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Review of Gas Resource Utilization Using Applicable Technologies: A Case Study of Nigeria

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----------ABSTRACT----------
The aim of this research is to review the gas resource utilization in Nigeria with applicable technologies used to achieve this.Nigeria is abundantly endowed with gas resources and therefore, must properly harness it and Government needs to create the right framework and enabling environment to drive the much needed investment and development of the gas and power sector.

The desire to utilize and monetize gas resources in Nigeria have led to the development of technologies such as Liquefied Natural Gas (LNG), Gas-To-Liquids (GTL), Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG). Apart from the Liquefied Natural Gas (LNG), there is the possibility of adoption of new technologies like Floating Liquefied Natural Gas (FLNG) for harnessing stranded gas resources in Nigeria's deep water areas. The current gas resource utilization status of Nigeria's abundant gas resources and applicable technologies are reviewed and evaluated in line with the global best practices.

Keywords: Gas monetization, gas utilization, Nigeria, Liquefied Natural Gas (LNG), Gas-To-Liquids (GTL), Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG).

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I. Introduction

Nigeria ranks among the world's top 10 nations in terms of oil and gas reserves. At about 179 trillion standard cubic feet, Nigeria is the largest gas resource holder in Africa and the 9th largest natural gas reserve nation in the world (Fig 1.1).The current reserves estimate is about 52/48 distribution between Associated Gas (AG) and Non associated Gas (NAG) with only a small fraction being currently utilized. Nigeria's gas estimated undiscovered potential may be up to 600Tcf (Ekaluo, 2015). Since 1958, Nigeria has built a vibrant oil and gas industry that is ranked within the top 10 globally in terms of reserves and production (Fig.1.1).
The Nigerian economy is heavily dependent on the petroleum sector. Nigerian Government needs to create the right framework and enabling environment to drive the much needed investment and development of the gas sector which exceed foreseeable needs of domestic, regional and export markets.

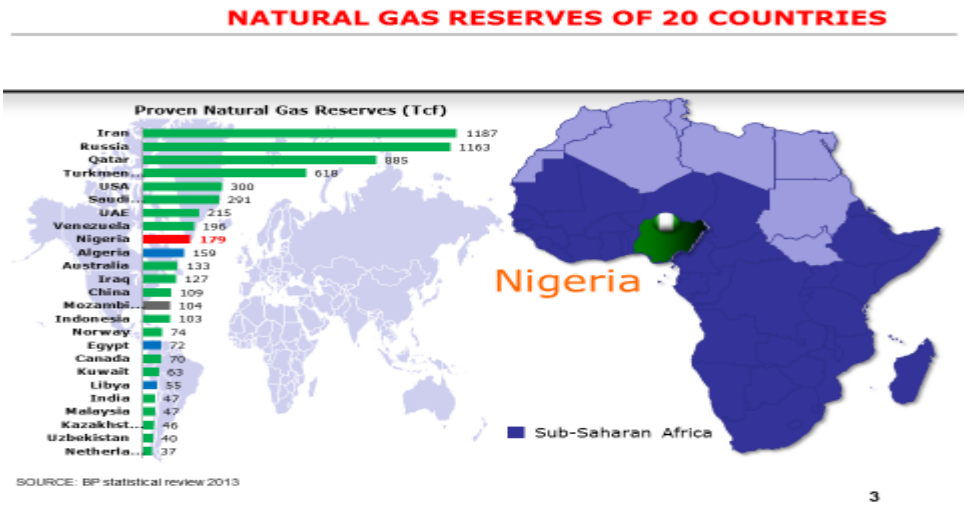


FIG. 1.1: NATURAL GAS RESERVES OF 20 COUNTRIES

SOURCE: BP STATISTICS REVIEW 2013

Nigeria is abundantly endowed with gas resources and therefore, must harness it to ensure adequate power supply to its teeming population. Government therefore needs to create the right framework and enabling environment to drive the much needed investment and development of the gas and power sector. Current gas reserves meet and exceed the needs of domestic, regional and export markets.

