



THE Consulting Engineer

A Four-Monthly Publication of The Association for Consulting Engineering in Nigeria (ACEN)

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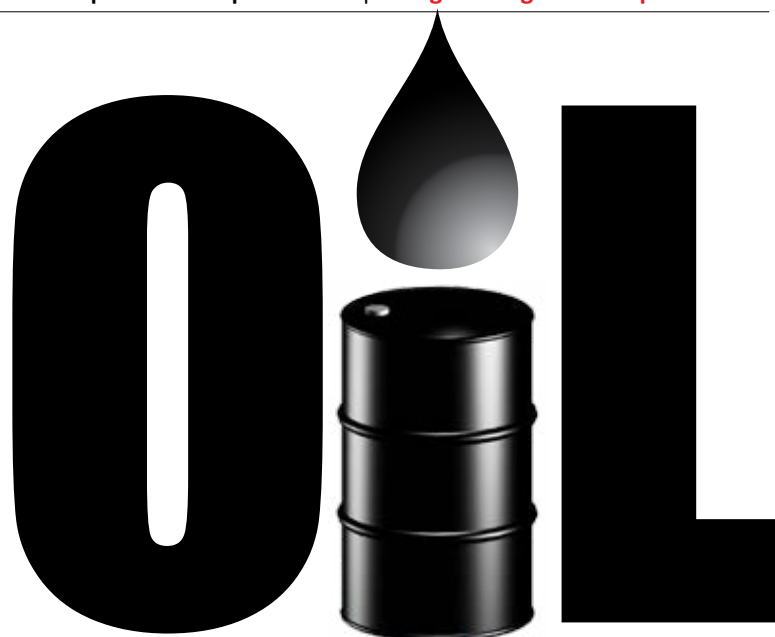
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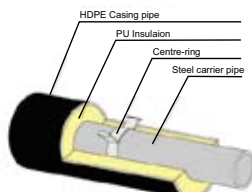
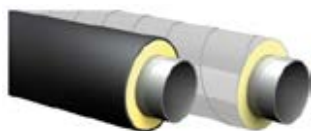
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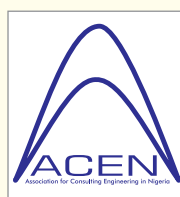


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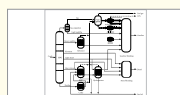
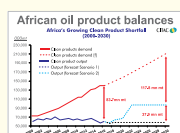
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FROM THE EDITORIAL SUITE

In this edition, the focus is on “Oil & Gas”. The two resources serve as the major revenue spinner in Nigeria. The oil and gas industry is vast. Therefore, the presentations by experts in this edition cover only a representative niche of the industry. The presentations are pointedly vital to the economy and should, therefore, prompt the policy makers to take certain actions that will improve the sector and bring more benefits to the government and the populace.

The 1st article on “Outlook for the Nigerian Petrochemicals Industry” is an eye opener. It is presented by Engr. Anthony Ogbuigwe, FAEng, FNSE, FNSChE, FICHEM, Chair, Governing Board of Centre for Gas, Refining & Petrochemicals, University of Port-Harcourt. Other articles presented are:

- i. Exploring Opportunities & Challenges in the Petroleum Industry Act-2021 by Engr. Onochie Anyaoku, FAEng, FNSE, FNSChE, Partner, Gulf of Guinea Petroleum Consulting Company Ltd
- ii. LPG Domestic Market Perspectives by Mr. Stanley Ezeorah, Business Development Manager & Mrs. Sebilat Quadri, Trading Manager, Gas Terminalling Ltd
- iii. Modern Technological Concepts in Refineries by Engr. Lasisi Ayansola, Fellow, Nigerian Society of Chemical Engineers
- iv. Deepening Indigenous Participation in Oilfield Chemicals Delivery in Nigeria by Engr. Dr. N. John Erinne, FAEng, FNSE, FNSChE, Managing Consultant, Chex & Associates, Past President, Nigerian Society of Chemical Engineers
- v. Petroleum Products Transportation Through Pipelines by Engr. Benedict Peter Akpan, Fellow, Nigerian Society of Chemical Engineers
- vi. Modular Refineries: Technical & Economic Perspectives by Engr. Stephen Idiata, Fellow, Nigerian Society of Chemical Engineers
- vii. The Conversion of Natural Gas to Electric Power: Engineering Perspectives by Engr. Simon Agada, MNSChE, MNSE, MACostE, Deputy Manager, Power Generation, Warri Refining & Petrochemical Company Ltd

Three competent firms in their areas of specialty are featured in the Special Supplement section. They are:



Engr. Ademola Adeboya, MNSE

- i. Boskel Nigeria Ltd, a highly respected firm in thermal process engineering with multiple competences in environmental solutions in the oil & gas industry and other sectors
- ii. Radiatt International Engineering Services Ltd, an experienced firm providing multiple engineering services in the oil & gas industry
- iii. Actolog Solutions Ltd, a renowned customer-centred service provider, marketing the world-class MAKELSAN range of uninterrupted power supply equipment, among other services in the power industry.

Other firms interested in featuring their firm's services and products should send enquiries to acenmagazine@acen.org.ng and they will receive attention. Our assurance to subscribers is that ‘Distinction’ will remain the hallmark of “The Consulting Engineer” magazine.

ACEN events are presented in memorable pictures in the following categories:

- 2021 ACEN Annual General Meeting
- Investiture of the 19th President of ACEN, Engr. Fatai Ajibade Oke, FNSE

We congratulate Engr. Fatai Ajibade Oke on his election to the position of ACEN President and wish him a successful two-year tenure.

Engr. Vincent Nnadi, FNSE, FNSChE, FIDA, FNIM, FIPS, is featured as “The Consulting Engineer” Personality. He retired as the Executive General Manager, Corporate Social Responsibility in TotalEnergies E P Nig. Ltd.

Engr. Enefiok Ubom, in his Tit-Bits column, points to the ‘bright and dark sides’ of Nigeria's petroleum industry. He clearly emphasizes the need to reverse the dark side. Read the details inside.

Finally, we say to all our partners to this edition: “Thank you for your contributions”. We encourage all our readers to continue with actions that will keep them safe and healthy.

Relax and enjoy your reading.

Engr. Ademola Adeboya, MNSE
(Chairman, Editorial Committee)

THE 19TH ACEN PRESIDENT ENGR. FATAI AJIBADE OKE

Engr. Fatai Ajibade Oke was born 27th January 1948. He attended Ilesa Grammar School, Government College, Ibadan and the University of Lagos where he graduated with a B.Sc. Hons degree in Engineering. He also has a Masters degree in Engineering from Ahmadu Bello University, Zaria.

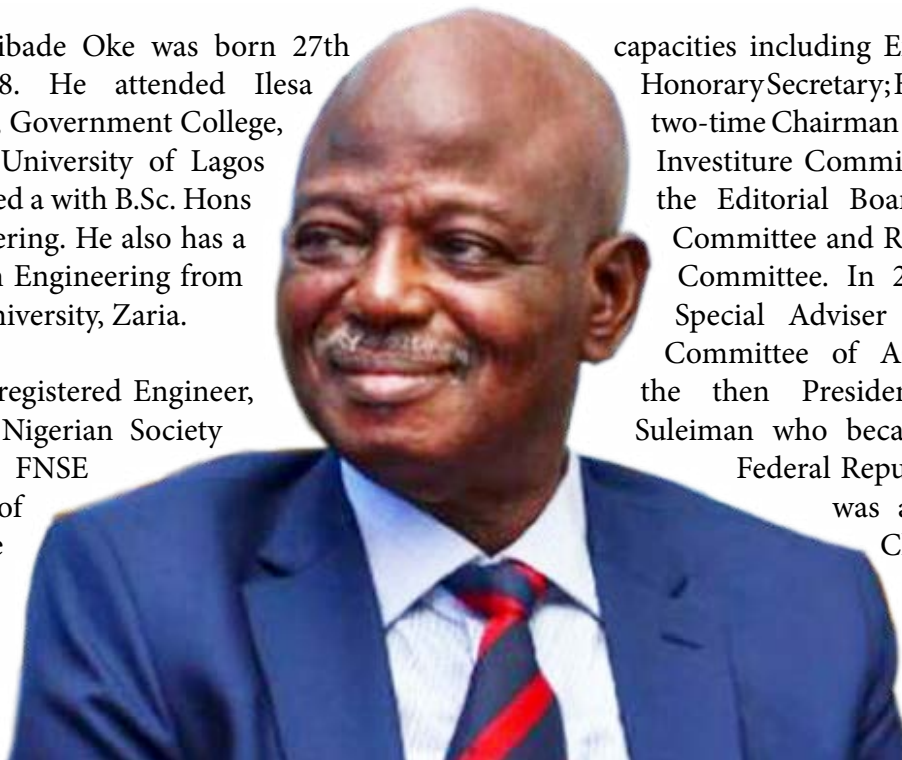
He is a COREN registered Engineer, a Fellow of the Nigerian Society of Engineers – FNSE and a Member of Nigerian Institute of Production Management.

Bade Oke joined Dunlop Nigeria Plc., as a Pupil Engineer in 1972 and rose

steadily through the ranks to become a member of the Board of Directors of the organization as the Sales Director, (Tyres). He retired in 1999 and became the Managing Director and Chief Executive Officer of Jibok Engineering Limited.

He is currently the Managing Executive of Tamilore Associates, a firm of Mechanical and Electrical Consulting Engineers. He was also a Director of Naseng Nigeria Limited. He is a widely traveled Engineer with lots of experience in tyre manufacturing and rubber technology, as well as in the manufacture of carpets and floor tiles, chemical adhesives and paints. He managed the expansion and modernization of the Car Radial Tyres production, a project that cost over Five Billion Naira.

He has assiduously served Association for Consulting Engineering in Nigeria, (ACEN) in many positions and



Engr. Fatai Ajibade Oke, FNSE

capacities including Executive Secretary; Honorary Secretary; Honorary Treasurer; two-time Chairman of ACEN President Investiture Committees; Chairman of the Editorial Board, Salary Review Committee and Revenue Generation Committee. In 2016/2017, he was Special Adviser to the Executive Committee of ACEN representing the then President Engr. Adamu Suleiman who became a Minister of Federal Republic of Nigeria. He

was also, severally, the Chairman of EGM and AGM Planning Committees. In 2018/2019, he was again the Treasurer after which he was elected Vice President of the

Association until his recent appointment as the 19th President of ACEN. Engr. Oke is a member of The Lagos Country Club, Ikoyi Club 1938. He is an avid Rotarian and is a Past President of Rotary Club Ikeja South amongst other distinguished positions he has held in the organisation.

“Engr. Oke is a member of The Lagos Country Club, Ikoyi Club 1938. He is an avid Rotarian and is a Past President of Rotary Club...”

He has received many awards including Merit Award, Association for Consulting Engineering in Nigeria (2015); Presidential Award, Association for Consulting Engineering in Nigeria (2009); Merit Award, Nigerian Society of Engineers, Ikeja Branch (1999); various awards from Rotary International, District 9110 Governors and Rotary Club Presidents to mention a few.

Bade Oke is married to Olabisi Oke and they are blessed with four children and five grandchildren. He is interested in sports, music and travelling.

PRESIDENT'S MESSAGE

The focus of The Association for Consulting Engineering in Nigeria (ACEN) as well defined in its Vision statement and properly expatiated by its mission statements is to be the ultimate group of reference to the Governments and people of Nigeria.

To attain the position, ACEN members must be competent, diligent and up to date in technology. We take pride in these qualities of our members and we constantly strive to improve on their qualities. One of the ways of achieving our goals is the publication of 'The Consulting Engineer,' a magazine published by ACEN thrice a year with different technological themes and associated topics.

The magazine therefore serves as a flagship for what ACEN stands for.

- 1) Informing and educating members on new developments in science and technology. Training members in the practice of the profession as well as in management practice
- 2) Training MDAs and the General Public in Engineering principles and practice. This serves as advocacy tools as it endears the Association to the people. The magazine has a wide coverage.
- 3) With circulation to The National and States assemblies, Universities and Institutions of higher learning, it is a strong advocacy tool for ACEN. It can even ginger the interest of young students in consulting engineering.

The magazine comes out three times in the year. Each publication has a theme and the articles that bear relationships with the themes. This year, the themes are Oil and Gas, Highway Engineering Services and Structures. We have over the years covered most of the aspects of Engineering Consulting, that our members are practicing in like Power (traditional and renewable), Environments including erosion control, transportation, water and sanitation, marine, aviation, mechanical, electrical, geotechnical, traffic control, civil and structures.

We welcome suggestions for themes and topics relating to the themes. We want to show the world that we can stand tall anywhere. We solicit and welcome cooperation and collaboration with our colleagues in MDAs and the general public.

At the beginning of the year the President sends a message analyzing the previous year giving expectation for the current year. Judging from the coverage and the acceptability of all the publications last year we are proud to say the publications achieved the objectives they were set to meet. We are proud of the Editorial Board. We thank the Chairman and members of the board.



Engr. Fatai Ajibade Oke, FNSE

"We welcome suggestions for themes and topics... We want to show the world that we can stand tall anywhere."

This year is full of many other activities that would be mentioned in the magazine. We already had the investiture of the President. We thank God and all for the success. We are hosting African Consulting Engineers (FIDIC Africa) in May. Arrangements are in top gear for a successful event. The chairman and the LOC are doing well.

By the grace of the Almighty, we will serve you with good publications.

Thank you enjoy this first edition of 2022

Engr F. Ajibade Oke, FNSE
(President)

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THE ASSOCIATION FOR CONSULTING ENGINEERING IN NIGERIA (ACEN)

The Association for Consulting Engineering in Nigeria, ACEN, was founded in 1971 and registered in 1979. ACEN is a body of registered independent private engineering consultancy firms and voice of the profession in Nigeria.

MISSION STATEMENT

“ACEN shall build a strong membership that fosters equal opportunities, creates competitive advantage through increased visibility with strategic partners and improves the standards of consulting engineering in line with international best practice”.

VISION STATEMENT

“To remain the ultimate reference business association of choice for organisations providing professional engineering consultancy services in Nigeria.”

FUNDAMENTAL OBJECTIVES

- Ensure that the highest level of technical competence and business ethics are brought to bear on the practice of the profession in Nigeria.
- Ensure that every State has the highest level of Consulting Engineering practice by having members in every state of the federation and the federal capital.
- Increase the number of engineering firms in the country relative to the size of the nation.
- Ensure that stakeholders in the built environment get maximum value for their investments by monitoring standards of practice within the industry.
- Grow the industry by promoting the growth of large consulting engineering firms.

ACEN MEMBERSHIP

Prior to December 2007, ACEN membership was open to individual and firm members, who possessed the required experience and professional integrity. At the 2007 AGM, a motion was passed limiting ACEN membership to firms. This was to further emphasize the business nature and focus of the association. Membership is therefore now open to Consulting Engineering firms with the adequate experience and commitment to continuous improvement in technical and business integrity. Today, ACEN's member firms numbering about 300 are located in the six geo-political zones and the FCT.



ACEN & COREN

The Council for the Regulation of Engineering in Nigeria is the statutory body with responsibility for the regulation of all Engineering activities in Nigeria. It is empowered to keep a register of all Engineering craftsmen, technicians, technologists, Engineers and Consulting Engineering Firms who wish to practice in the country. No individual or organization is allowed to practice Engineering in Nigeria without the approval of COREN. Thus, all member firms of ACEN must be registered with COREN and the members of such firms must also be individually registered by COREN.

ACEN has just recently been mandated by COREN to register on its behalf all consulting engineering firms in the country. Furthermore, ACEN President now seats on the Council of COREN. Thus, ACEN is now better positioned within the built industry.



ACEN & NSE

The Nigerian Society of Engineers is the umbrella association of all graduate Engineers in Nigeria and all Engineers employed in ACEN member firms are members of NSE. Conversely, most members of NSE with interest in Consulting Engineering practice are members of ACEN. ACEN focuses only on the business interest of Consulting Engineering Firms and her interest is, therefore, specific and complementary to the scope of COREN and NSE.



ACEN & FIDIC

The International Federation of Consulting Engineers is a 102-member organisation which provides the strongest platform for our international activities. FIDIC is the voice of Consulting Engineering all over the world, and this it does through seven major focus areas: Representation, Business Practice, Ethics/Integrity, Image, Sustainability, Globalization and Quality.

FIDIC is perhaps best known for its contracts documents, which are used all over the world, especially for international projects in the third world. The documents are used extensively by the Nigerian Federal Ministry of Works. In addition, FIDIC has Manuals on a Guide to Practice that teaches best practice in Consulting Engineering, Business Integrity Management and Quality Management amongst several others.

Two (2) ACEN members, Engr. J.I. Folayan and Engr. Bayo Adeola have served on the FIDIC Executive Committee, the highest level of the organization. Other ACEN members have served on committees and task forces of the organization, and members attend the yearly annual conferences in large numbers regularly.



ACEN & FIDIC Africa

FIDIC Africa is the FIDIC Group of African Member Associations which addresses specifically, African concerns. FIDIC Africa currently has 14 members, holds regular annual conferences and AGMs, and promotes networking among its members. Nigeria played a very active role in the formation of FIDIC Africa and has continued to be very active in the association.

ACEN former President, Engr. (Mrs.) Mayen Adetiba was once Chairman of FIDIC Africa while several ACEN members served on the Executive Committee. The current ACEN President, Engr. George Okoroma, is a member of the FIDIC Africa Executive Committee.

ACEN ACTIVITIES

ACEN provides a series of activities tailored to deliver service and benefits to our members in these key areas:

- Training through the ACEN School of Consulting Engineering.
- AGM & EGM for effective dissemination of information to members.
- Attending International Conferences. Membership / Certifying Standards.
- Advocacy.
- Quarterly Business Evening meetings to discuss topical issues affecting members.
- The Young Professionals Forum.
- Triannual publication of "The Consulting Engineer" magazine.
- Monitoring and follow-up on policies and bills relating to matters of engineering practice.
- Legal retainership program to advise members on legal issues.
- Advancing the practice of consulting engineering for favourable business environment for members.

Setting up of Special Task Forces on:

Collapse of buildings, conditions of engagement/ scale of consultancy remunerations, quackery, Industry study, formation of built industry transparency initiative, local content for the construction industry, etc.

CHALLENGES OF ACEN

Despite the fact that ACEN has been in existence for forty-one (41) years, some of the challenges leading to its formation have remained while new ones have emerged. The most notable current challenges are as follows:

- Unfavourable Government procurement policies especially in the states.
- Private sector perception.
- Loss of Engineers to other sectors due to low remunerations.
- Number, size and scope of ACEN Member firms.
- Delayed payments to members.
- Limited awareness and knowledge of the savings consultants contribute to the overall cost of projects if employed by governments and entrepreneurs.
- Inadequate corporate sponsorship to enhance smooth operations of the organisation.

OUTLOOK FOR THE NIGERIAN PETROCHEMICALS INDUSTRY

BY ENGR. ANTHONY OGBUIGWE



Engr. Anthony Ogbuigwe, FAEng,
FNSE, FNSChE, FICChemE
(Chairman, Governing Board
of Centre for Gas, Refining and
Petrochemicals University of
Port-Harcourt)

1.0 WORLDWIDE OIL & GAS OUTLOOK

The COVID-19 pandemic has had a marked impact on demand for crude oil and gas. On average, global oil demand was lower by 9.3 mbpd (million barrels per day) in 2020 compared with 2019. In reality, demand in April 2020 was estimated to be 29 mbpd lower than in the same period in 2019. During the second quarter of 2020, it fell to 23.1 mbpd below 2019 levels. Recovery occurred gradually from the middle of the year and by year end, the demand was approximately 2.7 mbpd below the levels in December 2019.

As a result of these drops, demand for fossil fuels products from refineries also dropped significantly. Car sales in March 2020 compared with March 2019 dropped by 48% in China, 55% in Europe, 50% in India and 38% in USA. Lower car sales impact on demand for gasoline, which is expected to be depressed going forward. The International Energy Agency (IEA) forecast for 2020 as a whole, was that gasoline demand will decline by 11% or 2.9 mbpd.

Similar impacts are expected to happen with respect to diesel demand. IEA forecasts that diesel demand will decline by an average of 2 mbpd compared with 2019. The lockdowns due to COVID-19 pandemic had an even greater dramatic impact on air transportation. The International Air Transport Association (IATA) estimated that flight capacity utilisation dropped by 65% below 2019 levels in Q2 2020, 40% in Q3 and 10% by Q4. As a result, the overall decline in demand for aviation kerosene was estimated to be 26% or 2.1 mbpd equivalent. Though significant recoveries in air, sea and land transportation and demand for related fossil fuels happened in 2021, the current levels are still below those of 2019.

Conversely, demand for petrochemical products has been increasing due to higher demand by consumers for packaging, personal protective equipment (PPE) especially COVID-19 related masks, face shields, laboratory coats, etc. This trend is likely to continue

as the world adjusts to a new normal after the COVID-19 pandemic. Hence, future demand for petrochemical products is forecast to rise significantly.

2.0 GLOBAL WARMING AND CLIMATE CHANGE CONCERNS

The trends described above are forecast to become even more pronounced in the light of worldwide concerns over global warming. The alarming rise in worldwide temperatures and the attendant disruptions to weather patterns has resulted in a determined effort by nations under the Conference of Parties (COP) to reduce dependence on fossil fuels which drive the release of carbon dioxide into the atmosphere. COP 25 and 26 which held consecutively in Paris and Glasgow resulted in countries making definite commitments to reduce carbon intensity. The drive towards carbon zero or at least carbon neutrality has resulted in targets to phase out production of internal combustion engines (ICEs). Several countries have announced definite dates to stop producing ICEs. Some have stipulated 2030, others 2035 and so on. A significant drop in demand for fossil fuels like petrol, diesel and kerosene is, therefore, a certainty. However, the IEA forecasts that demand for petrochemical products will continue to rise well beyond 2050.

3.0 REFINERY SUSTAINABILITY ENSURED BY LINKAGE TO PETROCHEMICALS

For some years now, there has been excess refining capacity in Europe due to declining fossil fuel demand and tighter legislation on environmental standards, lower sulphur levels in fuels (diesel, gasoline and kerosene), and vehicular emission levels. The Paris Accord has put more stringent controls on release of green house gases, CO_x and NO_x into the atmosphere. Several countries have adopted targets to curb greenhouse emissions by legislation. In some cities like London higher taxes are now in

force penalising internal combustion engine (ICE) cars when they are driven into “CONGESTION ZONES”. Electric vehicles (EVs) which have almost zero emissions are exempted. Hence, we are seeing a growing preferential shift to EVs in Europe, the USA and Asia. Several countries in Europe have adopted firm plans to phase out manufacturing of ICEs. Germany has adopted 2030, France 2035, ditto the United Kingdom.

The net impact of these measures is that several refineries have been shut down and decommissioned in Europe, USA and Asia. Old hydro-skimming and smaller capacity refineries are being squeezed out. Refineries with large capacities, advanced conversion units and hydrodesulphurisation units capable of producing to the modern standards are the survivors. While this trend has been going on since 2010, it has now accelerated.

4.0 IMPACT OF DECLINING CRUDE OIL DEMAND ON NIGERIA'S DEVELOPMENT

The implications of declining demand for crude oil are serious for a country like Nigeria which depends on crude oil for the financing of the nation's budget and development. Coupled with a reduction in demand, is the drastic drop in crude oil price. The double impact is that the Federal and State Governments have had to drastically revise annual budgets downwards in the face of declining revenues from crude oil exports. This is due to the fact that almost 80% of our forex earnings are from crude oil sales. For the first time, Nigerian crude was sold at a discount in Q2 and Q3 2020 in an attempt to find buyers. This situation has only marginally improved.

5.0 POOR ON-STREAM CAPACITY UTILIZATION OF NIGERIAN REFINERIES

For some time now, our local refineries have had very low capacity utilisation and operational reliability. On-stream performance hovered around 20% for many years, but has plummeted within the last three to four years to almost zero. This has been traceable to a number of factors:

- Non-performance of turn-around maintenance
- Lack of a culture of reliability centred maintenance
- Poor governance
- Existence of a system which depends on subventions from NNPC and Government subsidies for the sustenance of the refineries

During the first two to three decades of their operations, the refineries met all of the petroleum product needs of the country and exported the excess. They were operated profitably and did not rely on Government for any bailout. Sadly, the refineries have become cost centres rather than profit centres. This is not sustainable.

6.0 ARE REFINERIES STILL VIABLE?

Yes! Refineries are still viable. In spite of the decline in demand for fossil fuels in the developed world, the IEA forecasts that the demand in Africa will continue to rise from now till 2040 at the least. Indeed, the IEA forecasts that demand in Africa will rise by at least 50%. This is highlighted by the projections in Fig. 1. As at 2016, there was a gap of 83.7million metric tons between demand in Africa and local supply. The gap was met through imports. This gap is projected to grow to 155 million metric

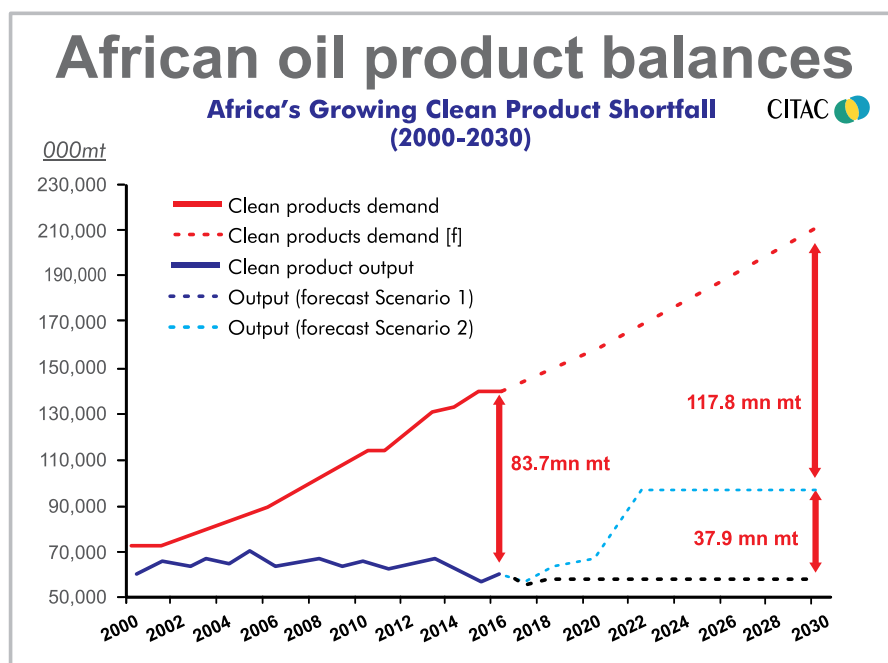


Fig. 1: African oil production balances

tons by 2040, if no new capacity comes on stream in Africa. It is anticipated that if Dangote Refinery comes on stream by 2022/2023, it will reduce the demand-supply gap by about 38 million metric tons.

Currently, 60% to 80% of the gasoline and diesel

fuel consumed in Africa is imported from Europe, the Middle East, Asia and the USA. This is an undesirable and very vulnerable situation which has dire implications for the continent of Africa as a whole and for Nigeria in particular.

Two trends are critical in determining sustainability of the refining sector at this time. The first is that concern about global warming has led to firm plans to de-carbonize transportation. Thus, electric vehicles and other renewable solutions are increasingly favoured. Developed countries have announced firm plans to phase out the manufacture of internal combustion engines (ICEs). Research into hydrogen fuel cells is gaining momentum. The second has to do with the increasing demand for petrochemical products rather than conventional fuel products.

7.0 ENHANCED CONFIGURATION AND PETROCHEMICALS FEEDSTOCK PRODUCTION

Refineries must be designed to competitively produce high value products. This implies full conversion technologies such as fluid catalytic cracking (FCC) or residue catalytic cracking (RCC), continuous catalyst regeneration (CCR), polymerization and

dimerization must be applied for production of feedstock for high value petrochemical products. Refineries must be revamped to reduce their dependence on production of vehicular fuels as the driver for their existence. The shift towards producing feedstock for petrochemical industries is justified by the robust demand for petrochemicals in both the domestic and international markets. Fig. 2 shows African petrochemicals market.

8.0 DEVELOPMENT OF THE NIGERIAN PETROCHEMICAL INDUSTRY

The first petrochemical plants in Nigeria were established in association with the refineries. The Warri Refinery was completed in June 1978 and commissioned in September 1978. It was a 100,000 barrels per day (bpsd) conversion refinery, complete with a naphtha catalytic reforming unit (CRU) and a fluid catalytic conversion unit (FCCU) for gasoline. It was debottlenecked and its capacity increased to 125,000bpsd in 1987. It was merged with the Ekpang Petrochemicals Plant which came on stream in 1988. The combined plants were then incorporated as the Warri Refining and Petrochemicals Company

African Petrochemicals market

Africa is home to 14% of the world's population

Economic development expected to spur polyolefin consumption

Based on planned capacity increases, Nigerian share of African ethylene capacity is expected to drop from 2nd place in Africa with 22% share, to 4th place with 15% share

Strong fundamentals

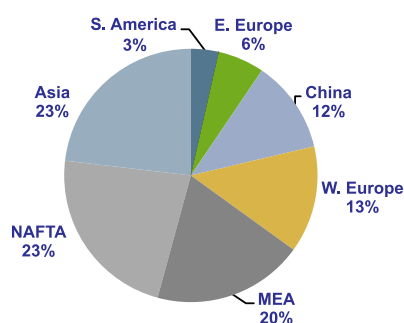
■ Significant scope for growth in African petrochemicals market

- Africa has the world's lowest per capita polyolefin consumption
- light manufacturing industries (particularly packaging and textiles) expected to fuel demand for plastics

Africa's substantial hydrocarbon reserves and low labor costs appeal to potential investors in downstream petrochemicals

- Attractive destination for expansion plans of global players
- Infrastructure gaps and political instability remain constraints across the continent

Global ethylene capacity



...Capacity build up ongoing

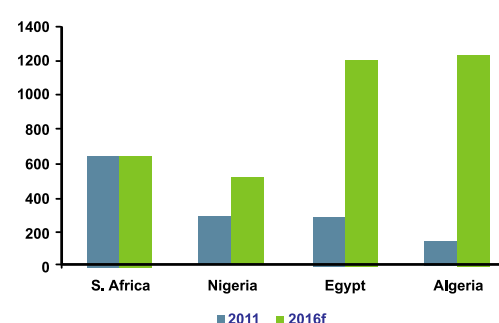
■ Africa's ethylene capacity expected to grow by more than 160% over the next 5 years

- 2 Large projects in Egypt and Algeria
- Several projects announced in Nigeria

■ South Africa's export potential limited by distance from high consumption markets

- S.A. expected to increase supply into the African continent while other producing nations export to developed markets

African ethylene production ('000 Tonnes)



Source: BP Statistical Review 2011, BMI: Nigerian Petrochemicals Industry report 2012

Fig. 2: African petrochemicals market

Developing Nigeria's Petrochemicals

Nigeria has the largest natural gas reserves in Africa

BMI rated Nigeria's business environment as the least attractive among Middle East and African Petrochemical Markets

Future focus on Fertilizer production may benefit first movers like Notore Chemicals

Despite obvious potential, Nigeria must overcome structural problems to attract investments

*Multiplier effect:
14mmt = \$11b
Investment = \$15b
Turnover = \$45b
GDP Impact = 53m
employment*

Strong fundamentals

- Nigeria is well endowed to build a strong petrochemicals industry
 - Abundant natural gas reserves
 - Evidence of significant unsatisfied local demand
 - Good geographical proximity for supply to major European markets

Key players

Eleme Petrochemicals

- Acquired by the Indorama Group in 2006, Eleme's facilities comprise of an NGL cracker, a C5+ distillation unit, Polyethylene (PE) plant and Polypropylene (PP) plant. It has a capacity to produce 240,000 metric tons per year of PE and 95,000 metric tons per year of PP.

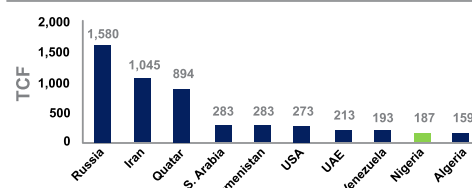
Notore Chemicals:

- Located in Onne, the Notore chemical complex has production capacity of 500,000 tpa

NNPC:

- NNPC is a state owned oil company. Its two refineries in Warri and Kaduna together have 18,000tpa carbon black, 35,000 tpa of PP and 30,000tpa Linear Alkyl Benzene capacity

Significant gas reserves



Investor appetite

- International investors recognize Nigeria's potential
 - In 2011, Natpet, a subsidiary of Saudi Arabia's Alujain Corporation, pledged to invest US\$3.5bn to establish a petrochemical complex in Nigeria
 - India's Nagayjuna Fertilizers and Chemicas also committed to build two fertilizer plants in Nigeria
- There are however limiting factors on the type and quantum of available capital
 - Specialized technology requires extensive and often expensive due diligence
 - Large gaps in required gas infrastructure constrain viability of projects
 - High capital intensity
 - Environmentally intrusive nature of industry limits participation of some potential pools of capital

Source: BP Statistical Review 2011, BMI: Nigerian Petrochemicals Industry report 2012



Fig. 3: Developing Nigeria's petrochemicals

Ltd. The petrochemical plant enabled production of 35,000 metric tons per annum (mtpa) of polypropylene and 18,000 mtpa of carbon black. The Kaduna Refinery was completed and commissioned in August 1980. Like the Warri Refinery, it was a modern conversion refinery, but had two parts: a 50,000bpsd fuels plant with a CRU and an FCCU; and a 50,000bpsd lubes plant for production of lubricating oil blend stocks and waxes and bitumen. Waxy crude required as feedstock for the lubes plant was imported from Saudi Arabia and Venezuela because all Nigerian crudes were naphthenic. The lubes plant was further debottlenecked in 1986 to 60,000bpsd. A linear alkyl benzene (LAB) unit was added in 1988 to produce raw material for the manufacture of detergents. With this addition, the combined plant was incorporated as the Kaduna Refining and Petrochemicals Company Ltd (KRPC). Thus, the nameplate capacity of KRPC is 110,000bpsd.

The major stand alone Eleme Petrochemicals Plant was constructed in Rivers State, completed in 1994 and commissioned in 1995. It was then incorporated as the Eleme Petrochemicals Company Limited and produced polyethylene and polypropylene. This was the first in a planned three phase development of the company which at inception was fully owned by the

Federal Government of Nigeria and operated by the Nigerian National Petroleum Corporation (NNPC). Almost all of its products were sold within Nigeria and led to the real growth of the petrochemicals industry in Nigeria.

After a few years of initial robust production, maintenance issues led to a progressive decline in production. This had a negative impact on the fledgling petrochemicals and plastics production sector in Nigeria. The Nigerian Government then took the decision to privatize the asset. It was sold in 2006 to Indorama Limited of Indonesia, whereupon its name was changed to Indorama Eleme Petrochemicals Limited (IEPL). The second and third phases previously planned by the Government are yet to take off. The production capacity of IEPL was quickly restored to maximum. Indeed, IEPL now caters to the demand for feedstock to plastic processing plants not only in Nigeria but to other parts of Africa and the world. The gas feed olefins plant and the polyethylene and polypropylene plants have a production capacity of 360,000 tons of polyethylene per annum and 120,000 tons of polypropylene per annum. IEPL has established itself as a leading and dependable supplier of more than 42 customised grades of poly-olefins to Africa

“Of note is the construction and commissioning of the huge Dangote Fertiliser Plant in Lekki in March 2022. Nigeria’s current national consumption of fertiliser is 1.5 million metric tonnes per annum. Future needs are estimated at about 7 million metric tonnes per annum.”

and beyond. It also produces 22,000 tons of butene-1 which is used in the production of linear low density polyethylene.

Indorama has expanded the plant and now produces fertilisers as well. It started production in June 2016 and has capacity to produce 2,300 tons per day of ammonia and 4,000 tons per day of granular urea fertilisers.

Of note is the construction and commissioning of the huge Dangote Fertiliser Plant in Lekki in March 2022. Nigeria’s current national consumption of fertiliser is 1.5 million metric tonnes per annum. Future needs are estimated at about 7 million metric tonnes per annum. Dangote Fertiliser Plant has capacity to produce 3 million metric tonnes per annum. Both the Indorama and Dangote fertiliser plants depend on gas as the primary feedstock.

9.0 RECOMMENDATIONS FOR GROWTH OF NIGERIA’S PETROCHEMICALS SECTOR

Fig. 3 which is from a BP 2011 document presented by Stanbic IBTC during an engagement between the Nigerian Society of Engineers and the Manufacturers Association of Nigeria, states the prospects for the growth of the Nigerian Petrochemicals industry.

There is a robust demand in Nigeria for the products which were to have been produced under the previously planned second and third phases of the petrochemical sector. They are presently being imported. They include methanol, vinyl products, emulsion paints, adhesives, fibres, nylon and various pharmaceutical products. We have the abundant gas reserves which will provide feedstock to petrochemical plants to produce these products and more.

To achieve the expected growth we must do the following:

- We must add value to our depleting oil and gas resources.
- i. Dependence on export of primary oil and gas resources is sub-optimal for our economy. Manufacturing within Nigeria to add value to our oil and gas is the most critical need of this country.
- ii. Wealth and GDP growth take place through manufacturing value addition. Jobs and skill development take place only when manufacturing occurs.
- iii. Our high population provides a ready market for manufacturing output. We should take advantage of this and stop robbing ourselves of this advantage by depending on imports.
- iv. The development of our petrochemical sector will enable us achieve the sustainable development goals (SDGs) and move towards achieving our net zero carbon emission targets and commitments as a country.
- v. Finally, we must promote establishment of special economic zones by siting petrochemical plants by providing:
 - Infrastructure (power, water, gas, skilled labour and logistics facilities) therein
 - Incentives to companies willing to come and invest and set up such plants
 - Grant such zones EPZ status.

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EXPLORING OPPORTUNITIES AND CHALLENGES IN THE PETROLEUM INDUSTRY ACT-2021

BY ENGR. ONOCHIE A. ANYAOKU



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1.0 INTRODUCTION

The Petroleum Industry Bill – 2021 was assented to by Nigeria's President, Muhammadu Buhari, GCFR on August 16, 2021, thereby transforming it into Petroleum Industry Act – 2021 (PIA – 2021) to serve as the new law governing the operations of Nigeria's petroleum industry. The industry has a long history and PIA – 2021 has now become part of that history.

Dipping briefly into the past, oil was discovered in Nigeria in 1956 at Oloibiri in the Niger Delta region after half a century of oil exploration. The discovery was made by Shell-BP which was, at the time, the sole concessionaire. Nigeria joined the ranks of oil producers in 1958 when its first field came on stream producing 5,100 barrels per day (bpd). Today, recoverable reserves are estimated at 37.0 billion barrels with an average production of about 1.9 million bpd including condensates. Nigeria's associated and non-associated gas reserves are estimated to be well over 187 trillion standard cubic feet (TCF). This places Nigeria among the top 10 countries in the world. With these huge figures in oil & gas resources and the associated 'petrodollars', the Nigerian government has over the years enacted laws meant to control the operations of various aspects of its petroleum industry. The latest of these laws is the Petroleum Industry Act – 2021.

2.0 PETROLEUM INDUSTRY ACT (PIA) TIMELINES / BACKGROUND

Table 1 provides information in a graphic format on the background/timelines leading to the eventual enactment of PIA – 2021. This enactment brought to a close a 20-year effort to reform Nigeria's oil & gas sector, with the aim of creating an environment more conducive for growth of the sector and addressing legitimate grievances of communities most impacted by extractive industries.

3.0 THE PIA-2021 STRUCTURE

The Petroleum Industry Act - 2021 (PIA-2021) is structured as Chapters, Parts and Sections. It

contains 5 chapters with each chapter is divided into parts. In total, the PIA 2021 has 319 sections, excluding the schedules to the Act. There are 7 schedules attached to the Act, and each schedule is divided into sections as well, while some are divided into Parts and sections.

3.1 CHAPTER 1

Chapter 1 is on governance and institutions. The structure covers sections 1- 65 with Parts I – V. The major highlights are:

- Changes to the Power of the Minister
Proposal to establish the following:
- 'The Commission' known as the Nigerian Upstream Petroleum Regulatory Commission. The Commission will maintain the 'Commission Fund' into which money accruing to the commission shall be paid
- The Frontier Exploration Fund (10% of rents on petroleum prospecting licenses (PPLs) and petroleum mining licenses (PMLs)
- The Environmental Remediation Fund by the Commission or Authority as the case may be.
- Nigerian Midstream and Downstream Petroleum Regulatory Authority ('The Authority')
- The 'Midstream Gas Infrastructure Fund' to promote infrastructural development in the midstream gas operations
- The Nigerian National Petroleum Company Limited (NNPC Ltd)

3.1.1 Minister of Petroleum

- Minister of Petroleum is appointed by the President subject to confirmation by the Senate
- Awards all upstream licenses upon recommendation by the Commission
- Exercises supervisory role in the Petroleum industry on behalf of the Federal Government

3.1.2 Nigerian National Petroleum Company Limited

The Act states that within 6 months from the commencement of this Acts, (which came into effect on Monday August 16, 2021), the Minister shall cause

to be incorporated under CAMA, a limited liability company which shall be called Nigerian National Petroleum Company Limited (NNPC Ltd).

Therefore, it is expected that by January 2022, NNPC Ltd would have been incorporated in line with this ACT & CAMA Ownership of all shares in NNPC Ltd will be held by Minister of Finance Inc. on behalf of the Federal Government.

NNPC Limited and any of its subsidiaries shall conduct their affairs on a commercial basis without recourse to government funds and their memorandum and articles of association shall state these restrictions.

NNPC no longer required to play the role of concessionaire under production sharing contracts (PSCs).

3.2 CHAPTER 2

Chapter 2 covers Administration. The structure covers sections 66 – 233 divided into seven parts – Parts I – VII. The Act introduces the following:

- Petroleum Exploration License (PEL) to replace the existing Oil Exploration License
- Petroleum Prospecting License (PPL) to replace the existing Oil Prospecting License (OPL)
- Petroleum Mining Lease (PML) to replace the existing Oil Mining Lease (OML)

3.3 CHAPTER 3

Chapter 3 deals with host communities development. In structure, it covers sections 234 – 257. The major highlight is:

- The Host Community Development Trust (HCDDT) - funded by the settlers to the tune equivalent to 2.5% of their actual annual OPEX

3.4 CHAPTER 4

Chapter 4 covers the Petroleum Industry Fiscal Framework. In

structure, it covers sections 258 – 306 divided into Parts I – XI. The Act introduces the following:

- Hydrocarbon Tax (HT) which effectively repeals the PPT
- Production Allowance and discards the Petroleum Investment Allowance and Investment Tax Credits.

3.5 CHAPTER 5

3.5.1 REPEALS

In view of PIA – 2021, the following laws are repealed:

- Associated Gas reinjection Act, 1979 CAP A25 Laws of the Federation 2004 and its Amendments
- Hydrocarbon Oil Refineries Act No. 17 of 1965, CAP H5 Laws of the Federation of Nigeria 2004
- Motor Spirits (returns) Act, CAP M20 Laws of the Federation of Nigeria 2004
- Nigerian National Petroleum Corporation (Projects) Act No. 94 of 1993, CAP N124 Laws of the Federation of Nigeria 2004
- Nigerian National Petroleum Corporation Act (NNPC) 1977 No. 33 CAP N123 Laws of the Federation of Nigeria as amended, when NNP ceases to exist pursuant to section 54(3) of the PIA 2020
- Petroleum Products Pricing Regulatory Agency (Establishment) Act 2003
- Petroleum Equalization Fund (Management Board, etc.) Act, 1975
- Petroleum Profit Tax Act Cap P13 LFN 2004
- Deep Offshore and Inland Basin Production Sharing Contract Act 2019, as amended

4.0 OPPORTUNITIES IN PIA – 2021

Petroleum earned the name “Black Gold” not just because it appears black when it comes out of the ground but because of the notion that oil business made those involved in it to be rich. Opportunities abound in PIA – 2021 to grow Nigeria’s oil earnings and make the country as well as other stakeholders in the industry to be rich. This will come about through the achievement of all the objectives stipulated in the Act. Some of these key objectives are as follows:

4.1 CHAPTER 1

Key objectives of the chapter are:

- Create efficient and effective governing institutions with clear and separate roles for the petroleum industry
- Establish a framework for the creation of a commercially oriented and profit-driven national petroleum company
- Promote transparency, good governance and accountability in the administration of the petroleum resources in Nigeria
- Foster a business environment conducive for petroleum operations

4.2 CHAPTER 2

The key objectives include:

- Create a conducive business environment for operations in the petroleum industry
- Promote the liberalization of the downstream petroleum industry

“The Petroleum Industry Act – 2021 has come to stay.”

- Promote the exploration and exploitation of petroleum resources in Nigeria for the benefit of the Nigerian people
- Promote the efficient, effective and sustainable development of the petroleum industry

4.3 CHAPTER 3

The key objectives are:

- Foster sustainable prosperity within host communities
- Provide direct social and economic benefits from petroleum operations to host communities
- Enhance peaceful and harmonious co-existence between licensees or leases and host communities
- Create a framework to support the development of host communities

4.4 CHAPTER 4

The key objectives are:

- Establish a progressive fiscal framework that encourages investment in the Nigerian Petroleum Industry, balancing rewards with risk and enhancing revenues to the federal government of Nigeria
- Provide a forward looking fiscal framework that is based on core principles of clarity, dynamism and fiscal rules of general application
- Establish a fiscal framework that expands the revenue base of the Federal Government, while ensuring a fair return for investors
- Simplify the administration of petroleum tax
- Promote equity and transparency in the petroleum industry fiscal regime

5.0 CHALLENGES ASSOCIATED WITH PIA – 2021

The following enumeration provides the major challenges which are considered to be associated with PIA – 2021 as enacted:

- The Commission and Authority are exempted from the provisions of any enactment relating to the taxation of companies or trust fund
- Non compliance with the principle of corporate governance laws in the appointment to the Board of NNPC Ltd
- Preventing Public Officers employed within the implementation of this Act not to be sued or to sue as the case may be...
- Imposition of up to 1% levy on the wholesale price of petroleum products sold in the country (0.5% each for the Authority and the Midstream Gas Infrastructure Fund)
- Lack of stabilization and contract enforcement provisions be provided for to ensure investment stability, and existing/legacy gas contracts, whether domestic or for export
- Tax deduction on interest on monies borrowed is subject to the satisfaction of the Commission that the fund was employed for upstream operations and the interest rates reflect market conditions
- Lack of Equity ownership by the host communities for the petroleum operations being carried on in their communities should be promoted

- Making the Host Communities responsible for FIRST LINE PROTECTION of facilities in their communities
- Ignoring the equity ownership by host communities, making provision that could marginalize the Host Community members from being part of the HCD BoT, and then expecting their full vested interest in being the first line of protection for the Settlers' facilities raises concerns

Other issues – Corporate governance

- Section 61(2) Application of Principle of Corporate Governance. Who are the Shareholders of NNPC? It is only a shareholder who holds a minimum of 10% of the voting interests in NNPC Limited that can request for a comprehensive written explanation of any section or decision taken by the Board of NNPC Limited. This negates the objective of transparency, accountability and good governance. The shareholders of NNPC Limited are the citizens but they do not have voting rights, hence they cannot put in such request. The principle of good governance should allow for any civil society organization or other invested or interested party to be able to put in such request. Besides the section stipulates that NNPC Limited may decide or can decide to withhold such explanation given the confidentiality agreement between NNPC Limited and a third party to which such information relates.

6.0 CONCLUSION

The Petroleum Industry Act – 2021 has come to stay. Looking to the future, this complex law can only be amended to serve the interests of the government, oil producing communities and oil explorers better than in its present form.



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LPG DOMESTIC MARKET PERSPECTIVE

BY MR. STANLEY EZEORAH & MRS. SEBILAT QUADRI

1.0 INTRODUCTION:

Liquefied petroleum gas (LPG) is a portable, clean and efficient source of energy. It is a mix of hydrocarbons with 3 (C3 – propane) and 4 (C4 – butane) carbon atoms, receiving its name from the fact that it can be liquefied by compression at room temperature. It is readily available to consumers around the world and is obtained during the extraction of crude oil or natural gas or from the refining of crude oil.

LPG has more than 1000 applications. It is used in transportation, commercial business, industry, farming, domestic heating and cooking, and recreational purposes. LPG has an exceptional advantage over other domestic sources of energy. These advantages include:

- Clean burning
- High energy value in addition to good flame control
- Easy to store and transport
- No spillage
- No soot
- Burners have a longer life hence maintenance is low.
- Environmentally friendly fuel with minimum sulfur contents & sulfur-free emissions, therefore, LPG can make a positive contribution to air quality improvement compared to diesel, kerosene, heating oil and solid fuels.



Mr. Stanley Ezeorah, Business Development Manager & Mrs. Sebilat Quadri, Trading Manager, Gas Terminalling Ltd, Lagos



2.0 DOMESTIC MARKET

In Nigeria, the Standards Organization of Nigeria (SON), and the Nigerian Midstream and Downstream Petroleum Regulatory Authorities (NMDPRA) are among the government agencies that provide standards, regulatory and operational policy frameworks for the LPG industry across the value

chain (See Fig.1). Required operational permits can be processed online on the NMDPRA website.

The current standard of LPG approved in the country is the standard defined in NIS:555 2020 which describes the minimum standards required for Liquefied Petroleum Gas (LPG) in Nigeria.

The Federal Government of Nigeria published the National Gas Policy and the National Petroleum Policy in the official gazette in December 2017 to replace the 2008 Nigerian Gas Master Plan. The National Gas Policy commits to ending gas flaring, creating an enabling environment for investors, seeking value addition for gas, and improving governance in the sector.

The Nigeria LPG Association, World LPG Association, Women in LPG and other industry stakeholders have been actively involved in LPG advocacy and safety awareness/training on safe handling to eliminate bad practices and substandard

operations in the country so as to safely deepen LPG penetration.

The domestic market has been experiencing a substantial yearly increase since 2017. According to the Nigeria LPG Association, LPG consumption rose to 1,000,000 metric tonnes in the year 2020, from 500,000MT yearly, due to increased demand which is a remarkable milestone for the domestic LPG market.

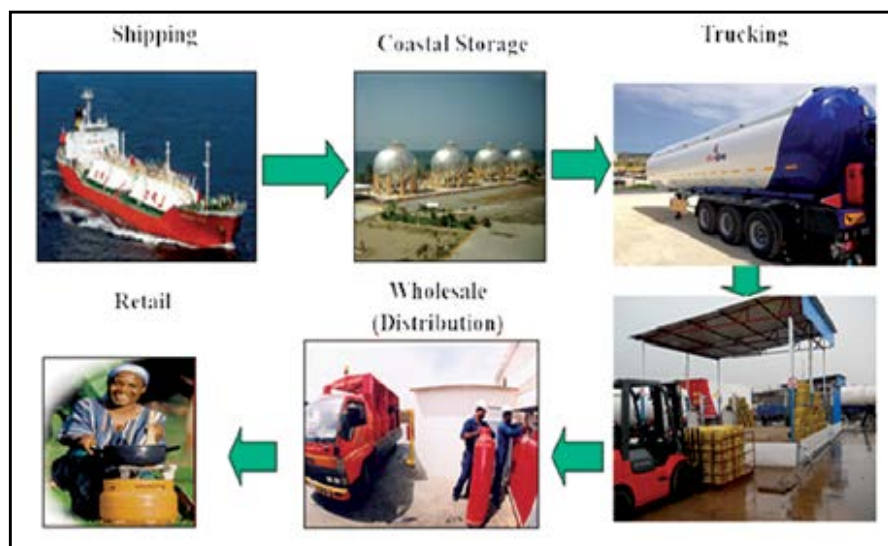


Fig. 1: LPG value chain

3.0 ENGINEERING PERSPECTIVE

3.1 LPG FILLING PLANT

LPG filling plants are facilities where LPG is filled into bottles (cylinders), stored and distributed. The plant receives LPG in bulk from different trucks of various capacities e.g 10MT, 20MT, 25 MT, 40 MT, etc., or pipelines from coastal terminals, processing plants or refineries.

LPG cylinder filling plants vary considerably in size, complexity and layout. The type and size depend on such factors as maximum potential throughput requirements, size and type of cylinder filled and the number/grades of products handled. The available land and budget are, of course, two other important factors when deciding on the investment.

The detailed design of filling plants, and the associated cylinder filling equipment, should be undertaken by an appropriate supplier based on the required performance specification. Some suppliers may have ISO 9001 accreditation or be working towards obtaining the accreditation. This will assure quality of business systems operations.

The plant specification should comprehensively cover the throughput, safety and quality requirements over various phases of development.

The following are among the essential aspects of the specifications:

- i. The set-up should conveniently allow the basic operations to be undertaken in the filling plant and maintenance areas e.g., cylinder inspection, cylinder filling, leak testing, checks to ensure no overfilling, cylinder evacuation and vapor recovery, valves reinstallation, cylinder requalification, maintenance and repair of cylinders, grit blasting, painting, etc.
- ii. Facilities should be provided to handle the products, including contaminated products encountered in the marketplace that need to be stored.
- iii. There should be a listing of all the relevant standards and legislation the plant is to comply with including health, safety, and environmental (HSE) requirements affecting personnel engaged in the operation of the plant and the protection of people and property in offsite areas.
- iv. Licensing and other requirements for operating an LPG plant should be in place. This should include a full risk analysis to identify any

potential hazards. LPG cylinder filling plants should be in industrial zones well away from centers of population

- v. The facility should adequately provide for the number of cylinder types/sizes and cylinder valve types involved as well as storage areas for full and empty cylinders.
- vi. The facility should adequately provide for the projected throughput per product, per cylinder size/type, per cylinder valve type, over the planning period and peak daily/weekly/monthly demand.
- vii. The plant capacity should be adequate for the number of productive operating hours available over the planning period and peaks.
- viii. Details of all operations and limits/tolerances related to each operation should be known e.g., filling accuracy, weighing accuracy and detectable leak, .
- ix. Manning levels, the degree of automation, method of transporting and handling cylinders should be established in the project development stage.
- x. The project should have capacity of requalification, repair, maintenance.
- xi. