ASSESSING THE PROSPECTIVITY OF THE AJOUKUTA – KADUNA - KANO NATURAL GAS PIPELINE

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ABSTRACT

The aim of this investigation is to justify the development of the Ajaokuta-Kaduna-Kano (AKK) Gas Pipeline within the federal republic of Nigeria. The project entails the construction and operation of a 614km Ajaokuta-Abuja-Kaduna-Kano 40'' Natural Gas Pipeline. The proposed pipeline will be provided with pipeline quality gas sourced from numerous gas gathering projects in the southern region of Nigeria, at a minimum pressure of 1,000 pounds per square inch gauge (psig) at the Ajaokuta tie-in, and delivered to Kano also at a minimum pressure of 1,000 psig. The long-term objective of the project is to provide gas to Europe, in view of the supply deficits following the Russia-Ukraine unrest, through the Trans-Saharan Gas Pipeline (TSGP) project. The TSGP upon completion, will provides a golden opportunity for Nigeria to exploit her gas potentials and utilize its gas resources to enable her earn as much revenue from it as it is earning from oil. Moreso, this will enable Nigeria meet her nagging domestic gas utilization needs; eliminate gas flaring and in the long run assist the nation meet global greenhouse gases/climate change policy requirements. Taking into account the scenarios presented above, there is an obvious need for Nigeria to promptly harness its enormous gas resources to (a) enhance its electricity generation; (b) stimulate its comatose industries (c) improve domestic use of gas and (d) boost its natural gas export and by extension its GDP. It is therefore believed by this research, that the proposed Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline Project is an additional stride within the Nigerian government policy as it will facilitate and ensure effective gas supply network in the North and South of Nigeria as well as moderate the environmental impact linked with gas flaring.

Keywords: Ajaokuta, Kaduna, Kano, Natural Gas, Pipeline, Nigeria

INTRODUCTION

Nigeria has an estimated 193 trillion standard cubic feet (Tscf) of proven natural gas reserves as stated by the Oil & Gas Journal (2022), making the country amongst the top ten natural gas resources in the world and the largest in Africa (Figure 1 and Table 1).

A substantial amount of Nigeria's overall natural gas production is either burnt or re-injected. Some of the country's oil fields lack the substructure to capture the natural gas generated with oil, labeled as associated gas. According to the most current data by the World Bank's Global Gas Flaring Reduction Partnership (GGFR), Nigeria burnt about 261 billion cubic feet (Bcf)of natural gas in 2018, making Nigeria the seventh largest natural gas flaring nation in terms of yearly natural gas flaring degree (World Bank Group, 2022). In December 2019, Nigeria LNG (NLNG) attained a financial investment decision, to add a seventh train to its current facility, increasing about 365Bcf, thus expanding the total capacity of the facility to 1.4 Tcf. The extension project was originally projected in 2005 but met numerous setbacks (Energy Information Administration, 2022).

Nigeria exports natural gas principally as Liquefied Natural gas (LNG). Both infrastructure and demand limitations are issues to exporting predominantly by pipeline to bordering countries. Nigeria commenced exporting LNG in 1999 when the initial two trains at the Bonny Island facility were concluded (Nigeria LNG, 2021).

The position of natural gas in the worldwide energy market appears to potentially grow, impacted by the acute increase in proven conventional and unconventional gas reserves internationally, and the greater significance and precedence given by the major energy importing nations to security and expansion of supply (Iyoke, 2013).

The transportation and storage of natural gas is more intricate than that of oil, and this impacted its slow deployment for a substantial period, in Nigeria specifically. The international gas market has transformed in the last couple of years and it is presently undergoing rapid market development in comparison to oil and coal (Economides, 2009). At present, natural gas is the third largest worldwide energy source (Figure 2) and its consumption is projected to increase substantially in coming decades. As stated by Gas Exporting Countries Forum (GECF) (2022) projections, natural gas will grow its portion in the worldwide energy mix from over 23% currently to nearly 27% in 2050 and will be an essential fuel in the switch to a lower-carbon energy structure. Oil will remain a significant source of energy, but its portion is anticipated to wane to 25%. In view of environmental issues, coal will decline suddenly to 13% with nations implementing policies to cut its role in the midst of carbon neutral obligations.

Investment in natural gas will remain growing owing to its accessibility, flexibility and due to it being a cleaner source of energy in comparison to coal and crude oil (Leather, 2013).

Furthermore, as natural gas is the purest burning hydrocarbon and coupled with its elevated efficiency of energy conversion when employed for power generation in combined cycle gas turbines, Economides and Wood (2009), projected that the natural gas industry would maintain a considerable growth over future decades. While, globally the main rival for gas in of late has been inexpensive coal for power production, predominantly in China, India, and Asia, in Nigeria gas contests primarily with petroleum yields. As oil is such a valued source of export income, it makes marketable sense for gas to oust petroleum products utilized locally, thus augmenting the quantities of oil and petroleum yields offered for export.

In line with the most recent estimates of British Petroleum (BP) (2022), Nigeria shipped about 23 billion cubic meters (Bcm) of LNG in 2021, placing Nigeria as the world's sixth-largest LNG trader, after Qatar, Australia, Russia, Malaysia, and the United States. Nigeria's LNG trades represented around 4.5% of LNG exported internationally. Spain was the leading importer of Nigeria's LNG in 2018, bringing in around 146Bcm of the country's LNG, afterward India (143Bcm), and then France(126Bcm) as shown in Figure 3 (Energy Information Administration, 2022).

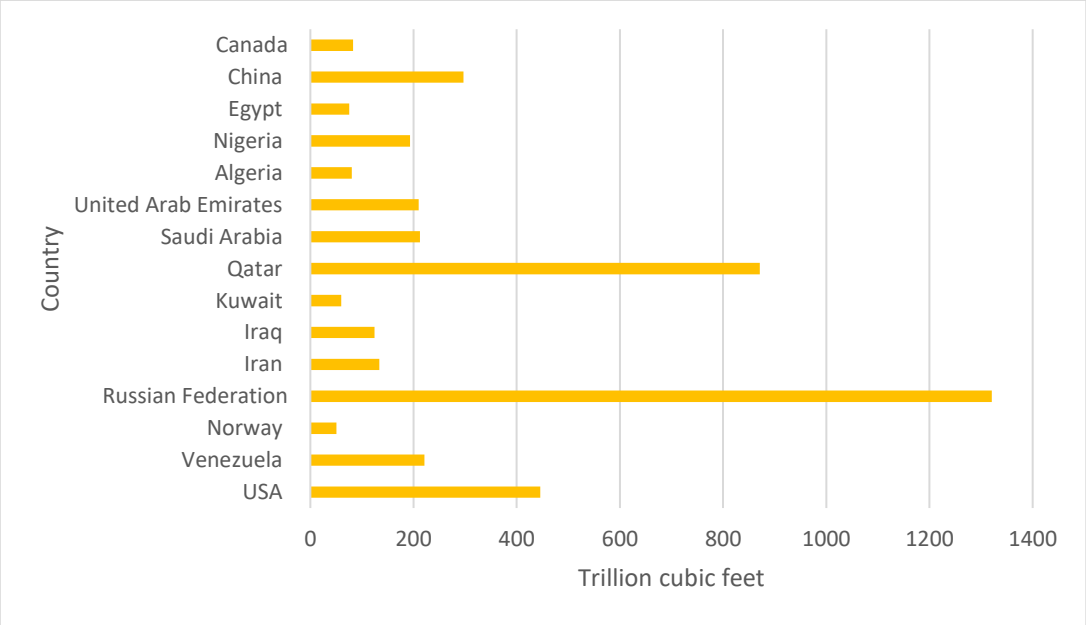

Figure 1: Total proved reserves by country at the end of 2021 (Source: BP Statistical Review of World Energy, 2021)