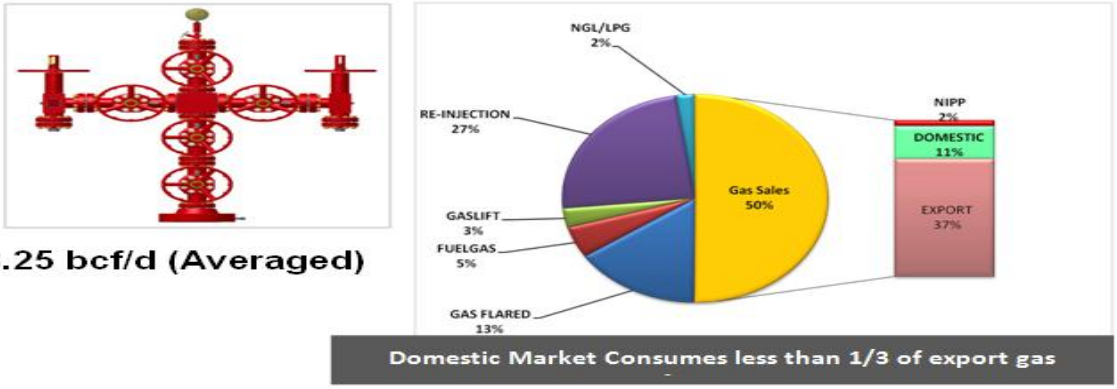
Natural gas is the cleanest-burning fossil fuel known to mankind and it is also becoming the energy source of choice worldwide. Nigeria is endowed with abundant natural gas reserves with current daily gas production of about 8.25 billion cubic feet per day (bcf/day) and less than half of the proven reserves have been committed to define projects (Osahon, 2014, Figs 1.2).

Nigeria has consistently been second worst gas flaring country after Russia, the country must take up the challenge and monetize the gas for the benefit of the country (Oniwon, 2011). These have contributed to increased interest in the LNG business as a means of utilizing valuable natural gas resources and contributing towards sustainable development.

II. Current Gas Utilization and monetization

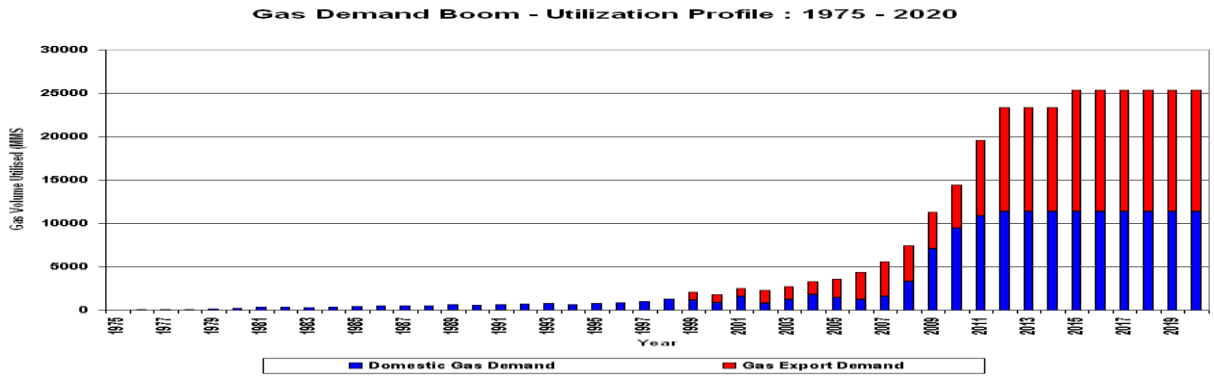
The only major investment in gas development in Nigeria has been the LNG projects. The Nigerian National Petroleum Corporation (NNPC) and other operating Exploration and Production companies are currently embarking on several gas utilization projects. Some of the gas that would otherwise be flared are converted to the LNG.At present, the domestic gas market is limited by the low level of industrialization and the inadequacy of the gas transmission and distribution infrastructure.

The desire to monetize gas resources and flare-out completely have led to the development of technologies such as Liquefied Natural Gas (LNG), Gas-To-Liquids (GTL), Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG). Apart from the Liquefied Natural Gas (LNG), there is the adoption of new technologies like Floating Liquefied Natural Gas (FLNG) for harnessing stranded gas resources. The FLNG is the water based LNG operations employing technologies designed to enable the development of offshore natural gas resources. The current management status of Nigeria's abundant gas resources and applicable technologies are reviewed and evaluated in line with the global best practices.



