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A Review on the Role of Natural Gas in Nigeria's Energy Transition

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1. Abstract

Nigeria's economic development relies to a greater extent on its power generation, with the country being heavily reliant on its oil resources over the years. With energy transition underway, meeting the twin goal of ensuring universal access and transitioning to clean sources of energy puts the country at an edge. Natural gas is currently sought due to its 'attributed transitional status'. While prices following basic economic theories play a role in influencing energy mix, other factors such as energy access, technology change, environmental implications and political factors impact energy production and supply, consequently the dynamics of its power sector.

This study is descriptive and analytical, making use of qualitative and quantitative approaches for data collection and analysis on the dynamics of prices of natural gas and renewable energy, energy access, gas production, natural gas technology, environmental and political opportunities, and challenges as some of the key factors in influencing Nigeria's transition. Natural gas with its wide abundance in Nigeria provides a bridge to meeting energy demand and has relatively lower emissions, with accruing economic benefits. Nigeria has emphasized the role of natural gas in its energy transition road map and investments and policies have currently been put in place. Clearly, Natural gas is playing and will continue to play a huge part in Nigeria's energy transition. With a good balance of investments, in clean energy sources, good policies and regulations on the exploitation and use of natural gas, Nigeria's environment commitments and economic goals can both be achieved, leading to a just transition.

Keywords

Nigeria, Natural Gas, Energy Transition, Renewable Energy, Sustainable Development

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2. Introduction

The 2030 Agenda has set the universal goal to electricity access by 2030 (UN Sustainable Development Goals 2030), with no country substantially been able to reduce poverty without an increased use of energy. For Africa, and Nigeria in particular, significant challenges and new opportunities characterize its energy future. Before renewable energy's technological viability can surpass its challenges to produce secure and sustainable energy, natural gas is seen as a suitable transition fuel (Smil, 2015).

Nigeria was ranked as the world's worst country with regards to access to electricity, with about 90 million of the total population without power supply (The Energy Progress Report, 2021). Its current installed power generations stand at 13,000MW, with the energy sector undergoing major transformation, including plans to generate 30,000MW by 2030, 3,000MW from renewables and 27,000MW from its existing and planned power plants to serve its over 200 million people (Nigerian Electricity Regulation Commission (NERC), 2022). Principal sources of energy in Nigeria include coal, oil, and natural gas, and other include Hydro, Biofuel, and Wastes (Ibrahim, 2021). Natural gas remains the main source of power, with a gradual shift towards solar PV as the country starts to exploit its large solar potential. Oil consumption fell by almost 25% in 2019 and remained stable in 2000, whilst it increased by 2%/year between 2010 and 2018, with transport sector being the main consuming sector (93% of total oil consumption) (IEA, 2021), with increase in natural gas consumption. Additionally with respect to its climate commitments, Nigeria unveiled its first Nationally Determined Contributions (NDC), setting an unconditional GHG emission reduction target of 20% below a BAU scenario by 2030 and a conditional target with international support up to 47% (i.e., a level of 244 MtCO2eq for the conditional target compared to a BAU level of 453 MtCO2eq). It is in this light that Nigeria targets 29% of its electricity production from renewables by 2030, including large hydro (19% in 2020), with 13.8 GW capacity (Nigeria's NDC, 2021)

Like most African countries, Nigeria faces the challenge of meeting energy needs and be on tract on energy transition path. To meet the overwhelming vista of expanding energy demand in the coming few decades, natural gas offers a clean base-load power to bridge the introduction of renewable energy (UNECA, 2020). Considering that Nigeria is at the early stages of development, it seems logical to use its available resources to attain acceptable levels of development. During the COP26 summit in Glasgow, Nigerian pledged to cut its carbon emissions and reach net-zero by 2060, underlining the key role of gas in the

country's energy transition roadmap (Bloomberg Green, 2021). The success of Natural gas as a transition fuel, however, is highly dependent on its pricing vis-à-vis competing fuels such coal, oil, and hydro and other renewables in the power generation market (Gürsan, 2021) amongst other factors. Renewable energy and efficiency measures are the most important drivers of the energy sector transition of the Sustainable Development scenario fully consistent with the Paris Agreement (IEA, 2012), however, this varies with countries, and across sectors, and within various timeframes.

This study investigates the role of natural (including factors that facilitate its use) and the state of Nigeria's natural gas and renewable energy as key to its energy transition.

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3. Methodology

The study adopted a descriptive study design and desk review research was conducted to collect data on (a) on natural gas prices for the period 1997-2021.This was obtained from US energy information agency (EIA), 2022. This interval was selected randomly depending on data availability, however, achieves the aim of showing trend in gas prices over the years (b) Latest LCOE Cost and total cost for renewables were obtained from IRENA 2021 publication on power generation costs: solar PV, bioenergy, hydro, and wind offshore. These renewable technologies are the current technologies in Nigeria, (c) Natural gas production statistics for Nigeria (1990-2020) obtained from the IEA Natural Gas Information, (d) Share of population with access to electricity (from 2015-2019) obtained from the World Bank. This was necessary to inform the unelectrified population. 2015 was chosen as the start date, because it was the kick-off year of the UN Sustainable Development Goals 2030. Lastly natural gas power plants in Nigeria were obtained from Global Energy Observation, while Gas flaring statistics were extracted from World Bank Global Gas Flaring Tracker Report, April 2021.

