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A NEW BEGINNING FOR THE PETRO-CHEMICAL INDUSTRY IN NIGERIA: MEETING CHALLENGES THROUGH AN EFFECTIVE EXPLOITATION OF NATURAL GAS

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ABSTRACT

This paper presents the results of assessing the challenges and opportunities to rehabilitating and sustaining effectively, our petro-chemical industry for development of Nigeria. We posit these challenges can be met through an effective exploitation of our natural gas reserves. Minimum recoverable volumes of 12.6 trillion cubic feet of ethane, propane and butane, major feedstock to the petro-chemical industry, are assured. This industry should urgently be rehabilitated to enhance and sustain the manufacture of plastics, rubber, and other products, major domestic and industrial inputs.

Keywords: Petro-chemical Industry, Ethane, Propane, Butane, Feedstock, Plastics, Rubber

INTRODUCTION

The rapid and sustainable development of Nigeria will require the functioning of major industries, such as the petrochemical and chemical industries. These industries play key roles as industrial multipliers by catalyzing virtually all arms of the economy of Nigeria, especially on their direct influence on the society's living standards – food, shelter, clothing, health and transportation. As shown in Figure 1, petrochemicals are chemicals derived from petroleum resources, such as natural gas, natural gas liquids, and crude oil.

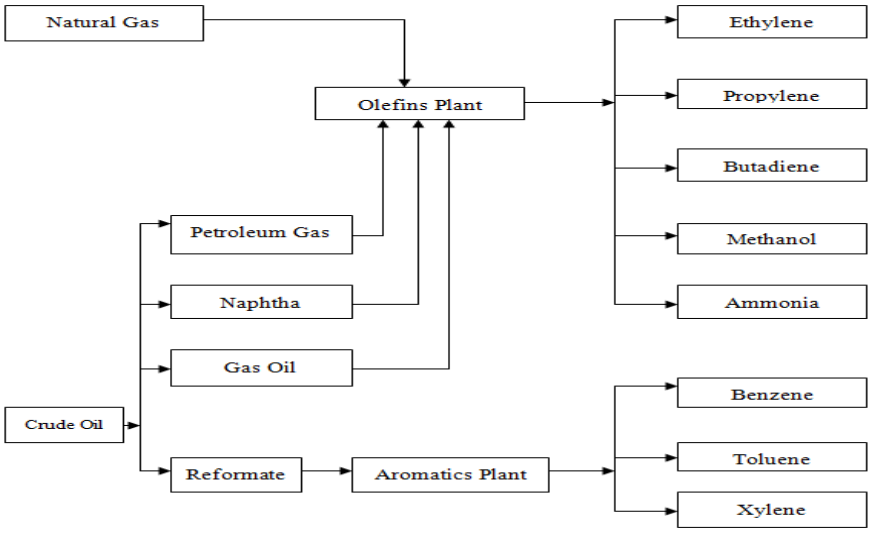

Figure 1. Base Petrochemicals from Crude Oil and Natural Gas

At present, Nigeria has three major petro-chemical complexes, namely: the Eleme Petro-chemical Plant (EPCL), the Kaduna Petro-chemical Plant (part of the Kaduna Refinery &

Petro-chemical Company – KRPC)), and the Warri Petro-chemical Plant (part of the Warri Refinery & Petro-chemical Company - WRPC).

Table 1. Phases and Products of Petrochemical Plants in Nigeria [1]

Phase	*Project/Product*	*Date of Availability*
I	Polypropylene, Carbon Black, Linear Alkyl-Benzene, Heavy Alkylate, Solvents, Benzene	December 1983
II	Ethylene Steam "Cracker", Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Polypropylene, Vinyl Chloride Monomer (VCM), Polyvinyl Chloride (PVC), Ethylene Oxide, Ethylene Glycol (EG), Plasticizer Units, Chloride/Caustic Units (C/S)	1985/86
III	Advanced Products based on simple Aromatics of the Xylenes type	1990

These plants were originally designed to be developed in three phases as shown in Table 1, and depended on the refineries to supply the raw materials [1]. Though sold to a core investor, the Eleme plant is yet to become fully functional, while the other plants are marginally working or shut down, due mainly to:

1. The lack of raw materials to the plants,
2. The lack of pro-active planning for alternative sourcing of raw materials for the petrochemical plants, exclusive the refineries.
3. The poor management of assets, characterized by:
   a. Poor maintenance of plants – frequent equipment failure
   b. Poor best practices - Corruption, low corporate responsibility, and poor attitude to work
4. The funding policy of the refineries and plants:
5. This is a key issue the NNPC must tackle to guarantee the reliability and high capacity utilization of the refineries to ensure availability of the raw materials for the petrochemical plants.

