



GAS PIPELINES IN NIGERIA: SINE QUA NON FOR ECONOMIC DEVELOPMENT

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Abstract:

The study reviewed the gas pipeline development in Nigeria and outlines needed strategies needed for sustainable development of gas pipeline for socio-economic development in Nigeria. There is inefficient gas pipeline development framework in Nigeria, based on the existing monopoly of the Nigerian Gas Processing and Transportation Company Limited (NGPTC) managing 1,500 to 2,000 km of gas pipeline all over Nigeria, while this is grossly inadequate to meet the domestic supply obligation. Extensive review of related literature was employed to obtain relevant data and information on the Nigerian gas pipeline. The study shows that gas pipeline is inadequate and additional 5,000km is required to meet the short and medium need, while about 10,000km gas pipeline will be needed in the long run. The study further revealed that gas is major source of revenue as N72.7 billion was generated from between 2017 and 2018. The study also reviewed the eight (8) critical gas infrastructures identified by the federal government of Nigeria, of which Obiafu-Obrikom-Oben (OB3) Pipeline Project and Ajaokuta-Kaduna-Kano (AKK) Pipeline Project has the final investment decision taken and are at construction and detailed engineering phase respectively. The proposed strategy to enhance gas pipelines development in Nigeria should be private sector driven and divestment of all existing gas pipeline infrastructure to private investors in order to ensure sustainable management that would increase the Gross Domestic Product (GDP), create employment and provide access to relatively clean energy. There is also need to have a gas pipeline transmission and distribution act that would stipulate the minimum requirement for gas pipeline investment in Nigeria.

Keywords: Gas Pipeline; Gross Domestic Product; Transmission and Distribution; Sustainable Development; Economic Development; Domestic Supply Obligation.

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1. Introduction

There is inefficient gas pipeline development framework in Nigeria, as the existing pipelines (transmission and distribution) have been solely managed by the federal government, through its agencies and parasatals, which includes : Nigerian Gas Processing and Transportation Company Limited (NGPTC), Nigeria Gas Marketing Company Limited (NGMC) and Department of Petroleum Resources (DPR) and they are in control of approximately 1,500 to 2,000 km of gas pipelines all over Nigeria, with limited or negligible private sector participation and this has

resulted to having inadequate domestic gas supply obligation, because the pipeline infrastructures are not enough to meet the local demand of natural gas (Department of Petroleum Resource Annual Report, 2017). According to DPR (2017), the Nigerian national pipeline capacity for the year, 2018 is 2.9 bscf/d with 2.0 bscf/d for the western region axis and 0.9 bscf/d for eastern region axis and this is relatively small to support economic development in Nigeria. While, according to the National Gas Policy (2017), there are proposed gas pipeline network, but the economics and commercial framework for this proposed pipeline network are still vague and need to be modeled for economic development from conceptual stage to operations, considering the Nigerian socio – economic conditions and long term framework, that would generate revenue to the Nigerian government and create positive economic multiplier effect such as increase in direct and indirect employment. The existing spread of gas pipelines is categorized into northern region, western region and eastern region. Figure 1.0 shows the gas pipeline network within the northern region of Nigeria and this clearly shows lack of gas pipelines within this region.



Figure 1.0: Northern Region Gas Pipeline Network

Source: Nigerian Gas Processing and Transportation Company (2017)

While figure 1.1 shows the western and eastern region gas pipeline network indicating the inadequacy of the existing gas pipeline network, though as the region with relatively more gas pipeline network and this is still inadequate to meet the demand or domestic supply obligation as there no gas distribution network within any major city or town in this region of Nigeria.

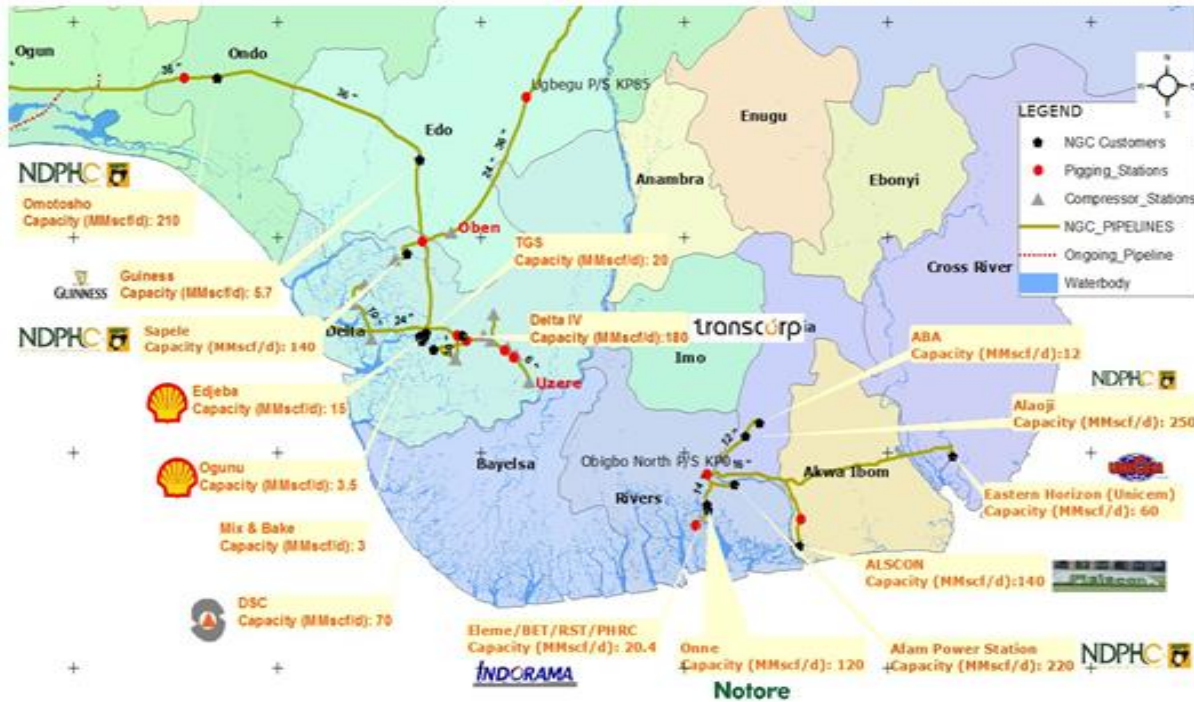


Figure 1.1: Western and Eastern Region Gas Pipeline Network

Source: Nigerian Gas Processing and Transportation Company (2017)

The Nigerian gas pipeline economics, planning and commercial framework is relatively very poor. There is no existing gas pipeline transmission system with an effective commercial frame work to encourage private investors to competitively build gas pipeline infrastructures that would create economic benefit in terms of boosting revenue to the government, improved direct and indirect employment for the growing population of over 180 million people. The existing economics and commercial framework for the Ajaokuta-Kaduna-Kano (AKK), 614Km gas pipeline that is being developed by the Nigerian National Petroleum Corporation (NNPC) and financed by the Chinese partners, has not created any economic framework and benefit such as massive employment for young and experience engineers, technologist and artisans from Nigeria due to poor gas pipeline economics and planning.

There is no policy framework enacted by the federal government of Nigeria on gas pipeline transportation (gathering, transmission and distribution) that would support effective management of gas production and utilization for economic development in Nigeria. The existing framework includes the following Acts, Plan and Policy documents:

- 1) Petroleum Act (1969)
- 2) Oil Pipeline Act (1965)
- 3) Guidelines for the Construction, Operation and Maintenance of Oil and Gas Pipelines and their ancilliary facilities
- 4) Gas Master Plan (2008) – There is no formal document on the gas master plan.
- 5) National Gas Policy (2017)

The aforementioned documents did not set out the framework for sustainable gas pipeline infrastructure in Nigeria. As a result of these problems, Nigeria has increasingly become a mono

economy, that is highly dependent on crude oil exports with poor attention to gas development using pipeline transportation.

Natural gas is a major contributor to the Gross Domestic Product (GDP) of many countries and it is employing thousands of people, generating millions of dollars in revenue and tax income. Natural gas is produced from the ground in large volume in order to be economically viable and from an international or global perspective; it is projected that \$231 billion would be added to the United States of America economic performance in 2035 from the gas industry, while according to DPR (2017) Nigeria loses \$10 billion due to gas flaring at the rate of \$2.00 per MMBtu (www.igu.org/natural-gas-powers-economic-growth).

NMA (2016) states that typically, natural gas plays key role in manufacturing industries in many developed economies and the transmission pipeline is required to move the natural gas to the market; United States of America spent 25.8 billion in year 2015 for the construction of 6,028 miles (9701.13 Km) of natural gas transmission pipelines with creation of 347,788 jobs while according to DPR (2017) about \$3.5 billion worth of inward investment is required to achieve the gas flare target by 2020 in Nigeria with projection of 300,000 associated jobs to be created. Gas production and utilization has been struggling to meet with domestic gas supply obligation due to lack of critical gas infrastructure, which is the pipeline and presently, there is a daily average domestic gas supply performance of 41% resulting from 1065.58 MMscfd supplied to the domestic market by eleven companies(DPR,2017).

Derefaka (2018) posits that Nigeria loses approximately \$1 billion of revenue through gas flaring, due to its inability to capture and commercialise flared gas in the country. He further stated that if flared gas is properly exploited, it has the potential to create 300,000 jobs, produce 600,000 MT of LPG per year and generate 2.5 GW of power from new and existing IPPs, as approximately 700mmscf/d is flared at 178 flare sites in Nigeria. Diugwu et al (2013) examined the relationship of gas production, utilization and flaring on economic growth of Nigeria using the classical Cobb-Douglas production, which posited that gas has a negative effect on the economic growth and that gas production is insignificant to economic growth in Nigeria ; However, Oduyoye et al (2013), explained that there is no casuality between natural gas composition and Gross Domestic Product (GDP) in the short run and posits that Nigeria has not been able to tap her natural gas due to poor infrastructure and as a result most of the gas are been flared.