Descriptive analysis was conducted, and descriptive statistics (percentage in form of graphs and charts) used to present the study results.

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4. Results

4.1 Natural Gas production in Nigeria.

The discovery of natural gas deposits has influenced policy and structural changes facilitating the uptake of natural gas as a transition fuel by Nigeria. Nigeria ranks 38th in the world for natural gas consumption, accounting for about 0.5% of the world's total consumption of 132,290,211 MMcf (Worldometer, 2022). Nigeria consumes 3,192 cubic feet of natural gas per capita every year (based on the 2017 population of 190,873,244 people), or 9 cubic feet per capita per day. It holds 187 trillion cubic feet (Tcf) of proven gas reserves as of 2017, ranking 9th in the world and accounting for about 3% of the world's total natural gas reserves of 6,923 Tcf and proven reserves equivalent to 306.3 times its annual consumption. This means Nigeria has about 306 years of gas left (at current consumption levels and excluding unproven reserves), ranks 12th in the world (Worldometer, 2022) in natural gas reserves. There are many gas fields in Nigeria, but the network still needs to be developed to transport gas, however, the government is working on logistics to ease the gas transportation from gas fields to final destinations.

Figure 1 below shows the steady increase in the natural gas production in Nigeria over the years with an increase of over 1,639,168 T-J Gross between 1990 (152,000 TJ-Gross) and 2020 (1,791,168 TJ Gross).

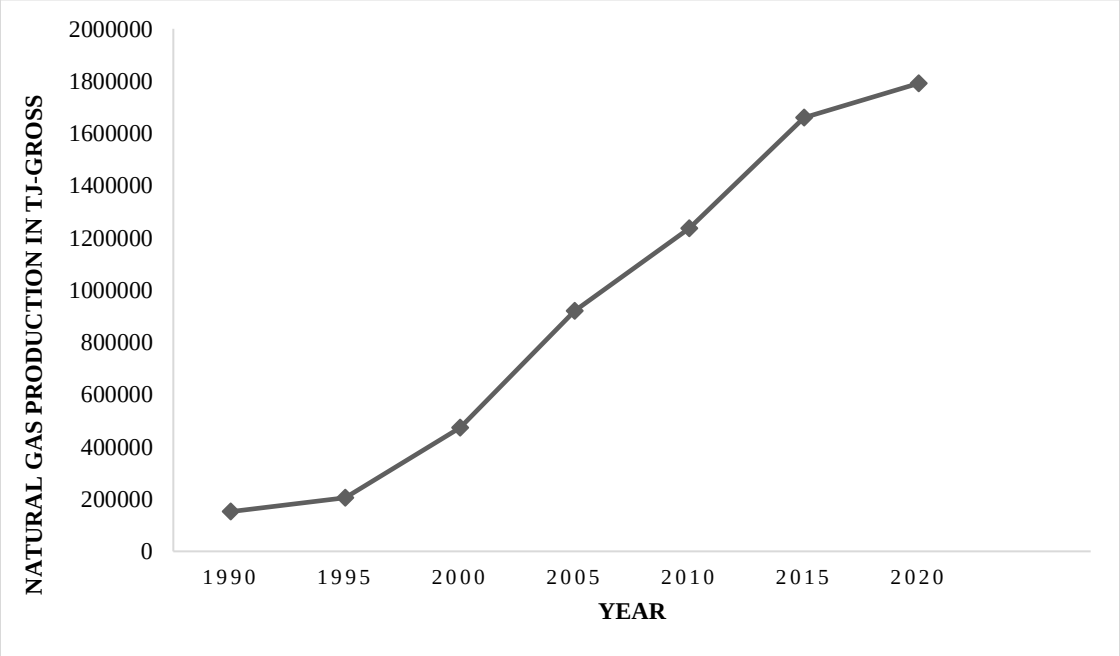

Figure 1: Nigeria's Natural Gas production in TJ-gross
Source: IEA Natural Gas Information, 2022

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4.2 Electricity access and Energy Mix

A social enabler of upsurge in natural gas usage as a transition fuel, is that it ensures access to modern energy (for both lighting and cooking) in Nigeria. Access to electricity is an important determinant in Nigeria's energy transition. About 44.6% of the population are without access to electricity, with 39.1 percent of Nigerians living below the international poverty line of $1.90 per person per day (2011 PPP) in 2018/19 (World Bank, 2021). Biomass stands as the preferred source of household cooking energy in Nigeria. However, over the years electricity/gas as household cooking fuel choice has improved from 0.5% in 2003 to 14.7% in 2018 (NPC, 2017).

Figure 2 below indicates that 2016 had the highest share of the population with access to electricity (59.3%), with a 4.9% decline in 2017, an increase of 2.1% and 1.1% in 2018 and 2019 respectively. These fluctuations could be as a result of poverty and lack of economic opportunities (Blimpo et al., 2019). From the graph, it shows the country needs to meet up with 44.6% of the share of population without access to electricity, otherwise reach universal access.