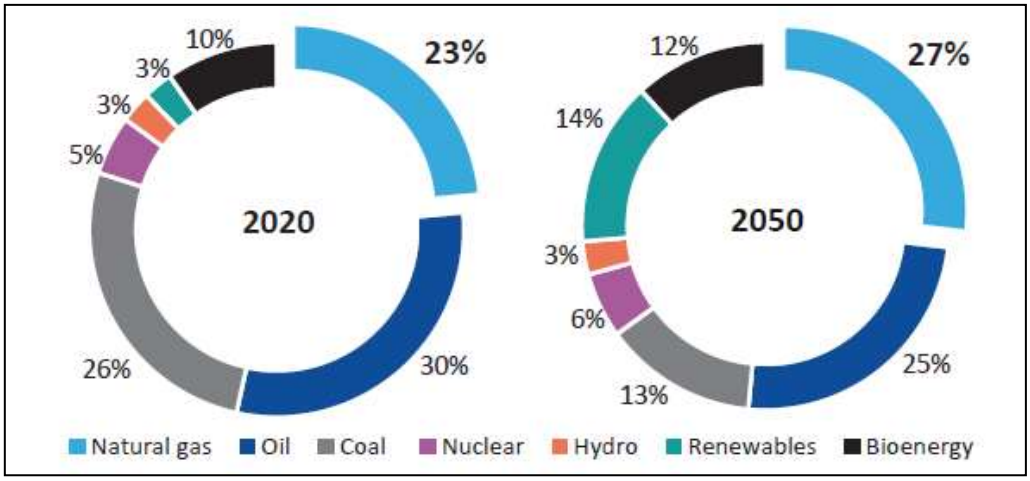

Figure 2: Global primary energy demand in 2020 and in 2050 (%) GECF Secretariat data

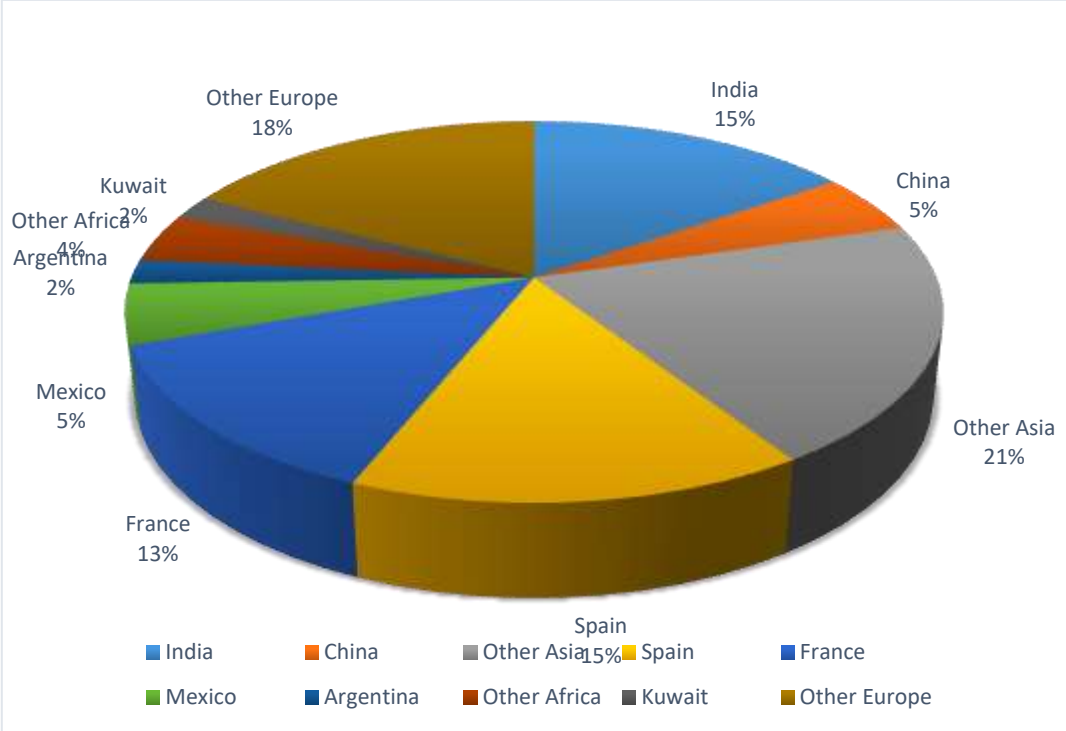

Figure 3: LNG Exports from Nigeria by Region (Source: Energy Information Administration, 2022)

Copious gas reserves exceed anticipated needs of the domestic, regional and export markets. In that regard, the Nigerian government is making concerted efforts to expand its natural gas market by developing the Ajakouta-Kaduna –Kano (AKK) gas pipeline.

The AKK Gas Pipeline Project constitutes the Phase 1 of the Trans-Nigeria Gas Pipeline (TNGP) Project (Figure 4) that is driven by availability of additional gas supplies from Assa Gas Plant, and the need of gas supply to the Northern/Eastern States through Obigbo-Umuahia-Ajaokuta pipeline and Ajaokuta-Kaduna-Kano pipeline. The project development will involve Surveying and clearing the Right Of Way (ROW), hauling and stringing of pipe(s), bedding of pipe(s), welding, digging of trench, lowering of pipe and backfilling, Installation of valves and special fitting and joint coating, Pipeline crossings on rivers, road, streams and other pipelines, Non-Destructive Testing (NDT) Surveying and ROW preparation will lead to vegetation clearing, loss of biodiversity, and loss of farmlands, crops, habitat and migration of wildlife. The gas transmissions pipelines will have a diameter of 40'' and length of 614km along the route. The pipeline will have three spur lines from the Abuja Node to the Abuja TGS, approximately 13.6km, from Kaduna node to Kaduna TGS approximately 200m and from Kano node to Kano TGS approximately 8.14km; respectively.

The Abuja and Kaduna spurs will be sized for 500 MMscfd each leaving up to 2,250 MMscfd available at Kano for local distribution and export in the future through the Trans-Saharan Gas Pipeline (TSGP) project shown in Figure 4. The project will be constructed, financed and operated by NNPC on completion.

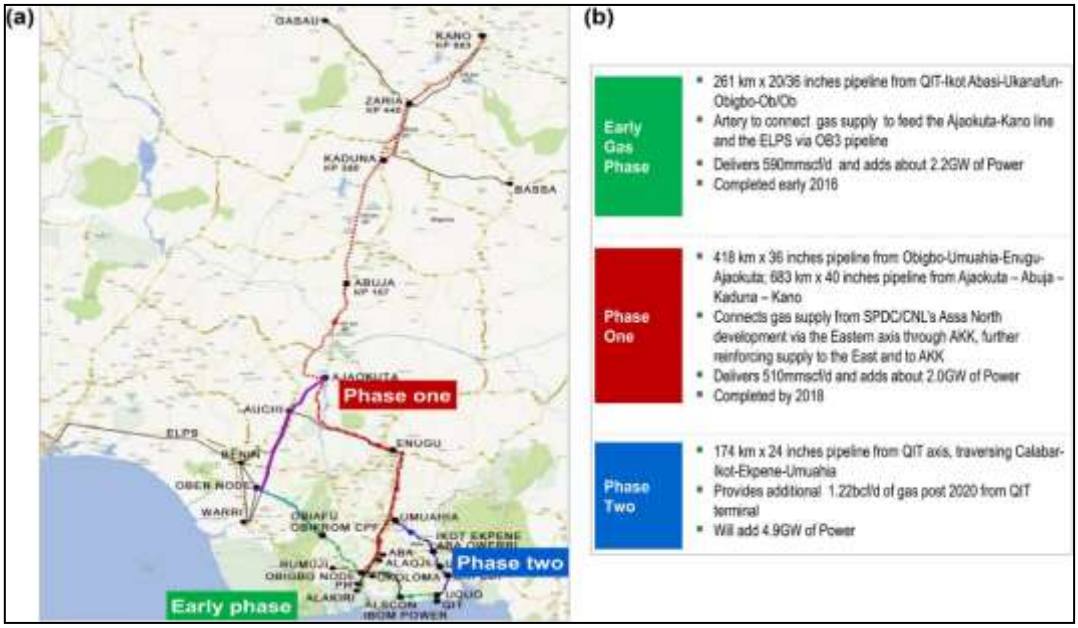

Figure 4:(a) Trans-Nigeria Gas Pipeline Project. (b) Trans-Nigeria Gas Pipeline Project Description. Source: (Nwaoha, 2014)

Figure 5: Trans-Sahara Gas Pipeline route. (Source: Wikipedia, 2022)

This paper aims to rationalize the development of Ajaokuta-Kaduna-Kano (AKK) Gas Pipeline and gas stations by the Nigerian government and put forward relevant information to facilitate the Nigerian National Petroleum Corporation (NNPC), private sector partners/investors and relevant regulatory institutions to make informed decisions in respect of the project.