The purpose of this study is to review the gas pipeline infrastructure development in Nigeria and to outline necessary strategies needed for sustainable development of gas pipeline for socio-economic development in Nigeria.

This study is significant because, natural gas is a resource that is more abundant and widely spread and this implies that it is more diversified than oil in terms of availability and this diversified gas should ensure better security of supply (BP Statistics, 2017).

Secondly, natural gas is making significant contribution to the world energy economy, because it is the cleanest of all fossil-based fuels, as natural gas emits 56.1 tCO₂ per TJ while the emissions from oil and coal are 73.3 tCO₂ and 94.6 tCO₂ respectively according to Subhes (2011). According to World Energy Council (2013), Natural gas emits 30% less CO₂ compared to oil and almost 70%

less compared to coal for an equivalent amount of energy; Therefore as the reduction of greenhouse is expected to gain momentum in the future, natural gas will surely strengthen its position and be a necessity for gas based industrialization and basis for sustainable economic development.

Therefore, the aim of this study is to outline economic strategies for the development of gas pipelines necessary for sustainable economic development in Nigeria.

2. Materials and Methods

The study adopts extensive literature and analytical framework model to determine the strategies necessary for gas pipeline and these include the following steps:

- 1) Extensive review of gas pipeline development in Nigeria
- 2) Review of the Nigeria critical gas pipeline infrastructure

The analytical framework involves extensive review and research deductions. The analytical framework steps include the following:

- Analysis of the gas pipeline developments in Nigeria
- Analysis of the critical gas pipeline infrastructures in Nigeria

The major sources of data in this study include the following:

- 1) Department of Petroleum Resource Annual Reports
- 2) Gas Aggregation Company of Nigeria (www.gacn.com)
- 3) Nigerian National Gas Policy (2017)

3. Results and Discussions

3.1. Gas Pipelines Development in Nigeria

Gas pipelines have been developed by the Nigerian National Petroleum Corporation (NNPC) through its strategic business unit; Nigerian Gas Transportation and Processing Company (NGTPC), formally Nigerian Gas Company (NGC), with varying economic models and frameworks, while the regulations of the gas pipeline is by Department of Petroleum Resource (DPR) (www.nnpc.com).

According to Adamu and Darma (2017), there have been gas pipelines in Nigeria as early as 1960, but this is not sufficient to deliver to the power stations, industries and other consumers with about 2000 km network of gas pipelines currently operating in Nigeria. There is gas pipeline inadequacy in Nigeria with about 5,000 km required. Nigeria gas to electricity sector comprises about a 1,000 km of pipelines and to meet the required demand, Nigeria needs about 10,000km of gas pipelines (www.greendeaalnigeria.org). However, according to Ndukwe (2007), the historical development of gas pipeline and utilization in Nigeria is as follows:

- 1956, First oil and gas discovery
- 1958, First commercial exploitation of oil
- 1963-1968, first non – commercial use of gas by SPDC to ECN Afam, Delta PPs and Aba industries

- 1978, NNPC/SPDC built 1st transmission pipeline (Ogorode – Sapele) to supply ECN Sapele
- 1981-83, NNPC built pipeline to supply steel companies at Aladja and Ajaokuta
- 1987, NGC built pipeline to supply NAFCON (Now Notore) Onne fertilizer
- 1988, NGC established to transport and market gas in Nigeria and West Africa sub-region.
- 1989, Escravos – Lagos gas pipeline system (ELPS) was built
- 1999, NLNG export commenced
- 2000, Gas distribution to industries in Lagos commenced
- 2004, Final Investment Decision (FID) on first export pipeline (WAGP)
- 2005, The electricity sector reformed by Act of Parliament
- 2005, New LNG programmes at advanced stages (Brass, OK etc)
- FID for first commercial GTL plant by Chevron Nigeria Limited
- 2006 Increased in-country capacity for cement-Obajana commenced operation
- According to National Gas Policy (2017), the identified critical gas infrastructures in Nigeria necessary to support efficient and stable gas demand and supply projected to support economic development includes:
 - 1) Aba-Owerri-Nnewi-Onitsha Pipeline Project
 - 2) Calabar-Ajaokuta Pipeline (CAP) Project
 - 3) Ajaokuta-Kaduna-Kano (AKK) Pipeline Project
 - 4) ELP-Ibadan-Jebba Pipeline Project
 - 5) Obiafu-Obrikom-Oben (OB3) Pipeline Project
 - 6) Expansion of ELP Phase 2 Project
 - 7) Oso Platform to QIT Pipeline Project
 - 8) Erha / Bosi Pipeline Project

In terms of revenue generation from gas transmission and distribution as reported by Nigerian National Petroleum Corporation in year 2018 (reported on 8th July, 2018), it states that the year under review yielded a total revenue from gas transmitted is N72.7billion translating to 292.91 billion standard cubic feet of gas as against the planned 429.92bscf thereby achieving 68 .13 percent of its target, Profit before tax was N6.75billion while profit after tax came to N6.11 billion within the period (www.nnpc.com).

