, 2017, 2018 to 2019 the total crude oil produced were 773,458,592, 669,997,933, 689,743,453, 701,431,890, 735,244,080 Million Barrels respectively. and the total amount of crude oil exports were 771,689,625 Million Barrels in 2015; 645,435,248 Million Barrels in 2016; 686,662,833 Million Barrels in 2017; 698,519,830 Million Barrels in 2018 and 732,896,583 Million Barrels in 2019. Often all these figures, the total amount of crude oil refined were 8,740,027 Million Barrels; 22,728,369 Million Barrels; 26,452,014 Million Barrels; 11,767,466 Million Barrels and 2,764,267 Million Barrels in 2015, 2016, 2017, 2018 and 2019 respectively. in summary, the total amount of crude oil produced was decreasing from 2010 down to 2016 but from 2017 up to 2019 there was increase in crude oil production. But there was fluctuation in the total quantity of crude oil export from 2010 down to 2016 and the increase in export was from 2017 up to 2019.

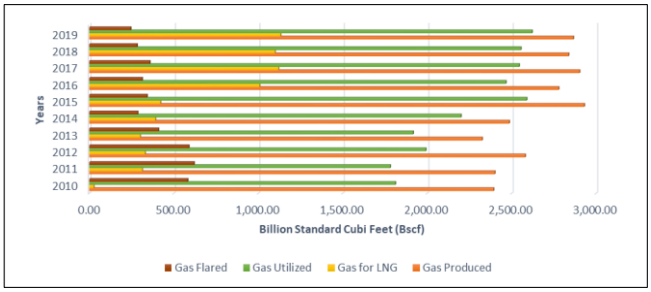


Source: Authors' Presentation using data from NNPC, 2019.

Fig 2: Crude Oil Produced, Exports and Refined

3.3 Gas Production and Utilization

The total gas produced, utilized, flared and gas for liquified natural gas is offered in Figure 3. The comparative presentation shows that out of 2,392.84 Billion Standard Cubic Feet of gas produced, a total of 1,811.27 Billion Standard Cubic Feet was utilized, 25.87 Billion Standard Cubic Feet was used as liquified natural gas and 581.57 Billion Standard Cubic Feet was flared all in the year 2010. But in the year 2015, the total quantity of gas produced increase to 2,929.85 Billion Standard Cubic Feet, while total amount of gas utilized reached 2,588.48 Billion Standard Cubic Feet, 421.19 Billion Standard Cubic Feet was for liquified natural gas but there was decrease in the total quantity of gas flared as the amount reaches 341.37 Billion Standard Cubic Feet. Similarly, in the year 2019 the total volume of gas produced, gas utilized and gas flared all decreases to 2,864.93, 2,620.58 and 244.35 Billion Standard Cubic Feet respectively. But the total volume of liquified natural gas increases to 1,132.24 Billion Standard Cubic Feet. In summary, the total volume of gas for utilization and liquified natural gas was increasing starting from the year 2015 to 2019 but the total volume of gas flared was decreasing also starting from 2015 to 2019. Ana this is the clear indication that gas for LNG and local utilization is increasing while the level of gas flared is decreasing for sample period of 2010 to 2019.



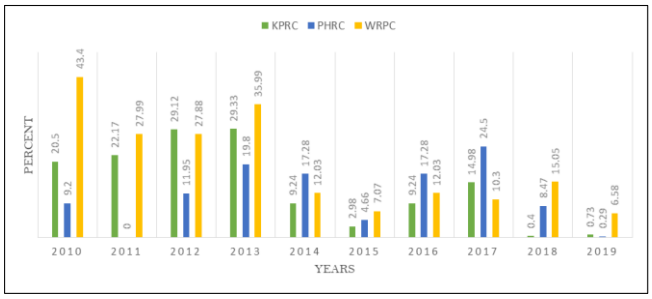
Source. Authors' Presentation using data from NNPC, 2019.

Fig 3: 10-Year Gas Production and Utilization

3.4 Domestic Refining Capacity Utilization

In Nigeria currently there are three active refineries and they include Kaduna Refining and Petrochemical Company (KRPC), Port Harcourt Refining Company (PHRC) and Warri Refining and Petrochemical Company (WRPC) and their refining capacities are expressed in percentage for the period of 2010 to 2019 as showing in Figure 4 below. In the year 2010 the capacity utilization for the KPRC, PHRC and WRPC were 20.50 percent, 9.20 percent and 43.40 percent respectively making a total percentage of 73.10 domestic refining of crude oil. But after 5 years i.e. in the year 2015, the total percentage of domestic refining capacities of three refineries fall seriously to 14.71 percent where KPC

accounted for the 2.98 percent, 4.66 percent by PHRC and 7.07 percent by the WRPC respectively. But in the year 2016, the total percentage had increase to 38.55 percent and out of this figure, KRPC accounted for 9.24 percent, PHRC accounted for 17.28 percent and WRPC accounted for 12.03 percent. Additionally, the total percentage domestic refining increases from the 38.55 percent in 2016 to 49.78 percent in 2017. Out of the 49.78 percent increase, KRPC contribute 14.98 percent, PHRC accounted for 24.50 percent and lastly, 10.30 percent was contributed by WRPC. But in 2018, the total domestic refining capacity decrease to 23.93 percent where the individual contributions of the three refineries were 0.40 percent, 8.47 percent and 15.05 percent from KRPC, PHRC and WRPC respectively. Additionally, in 2019 the total domestic refining capacity was very low given it at 7.6 percent and out of this percentage 0.73 percent was accounted by KRPC, 0.29 percent by PHRC and 6.58 percent by WRPC.