SOURCE: OSAHON, G 2014

FIG.1. 2: NATURAL GAS PRODUCTION AND UTILISATION



SOURCE: ONIWON, 2011

FIG 1.3: GAS UTILIZATION PROFILE (1975 – 2020)

There has been impressive growth in demand for gas (Fig.1.3). The demand is driven by a variety of sectors from power through to export LNG. The gas sector holds significant potential for Nigeria with robust reserve base and rapidly evolving demand base too. There is therefore the need to connect these reserves to market which is the key to realizing the economic potential of the gas reserves.

III. Applicable Technologies and Gas Projects

It is observed that application of technologies could accelerate monetization of Nigeria's natural gas resources. Nigeria can therefore learn from the applicable technologies and management of her abundant gas reserves.

The Nigerian Liquefied Natural Gas Company limited (NLNG), a joint venture between the Federal government and foreign oil majors was set up to harness Nigeria's vast natural gas resources and produce liquefied natural gas for export purposes. The plant built in Bonny island of Rivers state of Nigeria was completed in 1999. The NLNG is the only major gas development and investment in Nigeria to date. The plant complex has been described as 'Africa's largest single private sector industrial project' and the company is the biggest single contributor to government efforts to diversify the Nigerian economy and income portfolio (Omotowa, 2013). With six trains currently operational, the entire complex is capable of producing 22 metric tonnes per annum (mtpa) of LNG, 4 mtpa of LPG and 2.4 mtpa of condensate which is roughly 7% of the world's LNG consumption (Omotowa, 2013).Apart from the NLNG, other Greenfield LNG projects in Nigeria are the Brass Liquefied Natural Gas (Brass LNG) and Olokola Liquefied Natural Gas (OKLNG) Projects.

Brass Liquefied Natural Gas (Brass LNG) Project – The Brass LNG Ltd is a liquefied natural gas company incorporated in December 2003 by NNPC (49%), ConocoPhillips (17%), ENI international (17%) and Total (17%). The Brass LNG will export her products to the Atlantic Basin market (North America and Europe) where it seeks to become a key player.

The Olokola Liquefied Natural Gas (OKLNG) Project - This is located on the coast between Ogun and Ondo states, east of Lagos, Nigeria. Following the outcome of two separate studies conducted by Chevron/BG and Shell that proposed to NNPC the development of their respective Greenfield LNG Projects in the Olokola area. The NNPC, Chevron, BG International Ltd and Shell Gas and Power Developments BV (Shell) on April 13, 2005 signed a Memorandum of Understanding (MoU) for the LNG Plant, with 2009 and 2010 as target shipment dates respectively. The vision is to develop 22million metric tons per year (mtpa) capacity, to be executed in phases. It was, however, not feasible for the project to come on stream in 2010 as planned. OKLNG is designed for processing domestic gas and field condensate in addition to LNG production.

The LNG technology makes natural gas available throughout the world. Some of the gases that would otherwise be flared are converted to the LNG. This reduces the environmental impact of continuous flaring of large quantities of natural gas.

Apart from the LNG projects, other projects and applicable technologies in Nigeria are:

- Escaravos Gas to Liquids Project – The Escraros Gas to Liquids (EGTL) is another Chevron's multi billion project that will convert about 300 million cubic feet per day of residue gas (methane and ethane) into 34,000 barrels of high quality, environmental friendly diesel fuel, naphtha and liquefied petroleum gas (LPG). The EGTL project site, reclaimed through dredging, sand filling and dewatering is located about 100km south east of Lagos in a swampy gas-rich terrain at the mouth of Escravos River. The project is the largest in Africa and world's second largest (coming after Qatar's ORYX GTL). Preliminary discussions on EGTL project was initiated in the late 90's between NNPC and Chevron Nigeria Ltd. The EGTL which is being modeled after Qatar's ORYX GTL is designed to process ultra-low sulphur GTL products. Thus allowing commercial flexibility in monetizing Nigeria's huge gas reserves. Both GTL Diesel and Naphtha products will be marketed in line with the terms of an off-take agreement while the LPG will be sold back to EGP for co-mingling and export with the upstream JV LPG. The EGP is unique because that it signals the beginning of an effort to end gas flaring and also opened for Nigeria a new source of foreign exchange earnings through the export of its by-product especially Liquefied Petroleum Gas (LPG).