Generally, pipelines are part of the core infrastructure in the value chain of gas industry and pipelines are piping that transport fluids between offshore production facilities or between a platform and a shore facility; Pipeline can be sub-classified into three categories of flowlines, Injection lines and export lines (API 1111, 2009). According to Engineering Science (2006), pipelines transport liquid petroleum products from one point to another and there are generally three types of pipelines namely; Gathering lines, Feeder lines and Transmission lines.

Gas pipelines are usually designed and manufactured in accordance to the American Petroleum Institute (API) standards and they are classified by grades; the grade of the pipeline denotes the thickness of the internal thickness of the pipelines that has been designed and manufactured to prevent internal corrosion and operational stresses during the design life of the pipeline. The wall thickness of the pipeline takes into consideration the effect of internal corrosion of the pipeline due to the service or process fluid.

Wall thickness formula as per ASME B31.8 for gas pipes is shown as follows:

$$P_{(MAWP)} = \frac{2S(t-c)}{D} FET \quad (3.1.1)$$

$$t_{(min)} = \frac{PD_{(DESIGN)}}{2SFET} + c \quad (3.1.2)$$

S = Specified Minimum Yield Strength, psi

t = nominal wall thickness of pipe, in.

D = nominal outside diameter of pipe, in.

F = design factor,

E = longitudinal joint factor,

T = temperature derating factor,

c = corrosion allowance, in.

P = design pressure or MAWP, psig

3.1.1. Gas Pipeline Projects in Nigeria

The Infrastructure blue print for the Gas Master Plan (GMP), which mapped out the planned gas pipeline infrastructure needed including; connecting the gas networks in the western and eastern parts of the country, building new pipelines from the south to Ajaokuta, and to Abuja and then to the northern part of the country. The first part of the infrastructure required the construction of Central Processing Facilities (CPFs) in the Niger Delta region to process wet gas supply to onshore gas transportation networks and industrial plants and further to the Gas Master Plan, about 590km of gas pipelines have been completed and commissioned and these pipelines include the following :

- Oben – Geregu (196km)
- Expansion of Escravos -Warri-Oben (110km)
- Emuren-Itoki (50km)
- Itoki – Olorunshogo (31km)
- Imo River – Alaoji (24km)
- Ukanafun-Calabar (128km)
- NOPL (50km)

With these projects, it is expected that all the available power projects in Nigeria are connected to permanent gas supply pipelines (www.nnpc.com).

3.1.1.1. The West African Gas Pipeline Project

The west african gas pipeline project objective is to supply gas to some Economic Community of West African States (ECOWAS) countries, as a result of Nigeria's commitment to Article 48 of the ECOWAS treaty, which encourages member nations to co-operate, consult and co-ordinate their policies regarding energy and mineral resources. The governments of Nigeria, Ghana, Benin and Togo, through their ministries and departments responsible for energy matters, signed Heads

of Agreements (HOA) in 1995, to provide a framework of the project and project Implementation Committee to monitor the development of the project.

A commercial group comprising Nigerian Gas Company (NGC) and now Nigerian Gas Processing and Transportation Company (NGPTC), Ghana National Petroleum Corporation (GNPC), SOBEGAZ (Benin), SOTOGAZ (Togo), Chevron Nigeria Limited (CNL) and Shell Petroleum Development Company (SPDC) are involved in the gas sales supply arrangement (www.napims.com).

According to www.wagpco.com, The West African Gas Pipeline Company limited (WAPCo) is a limited liability company that owns and operates the Pipeline. The headquarters is in Accra, Ghana, with an office in Badagry, Nigeria, and field offices in Cotonou - Benin, Lome - Togo, Tema and Takoradi, both in Ghana. It is owned by Chevron West African Gas Pipeline Ltd (36.9%), Nigerian National Petroleum Corporation (24.9%), Shell Overseas Holdings Limited (17.9%), and Takoradi Power Company Limited (16.3%), Societe Togolaise de Gaz (2%) and Societe BenGaz S.A. (2%).

WAPCo Pipeline System

According to www.wagpco.com, WAPCo pipeline system is a 678 kilometer that links the existing Escravos-Lagos pipeline at the Nigeria Gas Company's at Itoki natural gas export terminal in Nigeria and proceeds to a beachhead in Lagos. From there, it moves offshore to Takoradi, in Ghana, with gas delivery laterals from the main line extending to Cotonou (Benin), Lome (Togo) and Tema (Ghana). The Escravos-Lagos pipeline system has a capacity of 800 MMscfd, and the WAPCo system will initially carry a volume of 170MMscfd and peak over time at a capacity of 460MMscfd.