There are two major sources of the raw material(s), from which petrochemicals can be produced, namely:

1. The refining and processing of crude oil, and
2. The processing of natural gas into the various components of methane, ethane, propane, butane, pentane$_+$.

Up till now, petrochemicals were produced exclusively from the raw material(s) obtained from the processing of crude oil from the refineries at Kaduna, Port Harcourt and Warri. The continued decline in the production capacity of the refineries, gradually led to the unavailability of the raw materials to the petrochemical plants. The quest for a rehabilitation of the petrochemical industry has prompted the alternative sourcing of raw materials for this industry by the Federal Government, and thus, our focus on natural gas.

Table 2 shows the estimated volumes of conventional natural gas reserves in Nigeria [2], which the Federal Government desires greater utilization of, on "gas to products" projects, especially, the gas to power, gas to liquids, and gas to LNG projects. A clear economic and sustainable development opportunity is the "gas to polymer". Fortunately, more volumes of

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natural gas are expected to be added to these reserves as more exploration and discoveries are made within the various environments – onshore and marine [3]. The NNPC reports that ethane, propane and butane constitute about 7 to 12% of the natural gas reserves [4, 5]. A 7% of 180 tcf reserves of natural gas (DPR 2007 reserves estimates), estimates the reserves of these components to be about 12.6 trillion cubic feet. Table 3 shows the breakdown of ethane, propane and butane reserves as to the category of our conventional natural gas - associated dissolved and non-associated.

Table 2. Estimated Reserves of Natural Gas in Nigeria [2]

Category	*Reserves (tcf)*
Associated (AG)	105.00
Non – Associated (NAG)	120.00
Total	225.00

Table 3. Estimated Reserves of Ethane and Propane in Nigeria [2]

Category	*Natural Gas Reserves (tcf)*	*Reserves of Ethane, Propane and Butane 7% of NG Reserves (tcf)*
Associated (AG)	105.00	7.35
Non – Associated (NAG)	120.00	8.4
Total	*225.00*	*15.75*

tcf = trillion cubic feet

Table 4. Volumes of Natural Gas Flared with Minimum Lost Income [6]

Year	*Volumes Flared (Bcf)*	*Loss at $18/boe ($billions)*	*Loss at $40/boe ($billions)*
1999	824	2.59	NA
2000	905	2.82	NA
2001	944	2.93	NA
2002	862	2-71	NA
2007	845	NA	5.63

NA – not applicable; Bcf – 1,000,000,000scf

The flaring of natural gas in Nigeria is a calamity – environmental and economic, which the Federal Government has been unable to stop over the years. The World Bank estimates that Nigeria accounts for about 12.5% of world's daily total natural gas flaring. Our operating companies flare an average of 2 billion cubic feet of produced associated gas per day, as shown in Table 4 [6]. A 7% of this translates to a minimum of 0.14 billion cubic feet of ethane, propane and butane flared, daily. This is a significant volume of ethane, propane and

butane that could be converted to the olefins – ethylene, propylene and butadiene, raw materials for the petro-chemical plants at Eleme and Warri. Ethane, propane and butane utilization from natural gas is a sustainable development opportunity, which will contribute to meeting the goals of vision 2020 of the Federal Government of Nigeria – establish Nigeria as one of the 20 leading economic powers by year 2020.

The polyolefins – derivatives of ethane, propane and butane, are major raw materials used in the production of wrap films, fiber, pipes, containers, automotive wares, etc. These find a wide range of domestic and industrial uses. Markets for these products abound in Nigeria, especially, in the major industrial cities, namely: Lagos, Onitsha, Ibadan, Port Harcourt, Kano, and Abuja. With a population of over 140 million, Nigeria is a major market for petro-chemical products. Frost & Sullivan [(7)] estimates that the petro-chemical industry in Nigeria was worth US$14.03 billion in 2008, and projected to a worth of US$29.7 billion in 2015.