  The EGTL project receives about 300 MMSCFD of residue gas (lean gas) feedstock from the EGP and converts same and achieve peak production rates of 22,100BPD of synthetic diesel, 10,200 BPD of naphtha and 7,500 BPD of LPG. This technology is provided by SasolChevron Holding Limited (SCHL), a joint venture between Sasol Limited of South Africa and Chevron Corporation.
- Oso Natural Gas Liquids (NGL) Project – This project is a joint venture between NNPC (49%) and Exxon Mobil (51%) to convert associated gas into Natural Gas Liquids (NGLs). Mobil Producing JV NGL plant is located in the southeastern part of Nigeria. This NGL recovery project was commissioned in November 1998 and designed to monetize associated gas. The project's current production capacity is 50,000 barrels

per day. The financing and award of EPC contracts for the expansion of existing facilities was concluded in December 2004. This Project has substantially reduced the amount of gas flared in Mobil's operational area.

3.1 Gas Injection Projects

- Belema Gas Injection Project – The Belema Gas Injection Project is a Shell/NNPC Joint Venture Project. SPDC JV Belema Gas Injection project is aimed at reducing gas flares in about five flow stations by re-injecting some of the gas, some for gas lifting and some for use as fuel by local industries. An estimated 80 mmscf/d will be utilized.

- Obiafu–Obrikom Gas Injection Project – This project is a NAOC/NNPC Joint Venture Project. The Nigerian Agip Oil Company (NAOC JV) constructed the Obiafu-Obrikom gas plant in 1985 with the initial capacity of 270MMSCF/day which has been upgraded to 400MMSCF/day. This gas plant was expanded in 1994 to supply NGL feedstock and fuel gas to Eleme Petrochemical Company Ltd to produce polymers. This was followed by the Kwale Gas Plant in 1987 with an upgraded capacity of 150mmscf/day. All these projects are geared towards reducing gas flaring in NAOC's area of operations.

3.2. Escravos Gas project (EGP)

The Escravos Gas Project (EGP) is one the first major gas project to gather and process associated natural gas in Nigeria. This project is a joint venture project between NNPC (60%) and Chevron Texaco (40%) to recover associated gas (AG) from offshore fields. The first shipment of Liquefied Petroleum Gas (LPG) came on stream in 1997. This is a key element in Chevron Texaco's initiative to reduce gas flaring and utilize gas economically from Chevron's north offshore Fields. The NGLs are stripped for export and the remaining gas is used domestically.

3.3. West African Gas Project (WAGP)

The West African Gas Pipeline Project (WAGP) is a joint venture between Chevron West Africa Pipeline Limited (36.7%), Shell Overseas Holdings Limited (18%), NNPC (25%) represented by the Nigerian Gas Company (NGC), SocieteTogolaise de Gaz (2%), Societe Ben Gas S. A. (2%) and Takoradi Power Company Limited (16.3%) for the extension of the existing Escravos to Lagos Pipeline (ELP) to Takoradi, Ghana. This project will transport gas from Nigeria to Ghana, Benin and Togo. It is also possible that the WAGP will be extended to markets in Cote d'Ivoire. Negotiations are on with a number of prospective buyers in the sub region. This project will traverse about 618km high pressure natural gas pipeline to transport natural gas produced in the Niger delta to power generation and industrial facilities in Ghana, Togo and Benin. The pipeline will have initial capacity to transport about 170 mmscfd of gas from Nigeria to market centres in Benin, Togo and Ghana.

Among the key conditions for this project are:

- The sale, transmission and purchase of natural gas must be performed on a commercial basis
- Third Party access to WAGP must be granted on a non-discriminatory basis
- The pipeline company and the sellers of natural gas must have guaranteed settlement in hard currency.

3.4 Natural Gas for Domestic and Power projects

Natural gas is used as the fuel in power generation, usually in gas turbine plant but occasionally used to fire boilers for steam plant. Domestic gas utilization in Nigeriaranges from electricity, petrochemicals, cement and fertilizer plants. Some operating oil companies in Nigeria are deeply involved in the supply of natural gas to prime the power plants.The issue of gas supply to power plants is being addressed to overcome the energy supply crises in Nigeria. Nigeria plans to grow the gas supply to power sector from 600mmscfd to 3.8 bcfd by 2015 with specific short to medium term focus on PHCN, NIPP, JV IPP and 3rd Party IPP (Oniwon, 2011).