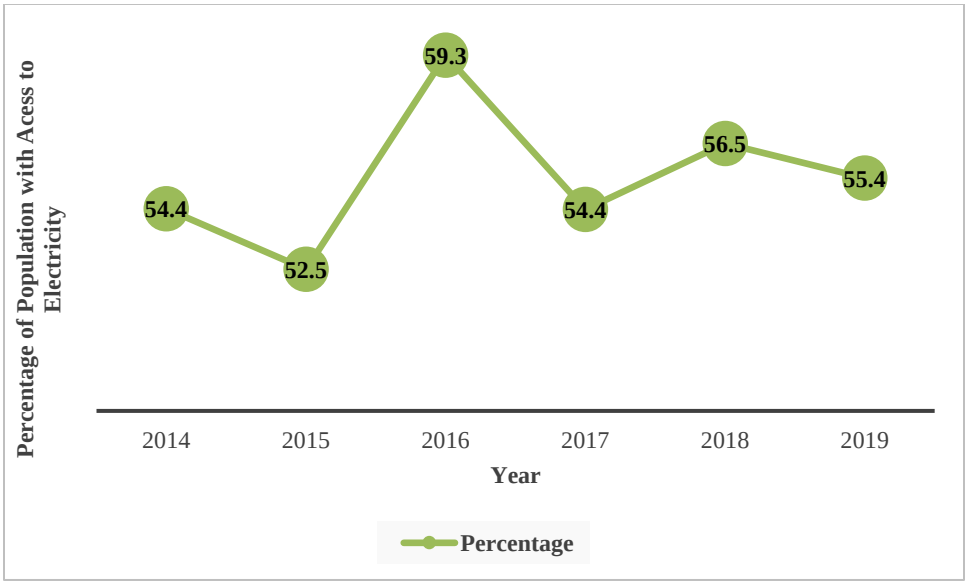

Figure 2: Share of population with access to electricity

Source: World Bank Global Electrification Database accessed 2022

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In Nigeria, the greatest share of electricity is generated from coal, natural gas, and oil (24.06KWh/yr.), solar (0.03 KWh/yr.), hydro (7.38KWh/yr.), with 80% of power generation from gas (EIA, 2020; IEA, 2019). Natural Gas Consumption since 2009 has increased on average by about 7%/year, with the energy sector absorbing three quarters of gas consumption: 39% for power generation, 36% for the oil and gas sector, 25% for industries (Enerdata, 2022). Share of renewable energy in primary energy consumption in Nigeria between 1990 and 2018 revealed a fall between 2017 and 2018 by 1.9% from an increase between 2016 and 2017 of (0.5%) (Statistica, 2018). An interesting narrative of Nigeria's electricity generation by technology in the Stated Policies Scenario, 2010-2040, by the International Energy Agency in 2021, shows that Natural gas will continue to dominate the energy mix over the coming years. This is clearly seen with increase in Gas fired powerplants in the country.

4.3 Natural Gas Technologies

Extraction of gas from unconventional resources has revolutionized national and global markets. Gas production is driven by technology, and recent advancement in technology has made new natural gas discoveries, as well as improvements in efficiency of natural gas producing technologies, unlike the past decade where fracking of shale gas was almost impossible, but due to technological changes, fracking have significantly expanded international gas supply, maintaining lower prices (UNECA, 2020). Technological changes for liquefied natural gas (LNG), such as floating storage and regasification, have improved gas supply options. Moreover, liquefaction has enabled the transport of gas to places with limited or no pipeline infrastructure (David, 2021)

Natural gas power plants are seen as important support for balancing the load on the grid in the event of intermittency of the renewable energy system. As shown on the table 1 below, Nigeria has 17 gas power plants, of which seven (07) are fully operational, seven (07) are partially operational and three (03) are under construction with a total design capacity of 7757.5 MWe. Most of the plants are the Open Cycle Gas Turbine (OCGT) (Global Energy Observation, 2018).

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Table 1: Gas Power Plants in Nigeria

Name of Plant	Type of Turbine	Status of Plant	Design Capacity (MWe)
Agip-Okpai CCGT Power Plant	Combine Cycle Gas Turbine	Operating fully	450
Afam VI CCGT Power Plant Nigeria	Combine Cycle Gas Turbine	Operating fully	685
Afam IV-V GT Power Plant Nigeria	Open Cycle Gas Turbine	Operating Partially	724
Alaoji OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Operating fully	504
Calabar OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Under Construction	562.5
Delta-Ughelli II OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Operating Partially	143
Delta-Ughelli Thermal Power Plant Nigeria	Sun-critical thermal	Operating Partially	942
Egbema OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Operating fully	338
Gbarain Ubie OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Under Construction	225
Geregu OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Operating fully	438
Ibom Power Plant Nigeria	Open Cycle Gas Turbine	Operating partially	191
Ihovbor OCGT Power Plant Nigeria	Open Cycle Gas Turbine	Under Construction	450
Olorunsogo OCGT Power Station Nigeria	Open Cycle Gas Turbine	Operating Partially	500
Omoku (Omuku) OCGT Power Plant Nigeria	Open Cycle Gas Turbine	operating fully	150
Omotosho I and II Power Station Nigeria	Open Cycle Gas Turbine	Operating Partially	785
Rusal Alscon OCGT Power Plant Nigeria	Open Cycle Gas Turbine	operating fully	534
Trans-Amadi I and II OCGT Power Plant Nigeria	Open Cycle Gas Turbine	operating partially	136
Aba Power Station (IPP)	Simple cycle gas turbine		140
AES Barge (IPP)	Simple cycle gas turbine	Not yet operational	270