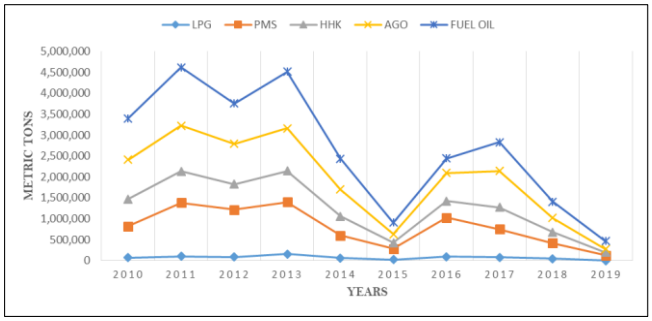


Source: Authors' Presentation using data from NNPC, 2019.

Fig 4: 10-Year Domestic Refining Capacity Utilization (Percentage)

3.5 Domestic Major Product Yield (Metric Tons)

Figure 5 below offered graphical presentation of major domestic yield of petroleum products expressed in Metric tons for the period of 2010 to 2019 in Nigeria. The figure shows the domestic trends of Liquified Petroleum Gas (LPG), Premium Motor Spirit (PMS), House Hold Kerosene (HHK), Automotive Gas Oil (AGO) and fuel oil respectively. The trends of PMS, HHK, AGO and Fuel Oil were fluctuating from the year 2010 up to the year 2013 but the trend of LPG was increasing at decreasing rate from 2010 up to 2013. But there was massive decline in the trends of all the products from the year 2013 down to 2015. But from the year 2015 up to 2017 there was an increase in the yield of major domestic products as shown by the increasing trends of these products. But from 2017 up to 2019 witness fall in the trends of these products also as shown by the Figure 5 below. In a nutshell, the trends of domestic yield of these products were fluctuating from the period of increase to the period of decrease.



Source: Authors' Presentation using data from NNPC, 2019.

Fig 5: 10 -Year Domestic Major Product Yield (Metric Tons)

3.6 Domestic Prices of Petroleum Products

Table 1 below present the domestic pump price per liter of the major petroleum products in Nigeria for the sample period of 2010 to 2019 and the major products include Premium Motor Spirit (PMS), Automotive Gas Oil (AGO) and Dual-Purpose Kerosene (DPK) respectively. The Table indicate that in the year 2010 the pump price per litre of PMS, AGO, DPK were N65, N115 and N50 respectively. But after the inauguration of the present government into office in the year 2015 the pump prices per litres of these products stands at N87 for PMS, N125 for AGO and N50 for DPK. After the first tenure of the present government in office, in 2019 the there was an increase in the pump prices per litre of these products where PMS reached N143, AGO was N210 and DPK was N150. Again, in the second quarter of 2020, there was also an upward review of the petroleum products where PMS was N160 per litre, AGO was N190 per litre and DPK was N195 per litre. In summary among the three petroleum products mentioned, PMS has undergone changes in the pump price per litre followed by the pump price per litre of AGO and lastly the pump price of DPK. The remaining explanation regarding the changes in the pump price per litre of these three products can be observe in Table 1 below.

Table 1: Petroleum Products Pump Prices in Nigeria

Years	PMS (litre)	AGO (litre)	DPK (litre)
2010	N65	N115	N50
2011	N65	N145	N50
2012	N97	N160	N50
2013	N97	N155	N50
2014	N97	N155	N50
2015	N87	N125	N50
2016	N145	N180	N150
2017	N143	N175	N150
2018	N143	N245	N150
2019	N143	N210	N150
2020	N160	N190	N195

***Source*:** NNPC Retail Limited, 2020.

4.0 Conclusion and Recommendation

The core objective of this research paper is investigating the possible utilization of liquified petroleum gas as an alternative to transportation fuel taken the data for the sample period of 2010 to 2019 in Nigeria and the data obtained were analyzed using power point graphical presentations. The presentations of the study given above; we have shown that the proven natural gas reserve is far better than that of the crude oil as such the gas production is more than that of the crude oil. For the period of 2010 to 2013 the total volume of gas flared is greater than the total volume of gas for liquified natural gas produced but from 2014 up to 2019, the total volume of liquified natural gas produced is higher than the total volume of gas flared. This signifies that there is abundant quantity of liquified natural gas that can be employed as vehicle fuels and by doing that will help in reducing the higher cost of transportation that is due to higher cost of fuels. Again, we have shown that there are currently three active domestic refineries operating in the country and the analysis of their utilization capacities have shown that Warri Refining and Petrochemical Company (WRPC) has the highest capacity followed by Port Harcourt Refining Company (PHRC) and lastly Kaduna Refining and Petrochemical Company (KRPC). The analysis of the domestic yield has shown that out of all the petroleum

products produced, LPG is the product that has the least production capacity among them and this may be due to the fact that there is underutilization of this product in the country that is why it is not refined in large quantity. The comparative analysis of the pump price per litre of the petroleum products have shown that there was an upwards review of the major petroleum products in the country for the sample period of 2010 to 2020. Also, the comparative analysis revealed that the changes in PMS pump price per litre is higher followed by that of AGO and DPK respectively.

To this end, it is recommended that apart from been the substitute for the transportation fuels, the Nigerian government can revive its industrial sector with the use of natural gas as this natural gas possess some multiple of industrial usage that consist of best ingredients provision for different products that include fertilizer, plastic, anti-freeze and fabric. As stated by Onyekwelu (2020) [19] the industrial sector is counted as the biggest consumer of natural gas as it is responsible for the 43 percent of the total natural gas utilized across all sectors and it is the second greatest employed source of energy in industry straggling electricity only. Again, as a matter of national development, the Nigerian government should ensure legal and regulatory framework surrounding together the commercial and technical aspects for the utilization of natural gas in country.

Conflict of Interest

The authors declare no potential conflict of interest regarding the publication of this work

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