The Power sector remains the most dominant user of gas. The short to medium term power agenda is focused on the requirement of thirty nine (39) power plants with potential for fifteen (15) GW of power by the end of 2015 (Oniwon, 2011, Fig 3.1).

Operators in Nigeria's gas sector have always preferred the export of gas against domestic usage as the former does not require huge investment in gas infrastructure. To encourage investment in domestic gas, the price of gas-to-power project was raised.

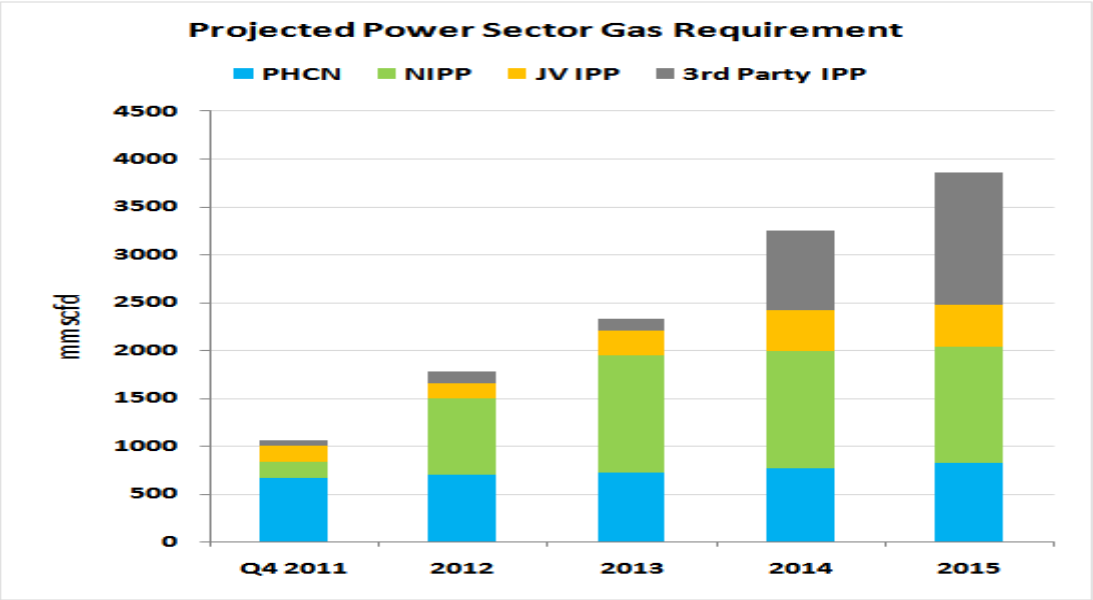
In order to improve Power generating capacity and reduce gas flaring, natural gas power plants were built by many operating oil and gas companies in Nigeria. Among the major thermal power plants are Egbin, Sapele, Okpai, Afam, Geregu and Omoku.

In the absence of initial private investments in gas infrastructure development, Government built the Egbin-Lagos Pipeline System (ELPS) to deliver gas from the Niger Delta to the Egbin Power Plant. This gas distribution network hasnot witnessed any major expansion except those recently driven by few private markets that are prepared to pay the appropriate price.

Several distribution schemes are also planned to help promote Nigerian consumption of natural gas

- The proposed $745 million Ajaokuta-Abuja-Kaduna pipeline to deliver gas to the Central and Northern Nigeria.
- The proposed $552 million Aba-Enugu-Gboko pipeline to deliver natural gas to portions of Eastern Nigeria.
- The Lagos State Government and Gaslink Nigeria Limited (Gaslink), a local gas distribution company, are developing a pilot programme to deliver natural gas to some residential areas in Lagos state. Gaslink began supplying gas to about thirty industrial customers in Ikeja industrial district, Lagos state

Part of the problem being encountered by these power plants and domestic markets is supply of low quality, wet gas with the attendant problems of accumulated condensate because the gas suppliers would not invest extra funds to strip and clean up the gas before delivery. Low returns greatly impacted by low purchasing power in the country and the huge capital investment required to commercialise gas for purposes of power plants and industrial uses pose great concerns to the sector.