The main offshore pipeline runs from east to west at an average water depth of 35 metres through some sections such as the south east of Ghana, south of Lome and the Benin – Nigerian frontier ranges between 50 to 70 meters. 20 inches pipeline is the main line, while Cotonou and Lome laterals are 8 inches respectively, Tema lateral is 18 inches. The termination point at Takoradi (Aboadzi) forms part of the main pipeline.

The pipeline transports purified natural gas free of heavy hydrocarbons, liquids and water; this is ideally suited as fuel for power plants and industrial applications. Eighty-five per cent (85%) of the gas is for power generation and the remaining for industrial applications. The customer / off-takers includes: the Volta River Authority's Takoradi Thermal Power Plant in Ghana, CEB of Benin and Togo.

3.1.1.2. Trans-Sahara Gas Pipeline (TSGP)

The Trans Saharan gas pipeline project (also known as the Algeria-Nigeria Gas Pipeline Project) is a planned investment of about \$20.0billion. The Project is planned when completed that it will transport up to 30 billion cubic metres of natural gas from Warri (Nigeria) through Niger Republic to Algeria on an annual basis. The aim of the project is to diversify gas supplies to Europe. The pipeline will be built and operated by the partnership of the Nigerian National Petroleum Corporation (NNPC) and Sonatrach. The NNPC and Sonatrach will hold a total of 90 per cent

equity shares, while Niger Republic would hold 10 per cent. The total length involved is 4128 kilometers (2565 miles) with the Nigerian section being 1,037 kilometers (644 miles), kilometers (523 miles) and 2,310 kilometers (1440 miles) in Algeria. The French Total Oil Company and Russian Gazprom are interested in participating in the project. This is expected to cost about \$12 billion for the pipeline and \$3 billion for the gathering centres. The benefits derivable from the project by Africa and Europe are enormous. First, it will contribute to the export diversification drive of the Federal Government of Nigeria (FGN). Secondly, it means an opportunity for closer cooperation, integration and a significant income for the transit countries such as Niger, Burkina Faso and Mali as well as Algeria.

3.2. Gas Pipeline Economics in Nigeria

Nwaozuzu (2018) states that typical natural gas pipeline construction costs vary between US\$ 800,000 per km to US\$ 2 million per km (for large diameter projects over rugged terrain) while a typical LNG project may require more than US\$10 billion of investment and lead time of 6-10 years from conception to completion. LNG tanker ships cost about US\$200 million. The cost associated with gas pipeline construction from global perspective is noted in this study, considering the fact that gas is a global commodity and the pipeline are designed to international standard such as American Petroleum Institute, National Association of Corrosion Engineer etc., while the typical cost associated with gas pipeline projects includes the following :

- 1) 24 inch Yucatan Peninsula gas pipelines, completed in 1999 and running 432 miles from the Mexican State of Tabasco to power plants in the Yucatan province cost US\$266 million.
- 2) 460 km line completed in 1996, from La Mora in Argentina to Santiago in Chile cost US\$360 million.
- 3) The 3,700 km pipeline from Bolivia to Sao Paulo in Brazil cost US\$1.8 billion.

While according to www.nnpc.com, the NNPC is currently developing the Ajoakuta-Kaduna-Kano (AKK) 614km pipeline and it is fully contractor financed economic model involving the Chinese Corporation, with 85 per cent of the money is expected to be funded by Industrial and Commercial Bank of China (ICBC), Bank of China, and Infrastructure Bank of China with Sinosure, China's Export Credit Agency (ECA) providing insurance cover, the remaining 15 per cent will be provided by the contractors which include Oilserve/Oando consortium, as well as Brentex/China Petroleum Pipeline (CPP) Bureau consortium and this project to bring \$3billion foreign direct investment into Nigeria, The project is currently at detailed engineering phase with The engineering, procurement and construction (EPC) contract for phase one was awarded to OilServe / Oando consortium in April 2018. The Brentex / China Petroleum Pipeline Bureau (CPP) consortium was awarded the EPC contract for phase three. According to www.hydrocarbons-technology.com, the pipeline is to originate from Ajoakuta and pass through Abuja and Kaduna and end at terminal gas station in Kano. The project will be executed in three phases, with phase one covering the construction of a 200km-long segment between Ajoakuta and Abuja Terminal Gas Station at a cost of \$855m. Phase two will comprise a 193km-long section to be built between Abuja and Kaduna at a cost of approximately \$835m, while Phase three will involve the construction of a 221km-long section between the Kaduna terminal gas station (TGS) and Kano TGS. This section will cost an estimated \$1.2bn to complete. Other infrastructure planned for the development includes various associated valve stations, as well as intermediate and terminal

facilities. The natural gas pipeline is expected to require the laying of 40in-diameter pipes featuring a total combined weight of 240,768t. Furthermore; the project will utilize 24in-diameter steel line pipes for spur lines, as well as 40in-diameter line break valves and future tie-in valves.