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The IEA (2010) report indicated that the Gas-Fired Combined Cycle Gas Turbines (CCGTs) are the most attractive among competitive electricity generation technologies, because of their very low capital investment cost, short lead time of construction, which is approximately one-year, high efficiency, operational flexibility, and low carbon emission intensity. However, CCGT make up only 11% of gas plants in Nigeria from list of gas power plants in Table 1 above.

4.4 Natural gas and Renewable Energy Prices

Basic economic rules put it that the higher the price of a good, the lower its consumption and vice versa, except for ostentatious goods. This concept is applicable in the energy scenario as the higher the energy price, the lower the consumption due to energy efficiency measures, energy savings and/or a switch to other cheaper alternative energy sources (REN21, 2019). Thus, energy prices and fuel costs play a vital role in the energy mix of a country. The IEA in 2017 predicted that European gas demand will decline in the future, (IEA, 2017) leading to a fall in global gas prices. In 2020, Covid-19 had an economic downturn in almost all countries and territories worldwide and by early June of 2020, all major gas markets were experiencing a fall in demand including China, Europe was the hardest hit market, with a 7% year-on-year decline in 2020. As a result, global oversupply is pushing major natural gas spot indices to historic lows (IEA, 2020). IEA also predicted that the falling price of natural gas might enable developing countries to increase their energy access with low environmental impact. Falling prices of Natural gas and renewables have considerably affected the energy mix of most countries.

Natural gas prices are a major determinant in its uptake as a transition fuel as well as its expansion, because of competition with other fuels such as coal, oil, and renewables in the power generation market. Though the narrative is often different with most sub-Saharan countries due to other additional factors, such as availability of finance for energy projects. Natural gas prices have declined in recent years to 3.76 dollars per million Btu almost the 90s level, after a gradual spike in the 2000s with peak price in June 2008 (12.68 Dollars per Million Btu) (see figure 3 below). Between 2019 and 2020, gas prices fell from 3.11 in January 2019 to 1.62 in June 2020 Dollars per Million Btu. However, 2021 saw an increase to 3.76 Dollars per Million Btu by December 2020 (EIA, 2022), just as the Covid 19 pandemic slowed down. This could be as a result of the gradual natural gas demand recovery, with consumption returning to its pre-Covid times. Emerging markets are benefitting from the economic rebound and lower natural gas prices. Stable and low prices are attracting demand for gas in both the industrial, electricity and the transport sectors.

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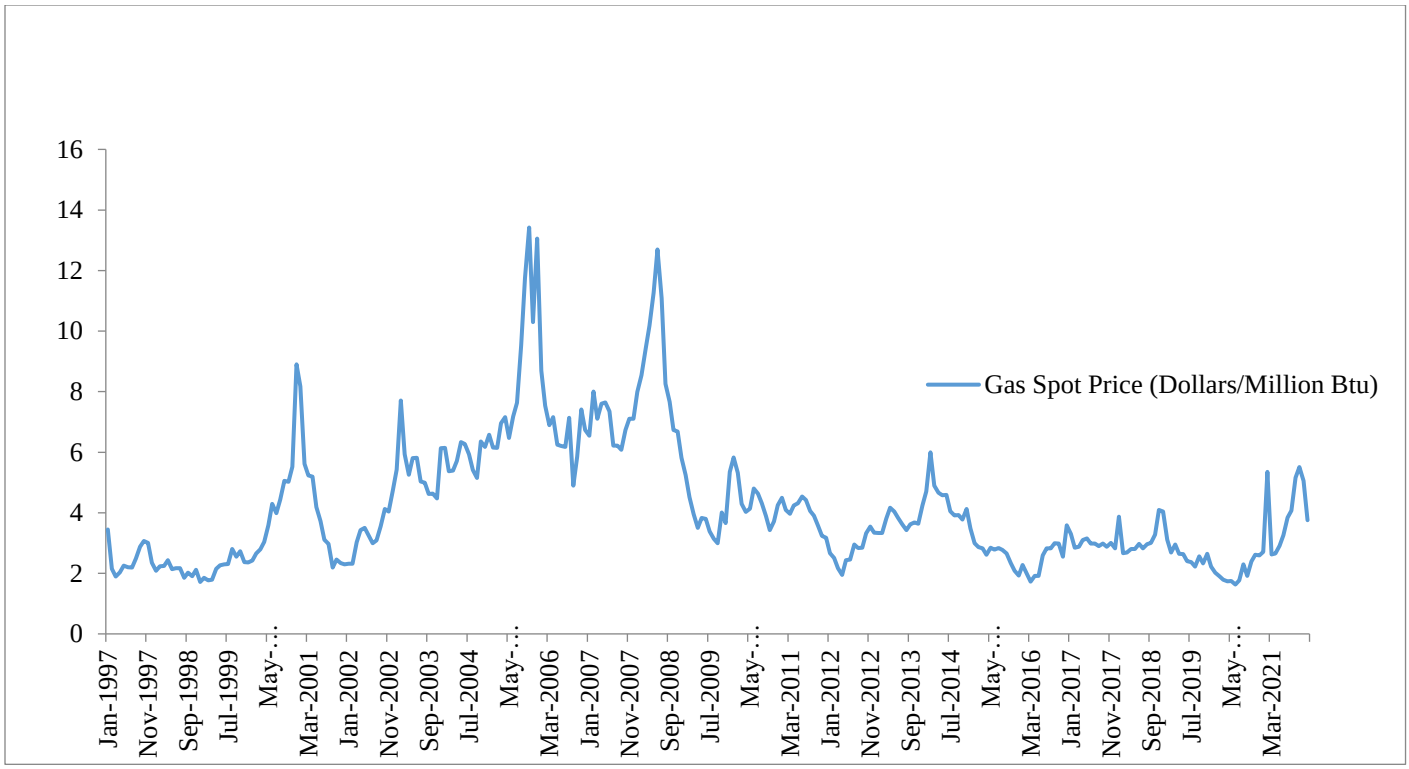