SOURCE: ONIWON, A. 2011

FIG.3.1: PROJECTED POWER SECTOR REQUIREMENT (2011 – 2015)

3.5 The Gas Based Industrialization Project

On the domestic front, NNPC and its subsidiary, Nigerian Gas Company (NGC) supply gas for power generation, feedstock to cement and fertilizer plants, glass, food/beverages and manufacturing industries. More local industries are now aware of the advantages and benefits of using gas, hence the increasing demand for gas.

The Nigeria gas based industrialization agenda which will involve some projects supposed to be in phases has kicked off (Oniwon, 2011). This initiative is anchored on a few planned investment agenda and projects.These projects are supposed to jumpstart gas industrialization with the delivery of Central Processing facilities, Fertilizer, Petrochemical, methanol and LPG plants.These are robust set of investor projects aimed at creating a platform to position Nigeria as a regional hub for gas based industries and also create basis for growth of secondary downstream industry.

Ige (2012) gave some details about these projects. The projects include the following:

- Petrochemicals -These projects involve the Xenel/NNPC JV 1.3MTPA polyethylene plant and 400KTPA polypropylene plant in Koko, Delta state of Nigeria. The other project is the Dangote Petrochemicals (900KTPA) petrochemical complex in Onne, Rivers state of Nigeria.
- Fertilizer - These projects will be handled by Nagarjuna/NNPC/DSG Joint Venture. The projects involve 2.6MTPA Urea/Ammonia Fertilizer plants in Koko, Delta State and other five blending fertilizer plants across the country, Nigeria. Other fertilizer projects are Dangote plant (2.4MTPA) Urea plant in Edo State, Brass Fertilizer plant (2.4MTPA) Urea plant in Bayelsa State and Indorama Ureaplant (1.34MTPA) in Eleme, Rivers State.

- Methanol – These projects are Dangote Methanol plant (450KTA) in Onne, Rivers State, Viva Methanol plant (1.98MTPA) in Lekki, Lagos State and the Indorama Methanol plant (1.2MTPA) in Eleme, Rivers State of Nigeria.

  In the proposedOgidingbe gas based Industrial Park, there are investment opportunities in areas of Free Trade Zone infrastructure, Port Infrastructure and real estate development. The aim is to create the largest gas industrial Park Sub-Saharan Africa with fertilizer, methanol and Power projects. The Ogidingbe industrial city is therefore expected to include a fertilizer plant, a petrochemical plant, a central processing facility and a power plant of 350MW capacity. The new industrial city would also involve large commercial and residential areas and provide significant direct and indirect employment.

3.6 The Nigerian Gas Master Plan (GMP).

The Nigeria Gas Master plan was approved in 2008 and the focus is on utilizing Nigeria Gas resources more efficiently. Key aspects of the plan include the domestic gas supply obligations, gas infrastructural development and gas Pricing Policy to guide commercial exploitation and management. The Gas Supply Obligation (DSO) is to ensure gas producers make gas available for domestic market especially power generation. The Gas Infrastructure Development is to support gas processing and gas transmission (south – north, east – west interconnection) while the Gas Pricing Policy is to support investments in gas infrastructure.

The Gas Master Plan Policy of the Federal Government according to Yakubu, (2011) is to among others:

- Guide commercial exploitation and management of Nigeria's gas sector
- Grow Nigerian economy with gas by stimulating the multiplier effect of gas in the domestic economy.
- Position Nigeria competitiveness in high value export market
- Guaranteeing long term energy security for Nigeria.

The Gas Master Plan therefore aspires to grow the gas resource base so as to catalyze growth of the wider national economy and guarantee long term energy security in Nigeria. Furthermore, the GMP is expected to guide the commercial exploitation and management of Nigeria's gas sector.

The Gas Master Plan is dependent upon an effective delivery system for the supply of domestic gas. Hitherto, most of our gas infrastructure were designed for export and domestic supply infrastructure was poorly developed and not subject to regulation (Okon, 2010). A Midstream Agency will be necessary to administer the strategic aggregator and responsible for the gas demand/supply model.

The gas infrastructure blueprint captured two investment categories as:

- Three (3) central gas gathering and processing facilities (CPFs) – West Delta (Warri/Forcados area), Obiafu (North Port Harcourt area) and Akwa-Ibom/Calabar area.