The multi-million dollar (the project was estimated to cost over \$400 million) OB3 gas pipeline is expected to increase domestic gas supply by two billion standard cubic feet per day (bscf/d) when it begins operation later in the year (www.thenationonline.net).

The west african gas pipeline construction and operations obtained financial guarantees of the World Bank. The total project cost is US\$974 million, out of which The World Bank guarantee for Ghana was \$80 million while the Multilateral Investment Guarantee Agency (MIGA) provided a \$75 million political risk guarantee for the West African Gas Pipeline Company which is set up to build, own and operate the pipeline. Plans are in the offing to extend the gas supply to Abidjan (Dami, 2012).

Herein below is a list of contract signed to enhance gas production and maximize economic gain:

1. The Tran-Sahara Gas Pipeline: 30 billion cubic meters capacity per year using 48 to 56 inches to be routed from Nigeria to Algeria and this would eventually serve other European countries on the long run. The pipeline will be connected to the Trans-Mediterranean, Maghreb-Europe, Medgaz and Galsi pipeline, which shall supply the gas to European countries

Pipeline Length = 4,128km (1,037km-Nigeria, 841km-Niger, and 2,310km-Algeria)

Business interest (Nigeria -45%, Algeria-45% and Niger Rebulic-10%)

According to Nwaozuzu (2017), there is waste of natural gas because of transportation difficulties, and this is a problem, because of the huge cost associated with engineering, procurement and installation of natural gas pipelines; it cost about 4-5 times as much to transport gas over land by pipeline compared to the cost of transporting oil. Nigeria as a gas producing nation lacks the pipeline infrastructure for domestic, regional and global market. The transportation cost of natural gas is a major factor driving the natural gas economics and it denoted by economics of scale as the higher the volumes, the lower the unit cost of delivery.

However, Nigeria needs about 10,000 km of gas pipelines to meet its power need and this would results to approximately to about \$1.2 per kilometer in terms of cost (www.greendealnigeria.org).

According to NNPC News, Vol 15, No 18 (2019), Nigerian National Petroleum Corporation (NNPC) is working to have Nigeria – Morocco gas pipeline that would be linked up with the existing Maghreb-Europe gas pipeline in northern Morocco to supply gas from Nigeria to Europe. The feasibility study has been concluded, while the Pre-FEED (Front End Engineering Design). The pipeline would transverse about fifteen (15) west african countries with intake and offtake parts in various countries.

3.2.1. Gas Transportation Tariff

According to National Petroleum Fiscal Policy (2016), a gas transportation tariff of \$0.8MMSCF has been approved by the Ministry of Petroleum, through the 2008 national gas supply and pricing

regulations. The applicable cap to gas transportation tariff shall be calculated and adjusted in accordance with the following formula:

$$CP = PP \times CPI_p / CPI_{p-1} \quad (3.2.1)$$

Where:

CP = Contract Price

PP = Producer Price

CPI = Consumer Price Index

4. Conclusion and Recommendation

Based on this study, there is need to privatize new gas pipeline investment and divest all existing gas pipeline to private investors in order to ensure sustainable management. The current gas pipeline operators in Nigeria is the Nigeria National Petroleum Corporation (NNPC) through its subsidiary Nigerian Gas Processing and Transportation. With Private sector participation, it will break the monopoly of the NNPC and bring foreign direct investment that would create competitive market gas pipeline. The positive economic impact of the full private sectors participation includes the following:

- 1) Increase in the Gross Domestic Product to Nigeria
- 2) Increase of gas pipeline infrastructure in across the country will generate over 5,000km of gas pipeline transmission and distribution network.
- 3) Increase in employment to tune of over 500 employed per year
- 4) Technology transfer from the use of modern gas pipeline
- 5) It would create access to the use of clean energy

Secondly there is need to have gas pipeline transmission and distribution policy, that would be rectified into an act by the parliament (the senate and house of representatives); The gas pipeline act shall stipulate the following as a minimum:

- 1) There shall be single regulatory body for gas pipeline in Nigeria
- 2) It shall contain clause to protect the foreign direct investors
- 3) It shall contain clauses on taxation accruable to the government
- 4) It shall the minimum requirement in terms of equity and debt ownership of the gas pipeline operating companies.
- 5) It shall provide relevant clause of local content employment to protect Nigerian, boost employment and gross domestic product.

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Appendices

Appendix A: Table 1.0: Nigeria gas pipeline specification

National Gas Specification			
1. Composition		Min	Max
	Hydrocarbon Dewpoint	-	10 ⁰ C (50 ⁰ F)
	Water content	-	75lbs/MMScf
	Methane (C ₁)	85%	95% by volume
	Ethane (C ₂)	0	10% by volume
	Propane (C ₃)	0	8% by volume
	Butane + Paraffin (C ₄ +))	-	5% by volume
	H ₂ S	-	4 ppm by volume
	Total Sulphur	-	28 ppm by volume
	CO ₂	-	4% by volume
	N ₂	-	3% by volume
	O ₂	-	10 ppm by volume
2. Heating Value			
	Higher Heating Value	1000	1150 Btu per scf
	Wobbe Index (HHV basis)	47	52
3. Delivery Temperature			
	Recipient Temperature	10 ⁰ C (50 ⁰ F)	49 ⁰ C (120 ⁰ F)

Source: Gas Aggregation Company of Nigeria/www. gacn.com (2018)

Appendix B

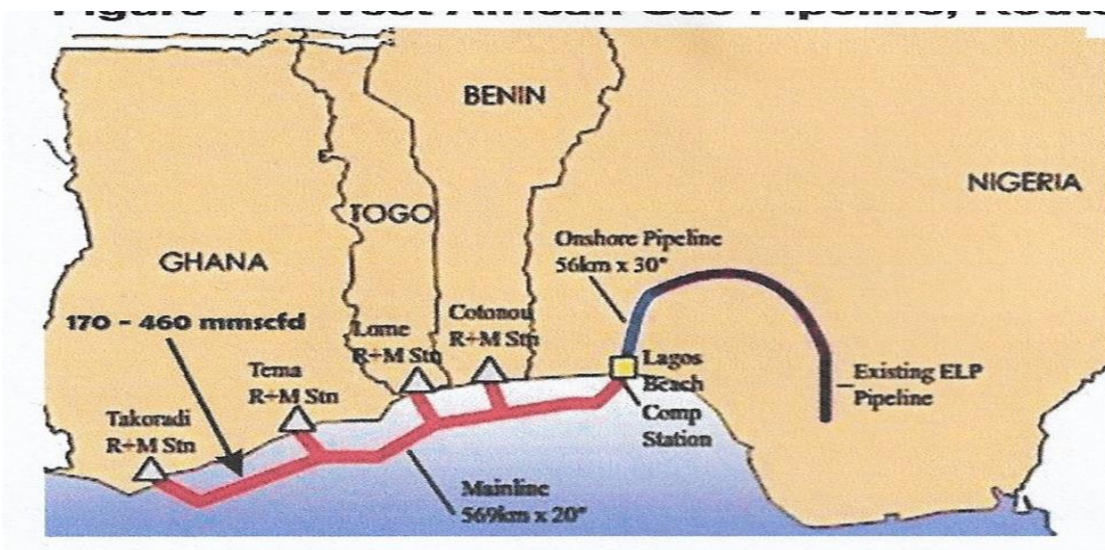


Figure 1.3: West African Gas Pipeline Map

Source: National Gas Policy (2017)

Appendix C

Table 2.2: Commercial gas distribution in Nigeria

S/N	Gas Supply System	Gas Consumers	Design Capacity, (mmscf/d)
1	Aladja Gas Pipeline System	Delta Steel Plant, Aladja	70
2	Oben - Ajaokuta Gas Pipeline	Ajaokuta Steel Plant	200
3	Sapele System	NEPA Power Station, Sapele	200
4	Obigbo North - Afam	NEPA, Afam	135
5	Imo River -Aba	Igi, Pz, Abatex Aba, Equitable	35
6	Alakiri - Onne	Nafcon, Onne	90
7	Escravos -Lagos Pipeline and the Spur Lines	Nepa Egbin Spur	600
		Nepa Delta IV Spur	172
		Ughelli	40
		Warri Refinery	45
		Wapco Ewekoro Wapco	94
		Ikeja City Gate /Otta/Agbara	50
		Pz Industries Ikorodu	4.26
8	Alakiri - Obigbo North, IkotAbasi	Edjeba & Ogunnu Housing Estate	26
		Aluminum Smelting Company (Alscon)	450

Source: Aimikhe et al (2013)