Figure 3: Natural gas prices 1997-2021)
Source: Data from US Energy Information Agency (EIA, 2021)

Furthermore, EIA's findings suggest that natural gas–fired power plants are cheaper to build with overnight capital costs ranging from $676 to $2,095 per kilowatt (or kW), depending on the technology. Typically, natural gas power plants have capacities range from 85 megawatts (IEA, 2020)

In the case of renewable energy, between 2000 and 2020, renewable power generation capacity worldwide increased 3.7-fold, from 754 gigawatts (GW) to 2 799 GW, as costs fell sharply, driven by steadily improving technologies, economies of scale, competitive supply chains and improving developer experience (IRENA, 2020). Costs for electricity from utility-scale solar photovoltaic (PV) fell 85% between 2010 and 2020 (IRENA, 2020). Considering the Predominant renewable energy technologies in Nigeria, the installed costs and levelized cost of electricity are shown in Table 2 below.

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Table 3: Renewable Energy Prices

	Totaled Installed Costs 2020 USD/kW	Levelized Cost of Electricity 2020 USD/kW
Bioenergy	2543	0.076
Hydro	1870	0.044
Solar PV	883	0.057
Offshore	3185	0.084

Adapted from IRENA Power Costs 2020

Looking at domestic and international trade, 80% of electricity production in Nigeria is from Natural gas, with a high local gas consumption of LPG in cooking over the years. Ongoing power sector reforms are responsible for expanding domestic gas consumption. Nigeria topped African exporters in Liquefied Natural Gas, (LNG), in 2021 with 17.9 million metric tons MMt (IHS Markit, 2022) and the successful completion of Ajaokuta-Kaduna-Kano (AKK) Project in 2023 would enhance domestic gas utilization and exports (Nigeria Natural Oil and Petroleum Corporation, 2022). Total Liquefied natural exports (BP's 2019 Statistical Review of World Energy) reveal its highest exports, 45% was to Europe (Spain 15%, France 13% and 17% to other European countries); Asia pacific (40%) and 15% exports to the Western Hemisphere, Middle East, and other African countries. It exports natural gas primarily as LNG, but however faces infrastructure and demand challenges to exporting primarily by pipeline to neighboring countries (EIA, 2020).

According to Nigerian National Petroleum Corporation (NNPC), Nigeria successfully secured funding for the Trans-Saharan Pipeline from China Export & Credit Insurance, with Nigeria putting up 15% equity and well as backing the loan for 85% of the cost with a sovereign guarantee. However, following the COVID-19 pandemic China is decreasing its exposure and has yet to disburse the promised funds. More so, at COP26, 20 countries and five development banks pledged to stop approving finance for unabated fossil fuels by the end of 2022, including the US, Canada, the World Bank, most of Western Europe, and six African countries. Nigeria however has continued investments and expansion of gas projects such as the LNG Train 7 project, natural gas expansion programme, Autogas policy, Trans-Saharan Pipeline from Nigeria to Algeria and hopes to secure more funding as well as mobilize local resources. Hospitable and attractive policies are sure to increase chances of acquiring external financing needed.