These will be regional gas processing hubs with the following processes:

- Wet gas will be treated, LPG/NGLs extracted, lean gas exported into the transmission system.
- Plants owned and operated as tolling facilities for third party gas.
- Plants can also access and purchase third party wet gas.

There are therefore a lot of identified infrastructure investment opportunities for credible interested investors.

The CPF through the extended gathering system can access and purchase stranded gas, the CPF can act as a physical aggregator of gas within the franchise area (Figs 3.2, 3.3). The CPF can also utilize acquired gas for own export LNG plant or for other downstream domestic use.

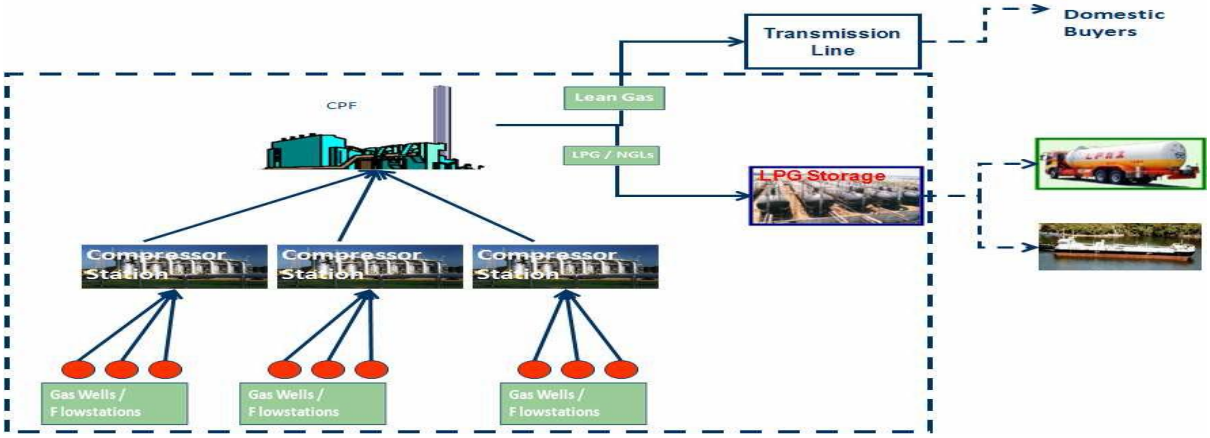
- Three (3) gas pipeline transmission systems including compressor stations – 1200 kilometers South-North line, 700kilometers Western system with 200 kilometers offshore extension and 200 kilometers interconnector system.

  The South-North system has the domestic and Trans Sahara as key markets with 3,800MMScfd as gas peak production. These consist of 56" and 48" pipeline system.

  The Western System includes the existing ELPS pipeline, offshore pipeline through Shagamu to Jebba. This system also has the domestic and WAGP as key markets with 3,250MMScfd as gas peak production. These consist of 36" and 42" pipeline system.