Table 1: Proved natural gas reserves by country at the end of 2021. (Source: BP's 2021 Statistical Review of World Energy)

S/No	Country	Trillion cubic feet	share of total
1	Russian Federation	1320.5	20.81%
2	Iran	1133.6	17.86%
3	Qatar	871.1	13.73%
4	Turkmenistan	480.3	7.57%
5	USA	445.6	7.02%
6	China	296.6	4.67%
7	Venezuela	221.1	3%
8	Saudi Arabia	212.6	3.35%
9	United Arab Emirates	209.7	3.30%
10	Nigeria	193.3	3.05%
11	Iraq	124.6	1.96%
12	Azerbaijan	88.4	1.39%
13	Australia	84.4	1.33%
14	Canada	83.1	1.31%
15	Algeria	80.5	1.27%
16	Kazakstan	79.7	1.26%
17	Egypt	75.5	1.19%
18	Kuwait	59.9	0.94%
19	Norway	50.5	0.80%
20	Libya	50.5	0.80%
21	India	46.6	0.73%
22	Indonesia	44.2	0.70%
23	Ukraine	38.5	0.61%
24	Malaysia	32	0.50%
25	Oman	23.5	0.37%
Total		**6346.3**	**100.00%**

THEORETICAL BASIS

At the end of 2021, the proved and probable reserve (2P) of Nigeria's gas was about 193*tscf,* rating it the 10th largest gas reserves in the world and constituting about 3% of the world's total natural gas reserves of 6,346 Tcf (BP, 2022). Additionally, Nigeria has a relatively high possible (3P) reserves base of about 75*tscf*, together with a potential for the development of additional undiscovered gas reserves currently estimated at about 600*tscf* by US geological survey. The gas resources, located largely in the Niger Delta region of the country, are characterized by high quality, rich in natural gas liquids (NGLs), and low in impurities (Akintunde, 2016). Ironically, the Nigerian gas sector is still relatively undeveloped, with relatively low levels of domestic utilization despite this potential. The Nigerian gas occurs at a 50/50 ratio of distribution involving Associated Gas (AG) and Non-Associated Gas (NAG). Just a small fraction of this quantity is presently being utilized (Nwaoha, 2014).

A large portion (approximately 63%) of the AG manufactured during crude oil production is presently being flared owing to the absence of sufficient critical infrastructures to convey the gas from the hydrocarbon producing area to consumers. So as to expand its income base and lessen the enormous wastage of valuable reserve as well as the undermining of the environment due to flaring, the Nigerian National Petroleum Corporation (NNPC), is robustly pursuing several natural gas operation ventures with its joint venture associates whereby AG would be utilized to accomplish the aforementioned objectives (NNPC, 2022).

Although a number of gas application ventures have now been concluded, commissioned and functional, various other projects are at different phases of execution. Furthermore, local businesses have started switching from the application of fuel oil to gas owing to rise in awareness.

Since 1976, however, the emphasis of the gas industry in Nigeria moved to the export market in the form of LNG and pipeline gas. This was followed by the development of the Nigerian Gas Master Plan (NGMP) in 1998. The NGMP's approach is to leverage the full potential of natural gas within the Nigerian economy whilst promoting global exports as well by striking the balance between domestic consumption and export.

The thrust of the NGMP is to provide:

a. gas to power
b. gas-based industrialization;
c. increased use of gas for vehicular use;

d. selective high value export through additional export via LNG projects and regional gas pipelines.

Over the last 4 years, the country has attained an annual growth rate of 20% in domestic gas consumption. Additional to shift in emphasis towards domestic gas consumption, the NGMP provided the policy frameworks for the:

- Domestic Supply Obligation (DSO) Regulation - DSO in place to jumpstart gas availability in the short-term and ensure reform through the future legislations
- Commercial Framework Reform - Bankable commercial framework reforms in pricing and revenue securitization to enable sustainable investment in gas supply and
- Scalable Gas Infrastructure Blueprint - National Blueprint for backbone gas pipeline and processing infrastructure that will enable flexibility in supply delivery.

To date over 1000km of major gas pipelines have been laid and commissioned, an additional 470km is presently under construction phase whilst a further 1400km is at the project development. With the effort in infrastructure development, Nigeria would have expanded supply capacity and also establish an integrated gas pipeline infrastructure grid across the entire country.

Summary of Nigeria Gas Resource/Reserves

Table 2 below highlights the summary of 2P and 3P gas reserves for the JVs/PSCs, NPDC and ten key Indigenous and Marginal gas producers (NNPC, 2013).

Table 2: Summary of Gas Resources/Reserves on Company Basis (2P &3P)

S/No	Company	2P Reserves (Bscf)-AG+NAG	Committed	Future commitment	Un-committed	P3 Reserves (Bscf)-AG+NAG	Remarks
1	SPDC JV	62,166	24,500	14,085	23,581	18,627	2P reserves constitutes about 40% of the overall gas reserves in the table
2	MPN JV	14,300	3,300		11,000	17,695	
3	CNL JV	26,800	7,683	6,851	12,266	9,300	
4	TEPNG JV	5,576	9,987	6,782	11,191	652	Both N/PSC companies do

5	NAOC JV	10,889	12,600	7,500	92,111	2,763	not have sufficient reserves to support their base load commitment. Their P3 reserves do not show any significant up-side
6	POOC JV	800	201		599	79	
7	JV SUB -TOTAL	120,533	58,271	35,218	27,044	49,116	
8	SNEPCo	17,245	270		16,978	4,051	The reported reserve is inclusive of the unitized fields in OML 129/135 (NNWA-DORO, BOLIA-CHOTA)
9	EEPNL	2,999			2,999	7,478	Significant P3 reserve migration to 2P required
10	TUPNI	1,458			1,458	244	
11	ADDAX PSC	4,894				1,621	THIS IS 100% owned by NNPC WITH ADDAX AS CONTRACTOR
12	POOC PSC	191			191		
13	STARDEEP /AGBAMI	988			998	1,161	
14	NAE	700			700		
15	PSC SUB -TOTAL	28,487	270		23,324	14,555	
16	NPDC	13,367	5293	4020	4,054	3,396	
17	KEY INDIGENEOUS COMPANIES	18,347			18,347	6,345	
18	TOTAL	180,734	63834	39234	72,769	73,412	

**181TSCF is the total 2P gas reserves of selected gas producers. The difference of about 7tscf between the 2P National Gas Reserves of 188tscf as at 01-01-2015) and the reserves of 181tscf in the above table is that of the remaining Indigenous/Marginal gas producers that this research did not engage.*