Realizing the importance of petro-chemical plants in our economy, the Federal Government has been promoting the emergence of new plants, especially the agreement between the China State Construction Engineering Corporation (CSCEC) and the NNPC, for the construction of three refineries and a petro-chemical complex. This new petro-chemical plant is expected to use natural gas to produce polymers, solvents and gas-based fertilizers, with the site yet to be determined by the NNPC. However, we ask the following questions:

1. Will this new plant fare better than the old plants?
    a. Raw materials and management issues,
    b. Critical infrastructure,
    c. Politics and best practices
2. How can Nigeria effectively embark on “gas to polymer”, a key and sustainable development opportunity [(8)]?
    a. The emergence of an effective master plan for a sustainable petro-chemical industry in Nigeria

We posit the answers to these questions, as follows:

1. A well defined and mutually beneficial policy, for the petro-chemical industry,
2. An effective plan for the optimum utilization of natural gas,
3. Emergence of new plants with clear mandates.
    a. Best Practices on need, location, and construction of new plants
    b. Effective funding and ownership structure

These will provide the path to effectively develop and sustain our petro-chemical industry, the provider of basic raw materials to various other sectors of our economy. We posit that new plants should be private sector driven, and properly dedicated to producing needed petro-chemicals, cost-effectively.

State of Petro-Chemical Plants in Nigeria

The petro-chemical plants at Eleme and Warri, established in 1988, were meant to produce polyethylene, polypropylene, carbon black and other products, that drive the manufacturing of plastics, rubber for tires and footwear, etc. – major end products for both domestic and industrial uses. The Kaduna petro-chemical plant, also commissioned in March 1988, was meant to produce linear alkyl benzene (LAB – installed capacity of 30,000.0 metric tons/year), tins and drums. The under-capacity utilization of the petro-chemical plants has

many implications. A major implication is the bridging of polyethylene and polypropylene, carbon black, etc., through imports, with the following consequences:

1. Continued economic drain of our foreign exchange earnings, and hence, on the economy,
2. Standards and Codes of materials not properly monitored – dumping of sub-standard materials into Nigeria – raw materials and finished products (a major challenge on the environment – climate change?),
3. Lack of reliable supply of feedstock to users of polyethylene, polypropylene, etc., and
4. Shut down of many plastic companies, due to the cost of imported raw materials, high overheads, etc., leading to such challenges as the propagation of unemployment.

Table 5 shows the installed capacities of the Eleme and Warri petro-chemical plants for the various products. The economic drain on the economy is enormous when we consider the volumes of chemicals that were imported over the last five years for the manufacture of plastics, paints and other polymers.

Table 5. Status of Eleme and Warri Petro-chemical Plants: Installed Capacity [9]

Plant	*Carbon Black (metric tons/year)*	*Polyethylene (metric tons/year)*	*Polypropylene (metric tons/year)*	*Cracker*
Eleme	-	240,000.00	95,000.00	Yes
Warri	18,000.00	-	35,000.00	Yes

The Federal Government estimates that about US$11billion yearly in imports in chemicals and fertilizers will be saved if the new Chinese/NNPC petro-chemical complex starts working. Polymer products have become part of our daily life. Nigeria must begin to re-establish her position as a major economic and business hub in Africa, with a well defined and mutually beneficial policy on the petro-chemical industry – a master plan.

A New Beginning and Sustainability of the Petro-chemical Industry: Challenges

It is good for the Federal Government to enter into an agreement to build new petro-chemical plants. However, the policy that guides this new path must de-bottleneck the following challenges, to create a new beginning, and eventually, sustainability:

1. Sustainable availability of feedstock, especially natural gas.
2. The placing of these new plants in economically strategic sites, with available critical infrastructures: pipelines, gas plants, etc., without ethnic politics.
3. Best practices – corporate responsibilities, financial responsibilities, QHSE, etc.
4. Sustainable funding and management – Government .vs. Private Sector Ownership
5. Research & development, and effective capacity building within the petro-chemical industry:
   a. Local technology
   b. Cost effective processes and products
   c. Market innovations

These challenges are the same bottlenecks that choked the old plants. The West Africa region has a very fertile market for petro-chemical products. Nigeria can serve the needs of this

market, partly being met by South Africa imports. To effectively rehabilitate the petro-chemical industry in Nigeria, these challenges must be resolved, for both old and new plants. For a new beginning, the drivers are as follows:

1. A proper due diligence on the technical and financial state of the old plants - Kaduna and Warri plants.
   a. Objective categorization of the state of the plants.
2. Availability of core business plans with definite path and targets.
3. Transparent transfer of the plants to competent core investors, that are technically and financially able, to profitably run and sustain the plants.
4. Engineering of facilities.
   a. To use natural gas as feedstock.
5. Sustainable sourcing of ethane, propane, and butane from gas companies/gas plants
6. Properly assess any needs for new plants.

We believe that it will be technically and financially prudent to first rehabilitate and sustain the old plants, before new plants should be built. The lessons learned from the rehabilitated old plants, will be used to manage any new plant(s); such as:

1. Fiscal policies – Right? Cost? Auditing? etc.
2. Management structure and ownership.
3. Level of adaptive local technologies that can drive our petro-chemical plants.
4. Sourcing of natural gas, with critical facilities installed in place – gas plants, pipelines, etc.
5. Local content – Human resources development, capacity building, etc.
6. Best practices – corporate responsibility, financial responsibility, community welfare, and respect for the environment – environment management solutions, etc.
7. Funding model for sustainability.

New Petro-Chemical Projects in Nigeria: Transparency and Reliability

Between October 2000 and April 2010, the Federal Government of Nigeria had given out approvals for three new petro-chemical plants, namely:

1. The Eurochem Technologies Corporation plant at Lekki, Lagos (2002),
2. The Emerald E&P Company/Garden Energy Resources plant at Anambra State (2008), and
3. The China State Construction Engineering Company/NNPC plant; site yet to be determined (2010).

Fortunately, each plant is projected to use natural gas as the raw material. The Eurochem plant is designed as a base methanol plant, expected to then convert the methanol to olefins, from which polypropylene and high density polyethylene will be produced. The capacities are:

1. 2.5 million tons/year single line methanol plant,
2. 400,000 tons/year polypropylene plant, and
3. A 400,000 tons/year high density polyethylene plant.

This plant expected to have been completed in 2006, was to cost US $2.5billion. The plant is yet to achieve any of its objectives. The Emerald E&P Company/Garden Energy Resources plant has not taken off, and may never take off. Funding is the major problem. The Chinese petrochemical complex is part of a three refinery/petro-chemical program. The petro-chemical plant is expected to produce polymers, solvents and agro-chemicals (fertilizers). This complex is expected to cost US $23billion [(9)]; to be financed by China Export and Credit Insurance Corporation and a consortium of Chinese Banks. Best practices – corporate responsibilities, financial responsibilities, and respect for local content, must be sustained by all parties.

We believe that the old plants should be properly rehabilitated, operated for at least four years and with lessons learnt; new plants should then be constructed. If the old plants are rehabilitated with upgrading of facilities, the markets for products can fill a high level of imports, before new plants can come on stream. The basic challenges that faced the old plants over the years will face any new plants, if the challenges are not taken care of.

Exploitation of Natural Gas: Gas to Polymer

Natural gas in Nigeria can be sourced from both conventional and unconventional sources, namely:

1. Conventional sources.
   a. Associated dissolved natural gas, produced with crude oil, and
   b. Non-associated natural gas;
2. Unconventional sources.
   a. Shale gas, which is available and abundant in Nigeria
   b. Coal – coal to methane, ethane and propane; coal to liquids.

Table 6 shows the major sedimentary basins in Nigeria in which natural gas has been discovered in great volumes. At present, only the Anambra and Niger Delta basins are seeing the exploitation of natural gas. Such companies as Gas Transmission Ltd (OPL 902) and Orient Petroleum Ltd. (OPLs 915 and 916) are determined to optimize the exploitation of natural gas in the Anambra basin. The major problem is the absence of critical infrastructure to move the gas to users such as the IPPs (gas to power) and/or industrial/commercial end users, who traditionally use the gas for heating and in boilers to drive their factories. These blocks could form the source of natural gas to gas plant(s) to feed the rehabilitated Warri petro-chemical plant.

Table 6. Major Petroleum Sedimentary Basins in Nigeria [(2)]

Basin	*Environment*	*Natural Gas*
Anambra	Onshore	Yes
Niger Delta	Onshore/Marine	Yes
Bauchi/Gombe	Onshore	Yes
Benue Trough	Onshore	Yes

In 2004, the Federal Government of Nigeria awarded 24 marginal fields, mostly in the Niger Delta basin, to local companies, in an effort to encourage greater local content in the

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upstream petroleum industry in Nigeria. Natural gas is found in all these fields, especially, in conventional forms. In Nigeria, they are three major producers – producing and potential, of natural gas, namely:

I. The IOCs and major Independents,
II. Major local companies, and
III. Marginal field operators.

We posit the following as the major drivers to effectively exploit natural gas, for the effective sustainability of the petro-chemical industry:

1. A separate natural gas industry to drive all gas based projects [(2)], especially the petro-chemical industry,
2. A data base of all categories of natural gas, noting:
   a. Location (OML), depth, geologic and engineering parameters
3. Growth strategies for natural gas reserves,
4. Pricing of natural gas – at competitive cost to petro-chemicals,
5. Type and location of natural gas infrastructures, and
6. Market opportunities for petro-chemicals

These will bring greater focus and direction to natural gas exploitation in Nigeria. Also, we posit that responsibilities should be given to the three categories of companies to drive approved gas projects, by supplying the natural gas for:

I. Export based projects; to IOCs and major Independents,
II. Gas to power; to major local companies, and
III. Gas to polymer/LPG; to marginal field and local companies.

We believe that the present scenario where natural gas is predominantly sourced from the conventional associated dissolved form by companies and used for their projects, is not optimal. A clear direction has to be given for the sourcing of natural gas for particular projects, such as:

I. The marginal field operators should be encouraged by the Federal Government to produce their conventional non-associated gas for "gas to polymer/LPG/chemicals" projects.
II. Incentives and greater access to inland blocks for natural gas exploitation should be given to these operators.

Qatar has a natural gas policy in which conventional associated dissolved gas is used for domestic purposes – power, plastics, fertilizers, etc.; while conventional non-associated gas is used exclusively for export based projects – LNG, GTL, etc. [(10)]. Is it impossible for Nigeria to evolve a policy such as this to effectively utilize the vast reserves of her natural gas, especially, to feed the petro-chemical plants?

In the past, the Eleme and Warri petro-chemical plants sourced all raw materials from the refineries – oil based olefins (ethylene and propylene). At present, these refineries are marginally functioning, and thus, cannot meet the needs of the petro-chemical plants. Where and how then, can the petro-chemical plants effectively source their raw materials? We posit that a clear cut policy on the proper exploitation of our natural gas, especially for ethane and propane components, will be a sustainable development opportunity, and good for the

economy of Nigeria. This will guarantee and sustain the development of the petro-chemical industry, a major part of vision 2020. We suggest the following:

1. Build at least 24 major Gas Plants in strategic places in Nigeria, exclusively for domestic projects – Anambra, Onshore Niger Delta, Gombe and Bauchi Basins.
2. Develop natural fields dedicated to petrol-chemicals, and achieve complete separation of the natural gas into useful components: Through the strategic gas plants
   a. Methane – Power, methanol, and methane based industries
   b. Ethane – Petro-chemical and ethane based industries
   c. Propane – Petro-chemical and propane based industries,
   d. Butane – Petro-chemical and other user industries,
   e. Naphtha – User industries
3. Build pipelines to supply the petro-chemical plants with the needed raw materials
4. Preferably, new petro-chemical plants should be placed as close as possible to sources of natural gas and the gas plants.

Ethylene and propylene from natural gas are cleaner and impurity-free than those from refineries. This policy should be in phases. Some of the infrastructures are already on ground, probably not working, but can quickly be put into operation. We see the few gas plants dedicated mainly to power. Our petro-chemical industry is very much a key sector of the Nigerian economy, and should be given its right place by the effective utilization of our natural gas to guarantee the availability of raw materials.

Gas to Polymer: Benefits to Nigeria

Great benefits abound for Nigeria through the "gas to polymer" projects if properly planned and executed. Basic benefits are:

1. Desired capacity in Local content:
   a. A new avenue for utilization of natural gas – less flaring
   b. A new policy on natural gas – probably a natural gas industry
   c. Employment and development of local workforce
   d. Emergence of local technology
2. Greater financial impact on the economy – less imports of petro-chemicals
3. Established culture of best practices
4. Research culture for industrial products – presently non existent
5. Access to West Africa markets
6. Sustainable development of local economy – meeting Vision 2020 of the Federal Government.

CONCLUSIONS

Ethane, propane and butane make up a minimum of 7% of our natural gas reserves. We looked into the state of our petro-chemical plants, the producers of polyethylene and polypropylene. The challenges on these plants were presented to guide the operation of any new plant(s). In the past, the old plants sourced their raw materials from our refineries, which are notoriously unreliable. The alternative use of ethane and propane from our vast volumes of natural gas, is a sustainable development opportunity. Nigeria can become a major

economic power, through an effective utilization of our abundance reserves of natural gas, which can and will attain wealth creation for her citizens. We posited the following:

1. A culture of best practice in all operations,
2. The creation of a separate natural gas industry that will drive effectively, all natural gas projects, especially the "gas to polymer", and
3. The abundance of benefits to be derived from a new and well managed petro-chemical industry.

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Nomenclature

DPR - Directorate of Petroleum Resources

IPPs - Independent Power Plants

NNPC - Nigeria National Petroleum Corporation

OPL - Oil Prospecting Lease

NLNG - Nigeria Liquefied Natural Gas

LPG - Liquefied Petroleum Gas

QHSE - Quality Health, Safety, and Environment