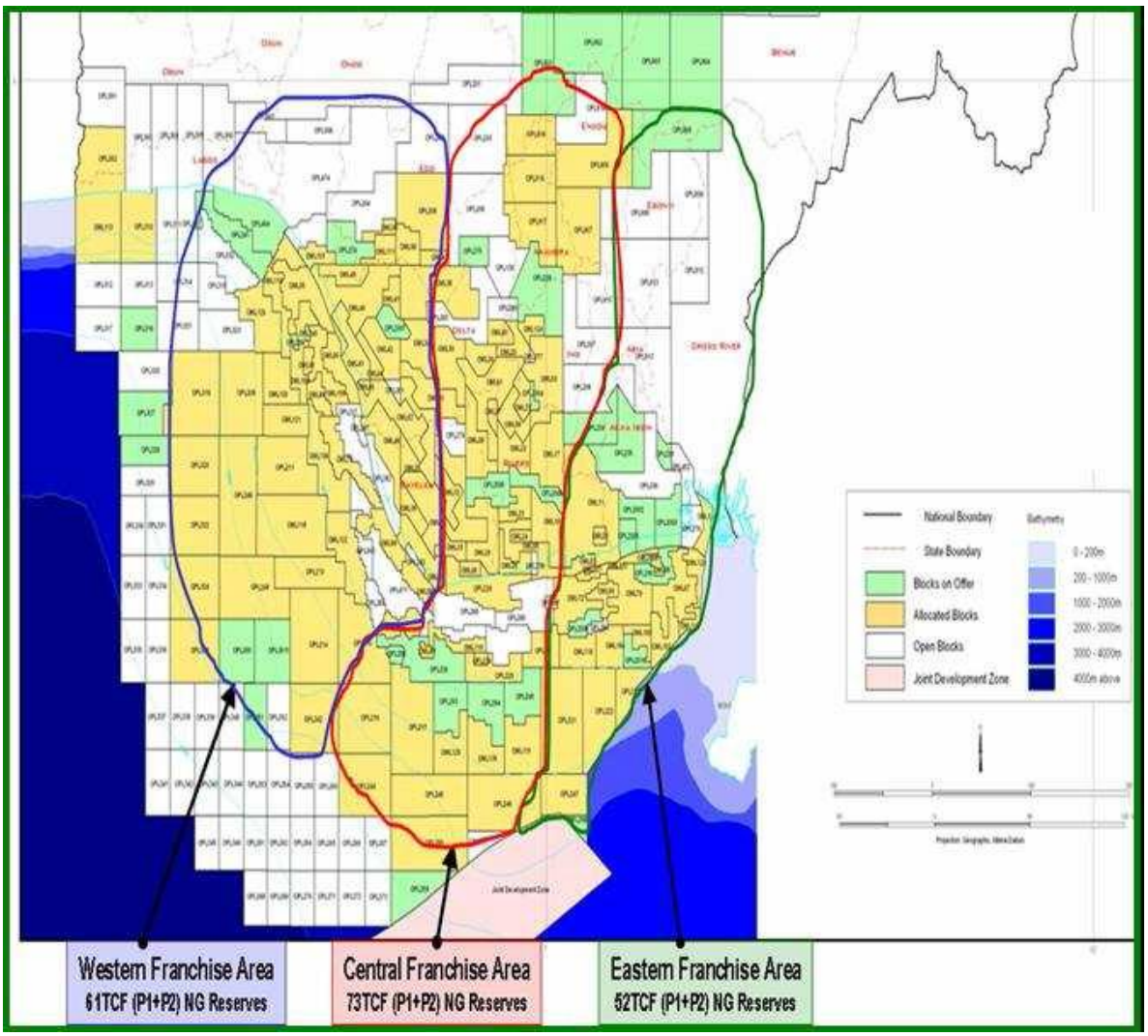
  The interconnector system consists of 36" and 42" gas pipeline system.

  The three (3) transmission systems will be operated independently and they will be interconnected.



SOURCE: IGE, D. 2008

FIG.3.2: GAS GATHERING AND PROCESSING FACILITIES



SOURCE: IGE, D. 2008

FIG.3.3: DELINEATION OF FRANCHISE AREAS

IV. Conclusions

i. The current strategies and technologies applied within the Nigerian oil and gas sector are currently what are obtainable on the global scale given the multi-nationality of most of the concerned companies as well as the transfer of knowledge and expertise across borders. This is evident from the operations of the NLNG, domestic power utilization and deep water gas exploration. The study finds that the same technology and strategies as applied in other oil and gas countries is also readily available and accessible within the Nigerian context of oil and gas operations.

ii. The main drivers of gas utilization in Nigeria had been the Government desire to create more wealth and diversify the economy of the country. The need to end gas flaring couple with rising domestic industrial demand for gas have also encouraged oil and gas operators in Nigeria to go into gas projects.

iii. Gas resources, if properly managed, enable industrialization and generate significant revenue for producing countries. The framework and applicable technologies for gas utilization are considered crucial in the development of gas resources.

iv. Nigeria's current strategic initiative on gas based industrialization should be vigorously pursued so as to enable gas used more for industries as observed in some countries where massive sustainable employment has been achieved with attendant increase in GDP.

BIOGRAPHY:

1. CARIM, A. Akintunde, had a BSc degree in geology and MSc degree in Petroleum geology from the University of Ibadan, Nigeria. He also obtained a MBA in Technology management. He is currently a PhD student in Technology management at the Institute of Engineering, Technology and innovation management (METI), University of Port Harcourt.
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