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4.5 Environment: Gas Flaring

Gas flaring account for a huge part of Nigeria's 75 million tonnes of CO2 equivalent emissions a year. Nigeria reduced flaring by 70% between 2000 and 2020, according to Tracking Gas Flaring Emissions 2020 by the IEA, motivated by tougher penalties and incentives to capture and sell the gas. Recent Gas flaring satellite data however, reveals that Nigeria has remained one of the top seven countries since 2012 flaring gas (Institute for Security Studies (ISS), 2020). As shown on figure 4 below, gas flaring in Nigeria increased by 0.43 billion cubic metres between 2016 and 2017 (7.31 and 7.65 billion cubic metres), while between 2018 and 2019, 0.39 billion cubic metres of gas was flared, and between 2019-2020, gas flaring reduced by -0.63 Billion cubic metres. Thus, between 2016 to 2020, Nigeria flared a total of 37.43 billion cubic metres of gas.

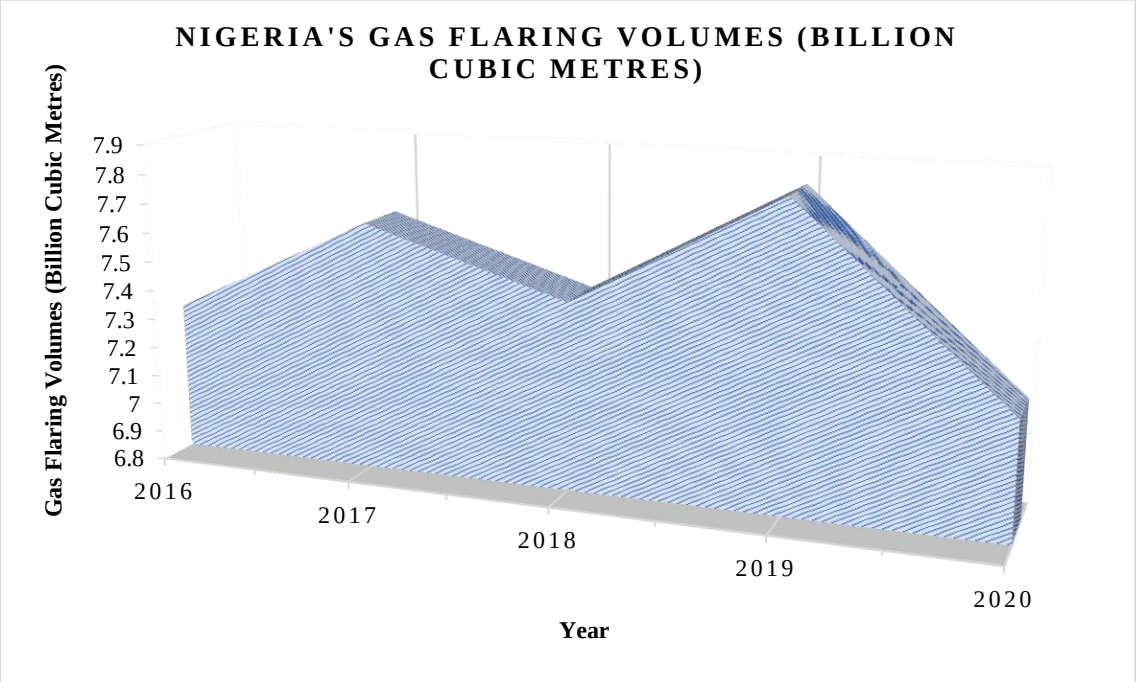

Figure 4: Global flaring tracker, 2021

Nigeria is a signatory to the 2001 Global Gas Flaring Reduction Partnership principles that aim at a flare-out date of 2030. In compliance with the UN Framework Convention on Climate Change, Nigeria also pledged in its first Nationally Determined Contribution to end gas flaring by 2030 (Nigeria's Nationally Determined Contributions, 2021).

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Through its National gas Policy, Nigeria is taking measures by encouraging the use of flare gas capture technologies, including power generation; replacing diesel fuel on site with gas; small scale GTL; mini-LNG plants; building gas infrastructure, including gas gathering lines (p. 62, Sec. 6.4.5); increase flaring penalties and false reporting penalties (p. 63, Sec. 6.4.7); prohibit flaring at green field projects and require a gas utilization plan (p. 63, Sec. 6.4.8); open an industry consultation mechanism to make sure flare targets and regulations are realistic (p. 63, Sec. 6.4.6). However, it will need technology transfer and training from developed countries (IEA, 2020).

4.6 Local Security concerns

Gas supply is mostly geographically located in the Niger Delta region, known for conflicts and insecurity (Habiba, 2018). Incidences of vandalism of gas supply infrastructure has increased, thereby reducing production and power supply, and causing significant social and economic losses, making gas supply unstable, and rendering the power supply system unpredictable (Umar et al., 2021). There is, therefore, the need for government to ensure all host community agitations are resolved to avoid production disruptions. Specifically, there is need for the government to increase surveillance activities around natural gas installation. This can be achieved through improving synergy among relevant security agencies as well as the adoption of modern surveillance equipment and techniques.

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5. Natural Gas in Nigeria's Energy Security and Transition

Natural gas is expected to play a key role in Nigeria's energy transition because of its low emission relative to other fossils, its high abundance (IEA, 2020). Thanks to Nigeria's large reserves, gas supplies are likely to be plentiful in the medium to long term (with increased natural gas production of about 92% between 1990-2020 and proven reserves 206.53 trillion cubic feet). For natural gas to remain relevant under the energy transition scenario which meets the Paris Agreement, significant abatement is required (Oxford Institute for Energy Studies, 2021), as such, deploying new technologies that reduce emissions such as CCGT plants and carbon capture could reduce net-carbon intensity of many fossils fuel uses. Results revealed that most of the gas plants in Nigeria are OCGT plants (out of the 17 gas power plants (both operational and planned), there are just two (02) CCGT), nevertheless, some of its OCGTs were built to accommodate future conversion to CCGT configuration. Moreover, gas flaring statistics reveal 70% reduction between 2000 and 2020, aiming at a flare-out date of 2030.

Demand for energy services is an essential pre-condition for energy transition. The existence of an energy resource alters the pattern of energy use to the extent that it can meet a demand for energy services (Peter A, 2010). Nigeria has and is making enormous investments in gas for both economic reasons, as well as meeting universal electricity demand and closing the 'energy access gap', (a high percentage its population (46%) currently unelectrified and millions of deaths per year as a result of lack of clean sources of energy, and poor and unreliable electrification) in line with the 2030 UN Sustainable goals and the 2063 Agenda of the African Union. Additionally, the energy mix plus the role of gas as a key fuel in the power sector is dependent on abundance and the ability of the electricity and gas sectors to develop and deploy massively high-performance and cost-effective technologies (World Energy Council, 2017). The government's aspirations for the gas sector include creating new industries out of the old oil industry (oil-to-gas switching), capturing economic value, and generating as much revenue from gas, as possible (Nigerian National Petroleum Corporation (NNPC), 2020). The power sector emerges as the backbone of the entire energy system (Dimitri et al., 2021), as well as the economy. Thus, a country like Nigeria with natural gas abundance may not be able to forgo monetization of a valuable natural resource with huge economic advantage for its development (Energy Capital & Power, 2021). That is why Nigeria's economy aims to be entirely gas-powered by 2030 with a declaration of 2021-2030 as the "Decade of Gas" initiative by the government (Vanguard, 2021).

An important component of energy transition is its focus on security, affordability amid high energy prices. Historic lows and almost stable prices of natural gas have increased its consumption in recent years (about 3 dollars / Million Btu between 2009-2021), though still relatively expensive, Nigeria is however blessed with natural gas abundance which automatically makes natural gas a key energy source. Lower cost of gas-fired-power plants have also increase natural gas investments, with overnight capital costs ranging from $676 to $2,095 per kilowatt (EIA, 2020). However, increased renewable power generation may decrease demand for natural gas (Stanley and Kate, 2020), as totaled installed costs for renewable power generation are falling sharply.

There is a global consensus on reduction of GHGs amidst deteriorating effects of climate change. Countries have been called upon to cut down emissions by gradual to complete reduction of fossil fuels, while embracing RE as clean and sustainable energy sources, otherwise, transitioning from polluting to cleaner sources of energy. Natural gas plays a major role in the short- to mid-term transition toward sustainable energy systems (Noesyahida et al., 2021). However, although natural gas might help energy transition by reducing emissions compared to coal, oil, long-term implications of investing in natural gas can work against reaching climate goals, with concerns that investments in natural gas will crowd out investment in renewable alternatives (Gursan and de Gooyert, 2020). However, recent increase in oil, natural gas and electricity prices in many markets globally has helped rebalance the energy transition conversation to focus on affordability, reliability and decarbonization which can be done with hybridization of power generation and industrial technologies (Jared A, 2022).The high flexibility of natural gas peaking combustion turbines has a dynamic ramping ability that can increase or decrease electricity generation within less than an hour, allowing it to respond rapidly to fluctuations on the demand side and adjust to fluctuating power produced from inconsistencies of renewable energy resources such as solar and wind (Huang et al., 2019), as well as responding to both seasonal and short-term demand fluctuations, and to enhance electricity supply security in power systems with a growing share of variable renewables (Blanco, 2018). The use of natural gas-fired CHPs can also support the integration of low-emissions sources of energy, including geothermal heat and power, solar, wind, and batteries (Kinnon et al., 2018).

Renewable power generation is rapidly increasing especially with significant price falls is the recent years. Solar photovoltaics have already become the cheapest way to produce energy in history (IRENA, 2020) with totaled installed cost of 883 USD/KW in 2020. Reaching rural areas in Nigeria through the grid has

been difficult due to the high costs of installations, as such, solar PV and other decentralized renewables will play a pivotal role in ensuring universal electricity access. Thus, policies encouraging the incessant entry of renewables to ensure complete energy transition are essential. Renewable energies therefore will gradually constitute a portion of Nigeria's energy mix, active in the trend toward diversification of the energy mix, resolving the dilemma between an unsustainable energy scenario and ever-increasing demand. Moreover, the country's commitment to a just transition is reflected in its government's flagship project under its Renewable Energy Master plan to electrify 5 million households and 25 million people using decentralized solar energy solutions, which is a major step towards closing the energy access deficit by 2030. Nigeria's CO2 emissions per capita in 2020 stood at 0.62 falling from 0.67 metric tons in 2018 (countryeconomy.com). Though natural gas account for the highest percentage of its energy consumption, there are plans for the continuous growth of renewables, as undoubtedly a promising solution not only to Nigeria's energy challenges but also most sub-Saharan countries, by way of its basic characteristics; sustainability and inexhaustibility, as it can be established in smaller units, thus, suitable for rural community management and ownership, thereby pivotal to economic development.