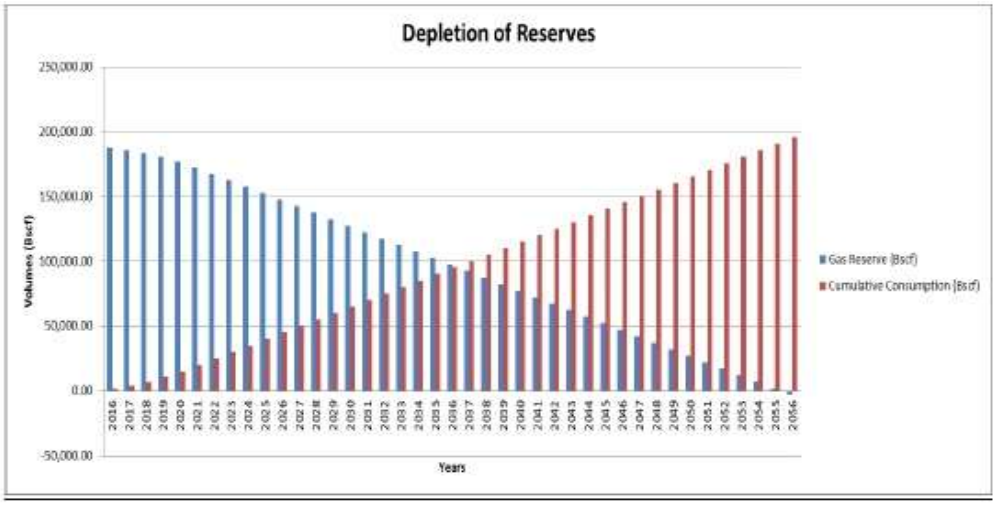

Figure 6: Depletion of Gas Reserves

The depletion plot above shows that with the current level of 2P National reserves of 193tscf, if we do not implement the plans/activities to migrate 3P (Table 2) reserves to 2P commercial category and also initiate deliberate gas explorations then the current 2P reserves will be fully depleted by 2055 as shown in Figure 6. There is, therefore, the need to increase gas exploration activities way ahead of 2055. Additionally, natural gas is predominantly used for power generation and industrial applications in Nigeria as depicted in Figure 7 below.

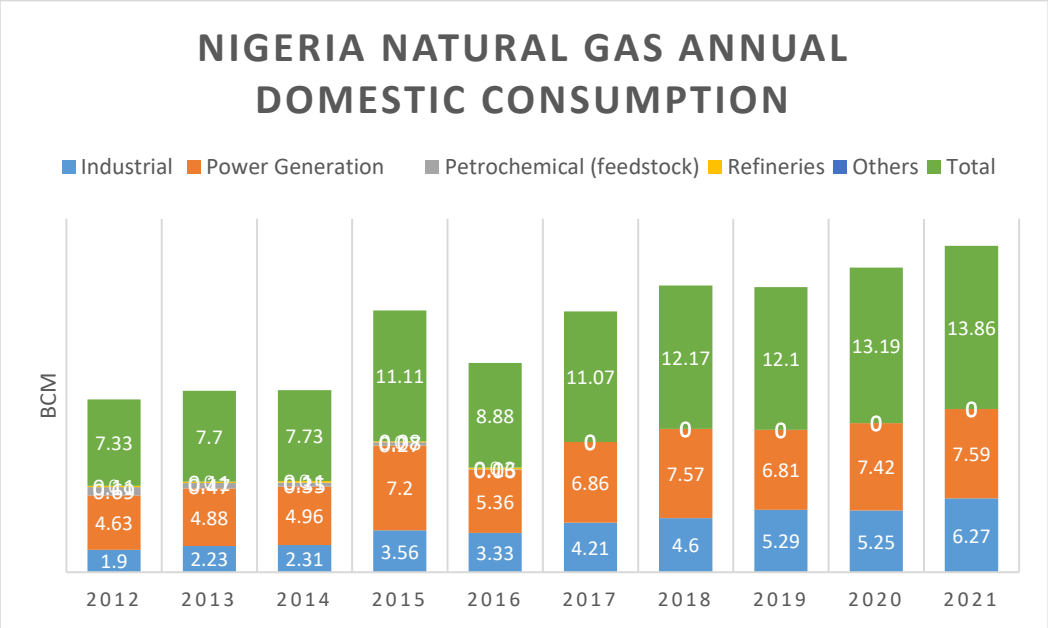

Figure 7:Nigeria Natural Gas Annual Domestic Consumption 2012-2021 (Source: GECF, 2022)

Global Gas Demand Projection

Natural gas is anticipated to become the prevalent fossil fuel by 2050, in view of its status as the purest fossil fuel, once merged with Carbon Capture Utilization and Storage and methane reduction technologies (International Energy Agency, 2020). Improved demand for hydrogen in the energy sector is likewise anticipated to improve the position of natural gas. This GECF (2021) predicts that international production of natural gas will remain rising by an annual average expansion rate of 1.2%, from about 3840 bcm in 2020 to 5625 bcm in 2050. The IEA (2022) also predicts natural gas production to grow steadily along with renewables at the expense of coal and oil by 2050 as depicted in Figure 9.

Natural gas is Africa's major prospect, not just as an evolution fuel to a green nation but likewise as an enduring solution for energy provision. The region is the fastest-growing area for production of natural gas. A great deal of this growth comes from developments in production for LNG exports in three ventures in Mozambique and Nigeria's LNG Train 7 project, in addition to the joint offshore development in Mauritania and Senegal, in addition to production from countries for instance Algeria and Egypt to back their local market development. Africa has augmented exploration undertakings in spite of a worldwide downturn in oil and gas investment and production.
GECF (2022) reckons gas production in Africa will rise by an average annual growth rate of 2.8% from around 230 bcm in 2020 to about 520 bcm in 2050.

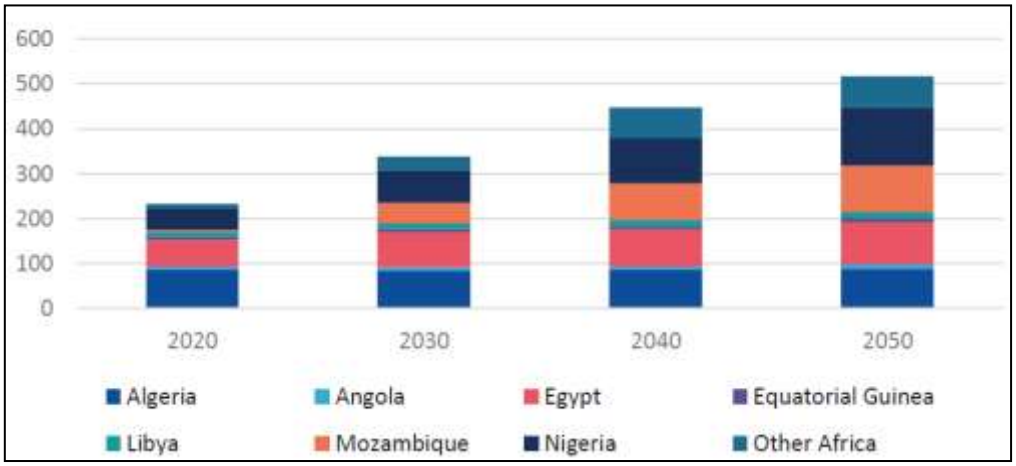

Figure 8:Outlook for Africa's natural gas production (bcm) (Source: GECF secretariat data, 2022)

The gas demand projection for domestic and export markets as shown in the Table 2 and other Gas Reserves Depletion Projections are based on the Aggregate Demand projection (GACN and NGC data) and current 2P National Gas Reserves (DPR's annual data book) respectively.

(i) The total gas demand grew from 6.2bscfd in 2016 to 13bscfd in 2020 and then to 15.0bscfd in 2035 (Table 2).

(ii) The demand appears to be relatively constant from 2021 when all the LNGs (except OKLNG that is currently in preservation mode and therefore its RFSU date not determined) are expected to have come on stream; the only increments are from Domestic Commercial Customers as shown in Table 2.