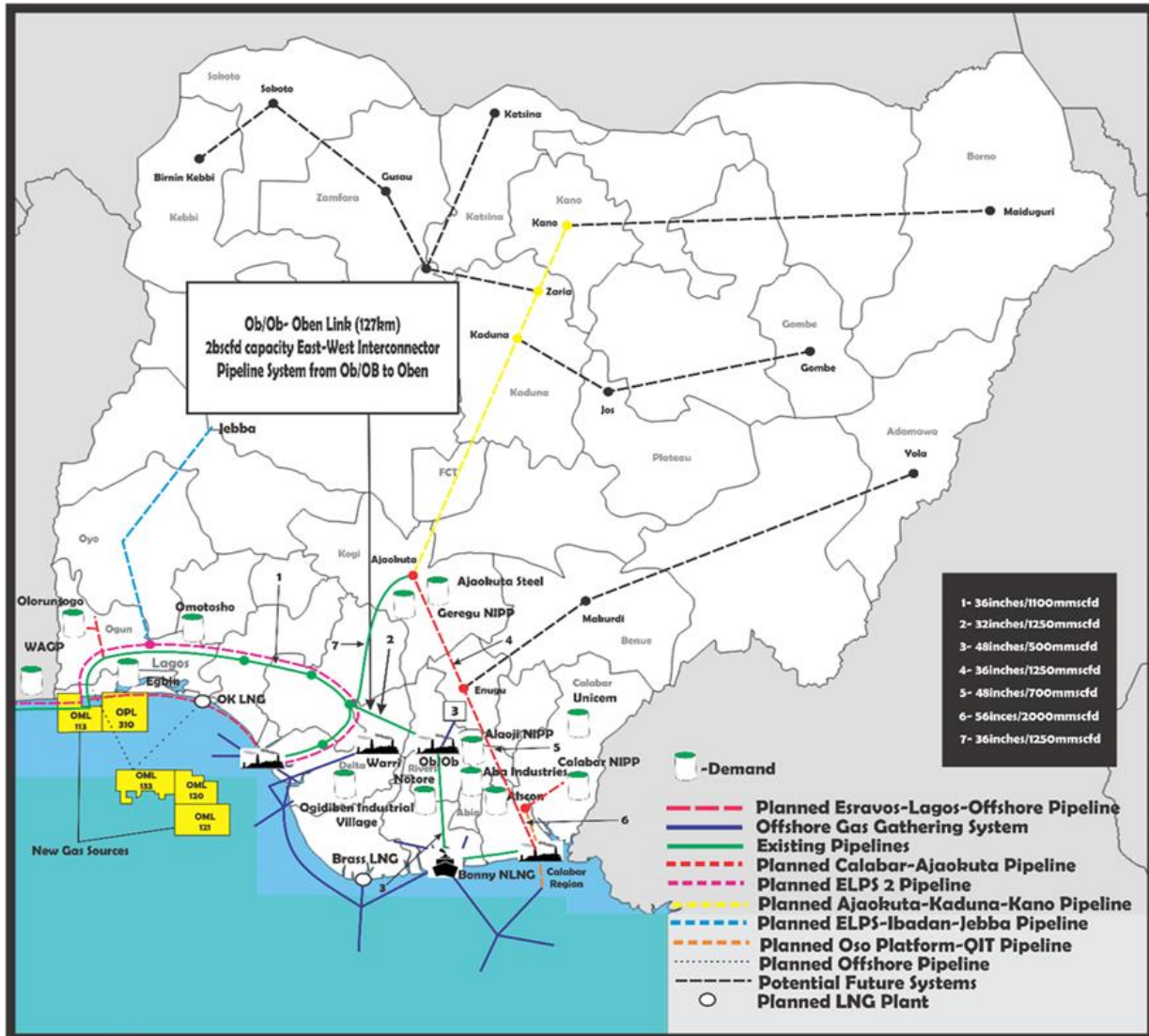
Appendix D



Figure 1.4: The Trans-Sahara Gas Pipeline Route

Source: Nigerian Gas Policy (2017)

Appendix E



A

Figure 1.5: Nigerian Existing and Proposed Gas Pipelines

Source: National Gas Policy (2017)

Appendix F

Table 2.4: Nigerian domestic gas obligation and performance

S/N	Company	Supply Oblig. (MMscf/d)	Ave. Supply (MMscf/d)	% Performance	Remark
1	SPDC	390	78.84	20	Disruptions on major exit pipelines constrained supply
2	Chevron	240	276.29	115	
3	Chevron EGTL	200	162.15	81	
4	ExxonMobil	230	0.00	0	Lack of infrastructure
5	NAOC	280	164.17	59	
6	TEPNG	160	15.01	9	
7	NPDC	300	162.28	54	
8	Addax	0	0.00	0	Gas supply awaiting PSC Gas Terms discussions
9	Pan Ocean	8	13.58	170	
10	Seplat	120	251.34	209	
11	Monipulo	8	0.00	0	Lack of infrastructure
12	Niger Delta	6	4.74	79	
13	Platform	18	20.52	114	
14	Frontier	13	77.22	594	
15	Universal	4	0	0	Lack of infrastructure
16	AMNI	8	0	0	Lack of infrastructure
17	Consolidated	7	0	0	Lack of infrastructure
18	Continental	6	0	0	Lack of infrastructure
19	Brittania U	0.5	0	0	Lack of infrastructure
20	Energia	18	1.59	9	
21	Eroton	32	0	0	Lack of infrastructure
22	New Cross	8	0	0	Lack of infrastructure
23	Aiteo	25	0	0	Discussions on-going with potential Off-takers
24	Dubri	3.5	0	0	
25	NNPC PSC	450	0	0	Gas supply awaiting PSC Gas Terms discussions
Total		2597	1065.58	41%	

Source: Department of Petroleum Resource (2017)

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