Though the growing desire for gas in the international market is driven by its cost-effectiveness among other fossils, the development and utilization of renewable energy should be accorded a high priority, especially in the light of increased awareness of the adverse environmental impact of fossil-based energy generation. Widespread use of renewable energy is important for achieving sustainability in the energy sectors in both developed and developing countries. Though critics insist Africa doesn't have to repeat the developed world's environmental mistakes and can "leapfrog" straight to renewables, which are cheaper, cleaner, and faster to develop, Nigeria's argument as well as other African countries, is not abandoning its natural gas and run the risk of ending up with an energy transition that unfairly deprives its citizens of energy access, as well as economic opportunities. Thus, the energy mix for 2030-2040 for Nigeria will be heavily affected by the decisions made now and beyond 2050, as well as innovation, research, and development, government policies.

In the face of an anticipated peak of energy demand growth, a move towards renewable energies and the possible emergence of disruptive technologies, fossil fuels face a perfect storm over the next thirty years though gas faces a moderately secure future with clear risks on the horizon (World Energy Council, 2017).

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Inadequate gas infrastructure, shortfalls in funding, uncompetitive domestic pricing are some of the numerous hurdles slowing down the role of natural gas Nigeria's gas.

Thus, a gas complementing renewable energy-based system is key in Nigeria's energy transition. With natural gas acting as a backstop for renewables, responding to sudden increases in demand and for hydropower, providing secure electricity supply when there is limited rainfall (Shell Plc, 2022).

5.1 Limitation of Study and Future Research

This review paper was an overview of the possible factors facilitating and/or limiting uptake of natural gas, relaying a concept that rate of uptake will possibly influence energy transition, thereby playing a role in Nigeria's energy transition. The research focused on key selected factors and perhaps not all factors that influence or limit the uptake of natural gas. The research does not look at the timeframe for transition in Nigeria and any timeframe mentioned was entirely based on available literature. Time constraint wasn't an exemption, as other angles of the topic could have been reviewed if not for limited time. Also, there is limited published and available literature and data on Nigeria's energy situation.

Thus, more research on additional factors playing roles in energy transition in developing countries, such as policies and regulations and their influence on energy transition is needed. Also, a critical research comparison of current price of natural gas with other elements in Nigeria's energy mix could be enlightening. More research could also be done on the social enablers that could influence natural gas uptake.

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6 Conclusion and Recommendations

Nigeria's energy sector transformation is driven by fossils especially natural gas, with its economic development highly reliant on energy expansion. With investments in clean energy sources, its transition and economic goals can both be achieved. As noted, Nigeria is highly endowed with Natural gas which accounts for over 80% of its power generation, as well as high renewable energy potential which will characterize its energy mix in the coming years. Meanwhile, apart from natural gas abundance, energy and economic poverty, low investment costs in gas power plants have created opportunities for production and supply, amongst other factors such as favorable polices and regulations. However, infrastructural, technological, financial, and political constraints, might limit production and supply of natural gas. Nigeria is committed to flare out gas by 2030, and if it succeeds, there will little or no hindrance to tapping its gas resources.

Natural gas could also be a reliable partner for renewable energy sources; providing critical support for wind, solar and hydroelectricity by helping to match supply and demand. Natural gas is also vital in parts of the economy that are more difficult to electrify, including industrial processes and freight transport. It is clear however that the energy future is gradually moving toward renewable energy and the transition period will to a greater extent be determined by both public and private investments made in the energy sector.

In this light some policy recommendations include enforcing energy modelling and planning for better decisions, policies, and regulations towards a more sustainable energy situation in Nigeria. This could be fortified with investment in research and development involving all necessary stakeholders, academia, NGOs, research institutes, government.

Energy transition in Nigeria requires development of infrastructure (generation, distribution, and transmission), thus, investing and updating ailing infrastructure or investing in expansion is an integral part of the energy transition and an enabler of modern technologies. However, Investments in infrastructure should be aligned with long-term plans and be reflective of broader strategies, including regional market integration.

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Regional planning can strengthen the capacity of countries (localities and communities) traversing the transition. Working collaboratively with other countries in Africa to implement strategic planning and integrate energy system planning and economic development is important

At a regional level, there are several ongoing initiatives such as the Renewable Energy Initiative (http://www.arei.org/), the Desert to Power initiative for Africa by the AfDB, Africa Energy modelling platform initiative by ECA and the OpTIMUS Community , The Africa Clean Energy Corridor (ACEC), cross-border trade of renewable power within the Eastern Africa Power Pool (EAPP) and Southern African Power Pool (SAPP), African Climate Resilient Facility(AFRI-RES) whose synergy and collaborative works will help usher African countries transit to a the clean energy world.

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