(iii) It is pertinent to note that domestic gas demand has been increasing steadily owing to the massive increase in power sector gas demand occasioned by the start-up of new power plants like Egbema NIPP (100mmscfd), Ebonyi IPP (400mmscfd), NNPC/ExxonMobil Power (110mmscfd), Azura Power (122mmscfd), etc.

(iv) In view of the above facts, it is proposed that Nigeria should arrange towards developing the power transmission networks to accommodate the projected growth in power generation.

(v) There is the need to review the data in collaboration with GACN on a quarterly basis to accommodate new requirements in the industry.

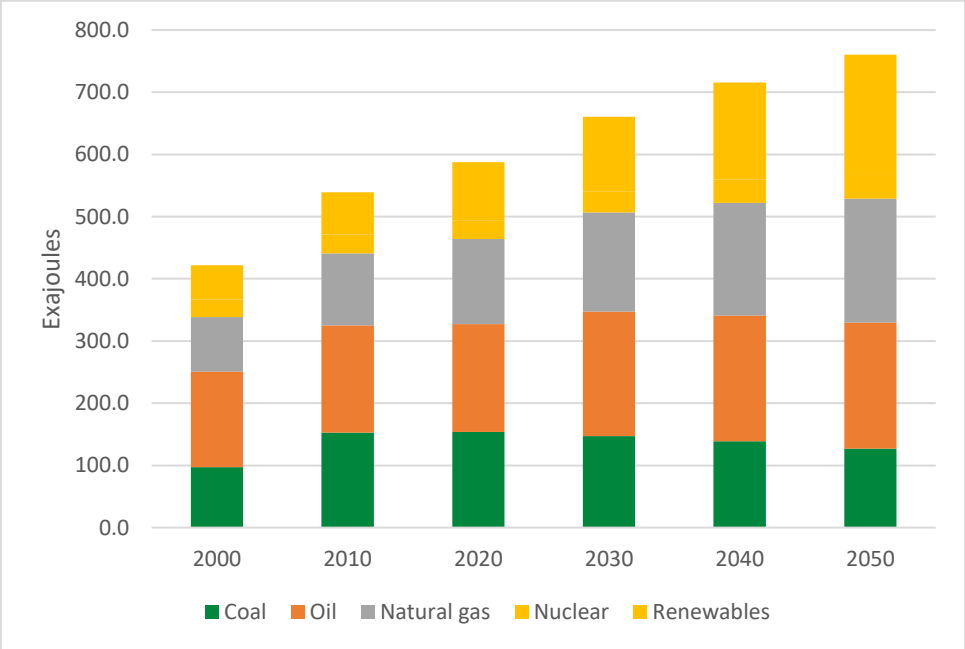

Figure 9: Total energy supply projections by source Net Zero by 2050 (Source: IEA, 2022)

Natural Gas Pipelines ventures in Nigeria

The Nigerian government's ambition to provide gas to consumers, improve the industrial sector in addition to being a key exporter has resulted to numerous new pipeline ventures. The gas sector in Nigeria is presently experiencing a major development, expanding from under 500 MMcf/d a few years ago to an anticipated capacity of over 5,000 MMcf/d by 2018 (National Petroleum Investment Management Services, 2022). This expansion has compelled a major overhaul of the current system and development of gas substructure. Gas Aggregation Company of Nigeria (2022)

suggested that the national pipeline gas design should be certified simply by the gas producers.

a) Western Gas Pipeline Network (WGPN)

The is primarily the Escravos-Lagos Pipeline System (ELPS) connected with the Oben – Ajaokuta Pipeline System which provides gas to the manufacturing districts of Lagos and the western area (National Petroleum Investment Management Services, 2022). The WGPN additionally supplies gas to the West African Gas Pipeline for distribution to bordering Gulf of Guinea nations. Numerous gas-fired power facilities are presently profiting from this continual provision of gas with additional extension being intended. Figure 10 shows the network of gas pipeline in the western region.

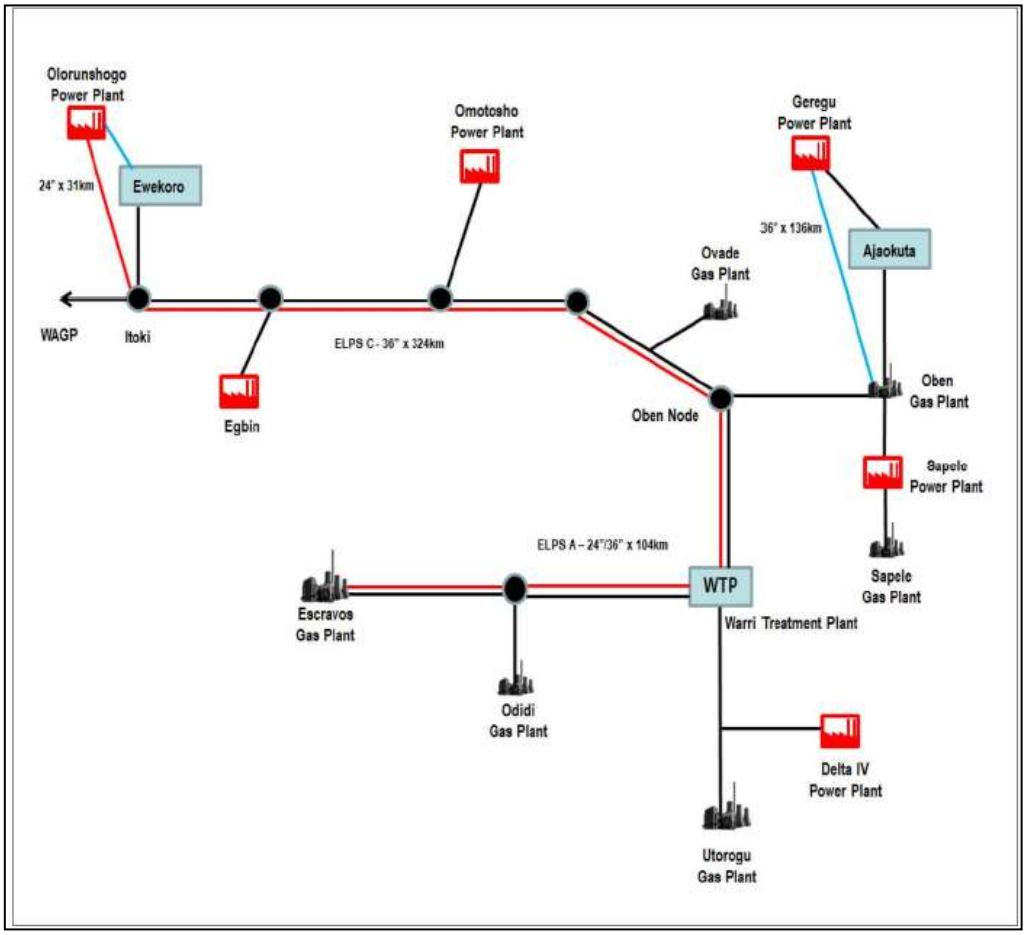

Figure 10:Schematic of the Western Gas Pipeline Network (Source: (Ige, 2013b)

Eastern Gas Pipeline Network (EGPN)

The National Petroleum Investment Management Services (2022) explained that the pipeline network in the eastern region involves some 812 Km with additional expansion intended, as shown by the schematic of this pipeline network (Figure 11).
The sections of the eastern gas pipeline delivery, which consist of the Qua Ibo/Calabar Ajaokuta Pipeline (CAP) system, are identified in Figure 12.

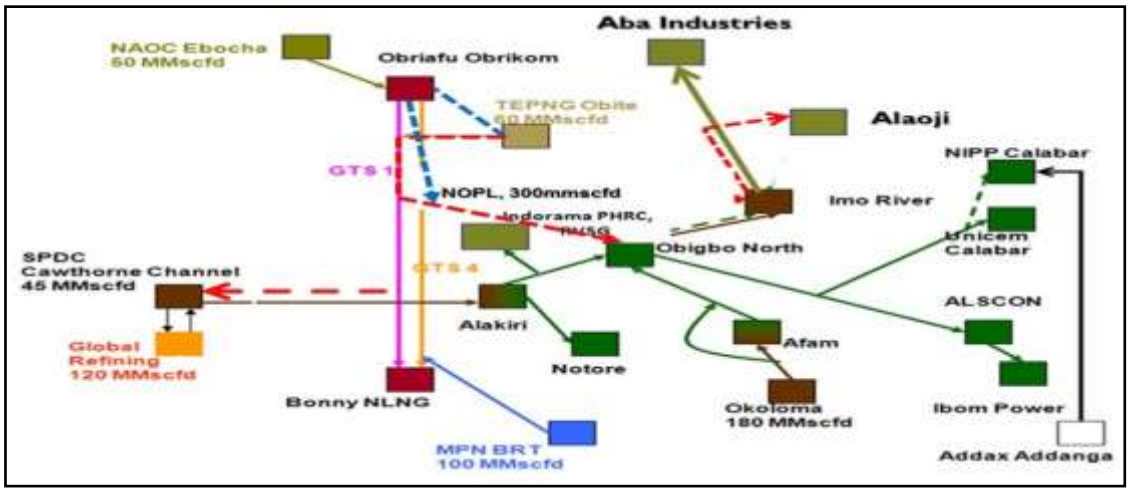

Figure 11:Schematic of Eastern Gas Pipeline Network (Source: Ige, 2013)

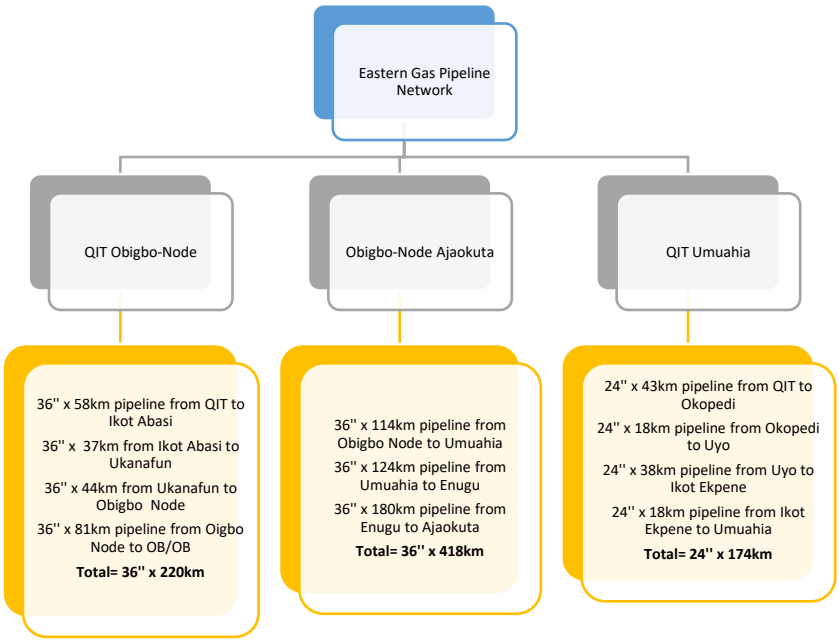

Figure 12:Eastern Gas Pipeline Network (Source: National Petroleum Investment Management Services, 2022)

East-North Gas Pipeline Network (E-NGPN)

This project is a vital element for expanding the gas network to the North and East of Nigeria, potentially extending it into the Sahara to expedite gas delivery to Europe. The total projected cost of the whole pipeline network is $5bn, and it is envisioned that it will be financed preferably, through an arrangement of loan and equity in a proportion of 60/40 (National Petroleum Investment Management Services, 2022). So as to secure this venture, a clear, secure pricing and monetary system for gas and power will be needed.

The planned northern pipeline system would possibly provide power, cement, and additional manufacturing sectors along its path and thereby accelerating employment and the local wealth. Northern gas pipeline network as envisaged by NNPC (2013) is composed of segments of the **Ajaokuta-Kaduna Kano (AKK) Pipeline** stretching a total length of 683 Km (Figure 5):

- 40" X 187 Km pipeline between Ajaokuta and Abuja
- 40" X 193 Km pipeline between Abuja and Kaduna
- 40" X 65 Km pipeline between Kaduna and Zaria
- 40" X 238 Km pipeline between Zaria and Kano

Figure 4 (a) and (b) illustrates the Trans-Nigeria gas pipeline venture which will be concluded in 3 stages. The first phase (in red) is the Planned East to North Gas Pipeline Network still to be completed.

Owing to the present gas reform proposed and now being executed by Nigeria, current industries which have been dysfunctional have been resuscitated, in addition to numerous novel companies which are being erected. Figure 12 identifies the critical gas pipeline infrastructure of Nigeria (current and in development).

West African Gas Pipeline (WAGP)

Nigeria commenced selling natural gas overseas via the WAGP in 2011, which is managed by the West African Gas Pipeline Company limited (WAPCO), and is mutually held by Chevron West African Gas Pipeline Limited (36.7%), Nigerian National Petroleum Corporation (25%), Shell Overseas Holdings Limited (18%), Takoradi Power Company Limited (16.3%), Societe Togolaise de Gaz (2%), and Societe BenGaz S.A. (2%) (U.S. Energy Information Administration, 2021).

The 678-kilometre WAGP (Figure 13) is connected to the current Escravos-Lagos line at the Nigeria Gas Company's Itoki Natural Gas Export Terminal in Nigeria and progresses to a
strategic position in Lagos from where it goes along an offshore channel at a mean water deepness of 35 meters ((WAGCo, 2022). From there it stretches to Takoradi, around Ghana, with gas supply laterals from the key line spreading to Cotonou, Lome and Tema (Ghana). The original capacity of 170 million standard cubic feet per day (MMscf/d) has been upheld and strategies are under way to expand volume to about 460 MMscf/d with the view of expanding the pipeline towards Ivory Coast at the west (US Energy Information Administration, 2012).

As stated by WAGPCO, 85% of the exported gas through this pipeline is utilized for power generation and the residual for industrial uses.

In recent years, WAGP has been unable to produce the projected volume of gas to its consumers owing to a number of factors such as: politics, policy, security, infrastructure, funding, unfavorable prices presented to gas suppliers etc. (Addeh, 2022).

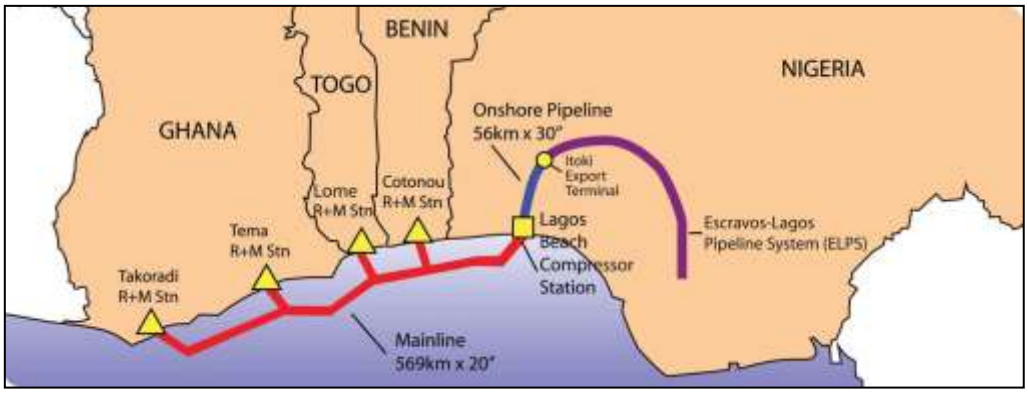

Figure 13:West African Gas Pipeline Schematic (Source: West African Gas Pipeline Company,2022)

Trans-Sahara Gas Pipeline (TSGP)

Nigeria and Algeria have continued to discuss the viability of constructing the TSGP for almost a decade. The proposed 2,500-mile or 4,500 km (Figure 5) pipeline would transport natural gas from oil fields in the Niger Delta region of Nigeria to Beni Saf export terminal Algeria for onward export to Europe (US Energy Information Administration, 2012). The pipeline and gas-gathering center's project's cost is estimated at $10 billion and $3 billion respectively, and would transport up to 30 billion

cubic feet/year of gas to Europe (Wikipedia, 2022). Several national and international companies (Total and Gazprom) have all indicated interest in the project.

Although certain setbacks like security challenges along the entire pipeline route, increasing costs, and on-going regulatory and political uncertainty in Nigeria continue to delay the project. It is unlikely to progress in the foreseeable future, but has potential to better secure Nigeria's long-term share of the growing European gas import market.

The aim of this venture is to provide gas to certain ECOWAS nations, pursuant to Nigeria's pledge to Article 48 of the ECOWAS Treaty, which urges member countries to co-operate, confer and co-ordinate their polities concerning energy and mineral reserves. A business group has also been established including Nigerian Gas Company (NGC), Ghana National Petroleum Corporation (GNPC), SOBEGAZ (Benin) and SOTOGAZ (Togo); and Chevron Nigeria Ltd. (CNL) and Shell Petroleum Development Company of Nigeria. (SPDC). A viability study was conducted and the report indicated that the WAGP was commercially and technically feasible. Talks are currently on-going with numerous potential buyers in the sub area which now include establishments in Senegal.

Off takers for AKK Project

A detailed analysis of existing potential off-takers from the AKK pipeline as well as planned and potential off-takers, including estimates of what their gas supply requirements over the next 15 years was carried out, including analysis of the following:

- Planned and potential power generation facilities that will be served by the AKK pipeline and any required gas feed pipelines coming off AKK e.g., Gencos, NIPPs and IPPs along and/or in proximity to the AKK route.
- Other planned or potential gas off-takers, including but not limited to fertiliser, petrochemical and agro -allied industries.

APPROACH AND METHODOLOGY

The methodologies employed in the development of this research and the tasks entailed the instituting of the policy context based on which the project was conceived and the business needs for the project. The needs analysis was a high-level review of the project's commercial rationale, and investigation of the demand for and desirability of the project. A technical scoping, describing the key technical parameters envisioned for the project was conducted. The research methods comprised carrying out interviews with key stake holders in the Nigerian Gas sector with responsibility for the development of AKK

Pipeline Project, and the review of pertinent documents such as journal papers, reports, and books.

APPLICATION, SUSTAINABILITY, JUSTIFICATION AND BENEFITS OF THE NIGERIAN AKK PROJECT

Project Sustainability

The proposed project is envisaged to be economically sustainable in view of the fact that natural gas that was traditionally flared at oil extraction sites for years has increasingly been recognized as an enormous income generating resource for Nigeria and now being captured for processing and sale both locally and internationally.

Economically, the project is sustainable because following successful completion, not much financial outlay will be required to sustain gas transmission. The Federal Government of Nigeria (FGN) has already approved new gas pricing and domestic supply obligation regulations. These regulations will ensure financial sustainability of the project as gas will be sold to customers: power plants, fertilizer industries, and for domestic use, etc., and profits accrued from the sales of the natural resources to maintain and operate the project.

Project Justification

Nigeria is a gas surplus nation, with gas reserve estimate of 193tscf, comprising 102tscf of associated gas (AG) and 86tscf of non–associated gas (NAG). In the last 40 years, since the start of active petroleum activities in Nigeria, about 23tscf of gas have been produced. The commercial demand of gas is about 0.33tscf of associated gas per year, which stands at about 1000mmscfd. LNG exports currently account for 40% of the quantity, while domestic users led by the power sector account for 60%.

Despite this endowment, Nigeria has remained a mono–cultural economy, dependent on the export of crude petroleum for over 90% of its export earnings. Associated and non-associated gas, which the country has in abundance, has historically been flared for no other reasons than inadequate critical infrastructures gas infrastructure, inappropriate/ unrealistic pricing of gas, low level of industrialization and inadequate consumptive capacities.

Table 3:Electricity generation using natural gas (Source: BP, 2021)

S/No	Country	Terra watt hour
1	USA	1693.8
2	Russian Federation	496.8
3	Japan	326.1

4	Iran	288.3
5	China	272.6
6	Saudi Arabia	215.9
7	Mexico	203.3
8	South Korea	176.4
9	Egypt	157.6
10	Italy	146.4
11	United Kingdom	124.2
12	United Arab Emirates	123.7
13	Thailand	113.1
14	Turkey	110.4
15	Taiwan	108.3
16	Argentina	93.3
17	Germany	89
18	Brazil	86.9
19	Canada	75.9
20	Spain	69.2
21	India	64.2
22	Malaysia	63.3
23	Netherlands	56.3
24	Indonesia	56.3
25	Australia	47.6
26	Kazakhstan	32.9
27	Vietnam	26.2
28	Nigeria	21.4
29	Poland	15.5
30	Ukraine	10.3

It is rather ironic that about 60% of associated gas is flared in a country where only 40% of Nigerians have access to electricity, while supply shortages are responsible for causing a 3% decrease in economic growth per year. Nigeria has vast reserves of petroleum and natural gas, and the potential to be one of Africa's richest nations. However, reliable power supply remains a challenge. With a population of 182.2million and an estimated GDP of $486.60 bn at Q12017, electricity generating capacity stands at slightly above 3500 MW. The average per capita electricity usage is 125 kWh. To put this into context,

Kenya has a population of 40.05million, a GDP of $64.4bn, average per-capita usage of 171 kWh, and installed capacity of 2299 MW. An even starker contrast is South Africa, with a population of 54.95 million and GDP of $360 billion, which has installed capacity of 40,000 MW and 4229kWH per capita.

Considering the deplorable energy situation in the country, the government plans to ensure that gas significantly contributes to the power sector target of generating 25,387MW by 2025. The plan includes an approval of a new gas pricing and domestic supply obligations regulation including: short-term, medium-term and long-term gas supply targets. One of the medium-term major domestic gas transmission systems is the first South - North gas transmission line that will take dry gas through Akwa Ibom/Calabar facilities to Ajaokuta, Abuja, Kaduna and Kano. The line will also serve the south-east states of Anambra, Abia, Ebonyi, Enugu and Imo.

The long-term target of the project is to supply gas to Europe through the TSGP. The TSGP will provide a golden opportunity for Nigeria to exploit her gas potentials and utilize its gas resources to enable her earn as much revenue from it as it is earning from oil. This project will enable Nigeria meet her nagging domestic gas utilization; eliminate gas flaring and in the long run help the nation meet worldwide greenhouse gases/climate change policy requirements.

In view of the above scenario, there is an obvious need for Nigeria to promptly harness its vast gas resources to:

i. increase its electricity generation;
ii. stimulate its comatose industries;
iii. increase domestic use of gas;
iv. augment its natural gas Exports.

The ongoing Ajaokuta-Abuja-Kaduna-Kano Gas Pipeline (Phase I) Project construction and operation is a further step within the government policy as it will help guarantee supplies network in the North and South of Nigeria and as well as reduce environmental impact associated with gas flaring.

Project Benefit

In keeping with the experience of other gas producing countries, Nigeria has the promise of have reaping enormous economic benefits from their gas industries, specifically in employment generation; as a catalyst to diversification into petrochemicals and other industries; wider job creation in the industry itself from upstream, midstream (gas transportation), and downstream local distribution companies; and taxation of profits

and of gas production. In particular, the project will open-up opportunities for construction of power plants in the north of the country and generally improve the power situation of the country. It is also expected to encourage the use of gas by existing cement, fertilizer and steel factories in the project area and stimulate the construction of new ones. The project will additionally expand the gas supply system in the North of the country to meet the growing gas and energy demands in the region. The project will open up new areas of opportunities in the project area thereby reducing gas flaring (by improving environmental and safety standards).

Specific sectors of the economy that will benefit directly for the project includes:

Power Sector: About 300mmscfd of gas goes into production of 65% of Nigeria's 111Kw/cap of electricity. It is anticipated that Nigeria's power needs will grow at an estimated 2.5% every 10 years. Hence, The AKK natural gas pipeline is envisioned to enhance Nigeria's power generation capacity by increasing 3,600MW of power to the national grid and deliver electricity to the northern region of the nation with delivery from the south. The project will open-up opportunities for construction of power plants in the north and generally improve the power situation of the country.

Cement Sector: Nigeria imports approximately 5% of her 6 million tons of cement per year requirements, the nation is the highest user of cement in Sub-Sahara Africa. It is anticipated that at 7% annual growth rate, cement imports can be eliminated. This will involve conversion of existing plants and addition of new ones.

The project will encourage the use of gas by existing cement factories in the project area and construction of new ones.

Fertilizer Sector: Nigeria with 13Kg/ha application has a total fertilizer consumption of about 800,000 metric tons per year and an anticipated growth rate of about 6-7% per annum. The project will encourage the construction of fertilizer plants in the project area, which will expand farming activities and reduce Nigeria food imports.

Steel Sector: Nigeria's steel demand currently stands at about 0.4 million tons per annum compared with the less than 1% capacity utilization of installed capacity of about 2.3 million tons per annum. Full recovery of the steel sector is expected to account for gas utilization increase. It is expected that this project will encourage investment in the construction of steel plants in the north.

Export and Other Projects: Other anticipated and planned key growth sectors are projected to involve gas utilization increase from the current 100mmscfd to 410mmscfd in the short term. Industry experts predict that export - oriented projects could grow to about 4000mmscfd in the short term. The expected revenue from export through the

TSGP will greatly improve the country's economy and project Nigeria to the competitive international gas market presently dominated by Qatar and Russia.

A pictorial representation of products and benefits accruable from the AKK project can be seen in Figure 14 below.

Figure 14:A global framework of the expected AKK based natural gas process extraction, utilization and conversion routes. Source:(Nwaoha, 2014)

Many of these routes for natural gas are being exploited and considered in Nigeria. However, because gas and oil resources in Nigeria are sweet there is little sulphur produced, the hot climate means that using gas for space heating is not necessary and industrial demand for hydrogen remains limited.

CONCLUSION

The worldwide populace is set to increase to 9.7 billion in 2050 which will form a growing pressure on demand for energy. The swiftest growth will be witnessed in Africa, where the inhabitants is projected to almost increase twofold to 2.5 billion by 2050. Virtually 70% of the entire populace in 2050 will reside in municipal environments,

indicating larger usage of electricity in final need in addition to demand for fuel supplies to power stations. This could have a favorable bearing on gas demand as a complement to enhanced renewable electricity. Given Nigeria's proven reserves is about 306.3 times its yearly consumption, it is projected that the nation has roughly 306 years of gas remaining, at present consumption rates. This should promote the application of natural gas in Nigeria by embarking on ventures such as the AKK pipeline project. The project is technically feasible and commercially viable, with a very strong liquidity position, sufficient to repay the principal and interest and still leave enough to adequately compensate the promoters. Furthermore, the venture would facilitate high value export following the supply deficit ensuing from the Russia-Ukraine unrest and aid European nations to wean themselves off Russian gas imports.

It is recognized that there is a worrying degree of social unrest in the North Eastern region. The Government of Nigeria is taking action with respect to the various dissident groups, and hopefully the present unrest in the area will be resolved before AKK Pipeline Project moves to the construction phase. During the same period, it is also to be hoped that personal security in the remainder of Nigeria will improve to the level where the gendarmerie or military will not be necessary to safeguard personnel, often isolated, who will be working in the field on the various pre-construction studies.

With regards the environmental concerns, there are established engineering and construction solutions to mitigate the temporary impact despite a pipeline in construction having a key, but transient impact. Following reinstatement, the impact of the pipeline is minor, the major lingering impact being exhaust emissions from gas compression stations, the effects of which will be minimized by improvements in gas combustion in the gas turbine drivers.

By and large, this project presents numerous benefits for Nigeria in terms of its economic revenues, its local industries and its populace. It would be feasible to accomplish this in a manner where all shareholders, including foreign stakeholders and export clients, share the returns fairly.

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LIST OF ABBREVIATIONS & ACRONYMS

AG	**Associated Gas**
AGI	Above Ground Installations
AKK	Ajaokuta – Kaduna – Kano
AMB	A.M. Best's Assessment of Economic, Political & Financial Risks
BT	Build and Transfer
BOT	Build, Operate and Transfer
Bscfd	Billion standard cubic feet per day
BVS	Block Valve Station
CAP	Calabar – Ajaokuta Pipeline
CAPEX	Capital Expenditures
CBN	Central Bank of Nigeria
CS	Compressor Station
CH_4	Methane
CRT	Country Risk Tier
DFBOT	Design, Finance, Build, Operate and Transfer
DFI	Development Finance Institution
DPR	Department of Petroleum Resources
DSCR	Debt Service Coverage Ratio
ECA	Export Credit Agency
EGP	Early Gas Phase
EIA	Environmental Impact Assessment
ELPS	Escravos Lagos Pipeline System
EMP	Environmental Management Plan
EPC	Engineering, Procurement and Construction
FEED	Front End Engineering and Design
E&P	Exploration and Production
EPCC	Engineering, Procurement, Construction and Commissioning
EPCIC	Engineering, Procurement, Construction, Installation and Commissioning
FAT	Factory Acceptance Test
FCT	Federal Capital Territory
FDF	Federal Department of Forestry
FEED	Front-End-Engineering Design
FMoEnv	Federal Ministry of Environment
FORMECU	Wildlife, Forestry Monitoring Evaluation and Coordinating Unit

FGN	Federal Government of Nigeria
FRIN	Forestry Research Institute of Nigeria
Genco	Electricity Power Generating Companies
GIS	Geographic Information System
HSE	Health, Safety and Environment
IOC	International Oil Companies
IPS	Intermediate Pigging Station
IRR	Internal Rate of Return
IMF	International Monetary Fund
IPP	Independent Power Producer
LBV	Line Break Valve
LIBOR	London Interbank Offer Rate
LLCR	Loan Life Coverage Ratio
LNG	Liquefied Natural Gas
MDA	Ministry, Departments and Agencies
mmcf	Million standard cubic feet
Mmscfd	Million standard cubic feet per day
Mn	Million
MoF	Ministry of Finance
NGL	Natural Gas Liquids
NGMP	Nigerian Gas Master Plan
NIPP	National Integrated Power Project
NNPC	Nigeria National Petroleum Corporation
NPV	Net Present Value
NAG	Non-Associated Gas
NAICOM	National Insurance Commission
NTB	NNPC Tenders Board
NDT	Non-Destructive Testing
OB/OB	Obiafu/Obrikom
OB3	Obiafu/Obrikom to Oben
OBC	Outline Business Case
OPEX	Operating Expenditures
PPMC	Pipelines and Products Marketing Company
PRG	Partial Risk Guarantee
PRMS	Pressure Reduction and Metering Station
PSC	Production Sharing Contract
psig	Pounds per square inch gauge
2P	Proved and Probable Reserves
3P	Proven, Probably and Possible Reserves
PAP	Project Affected Persons
ROW	Right of Way
tscf	Trillion standard cubic feet
tscfd	Trillion standard cubic feet per day
WAGP	West Africa Gas Pipeline
QIT	Qua Iboe Terminal
SCADA	Supervisory Control And Data Acquisition
SIA	Social Impact Assessment
TNGP	Trans-Nigerian Gas Pipeline

TSG	Terminal Gas Stations
TSGP	Trans-Saharan Gas Pipeline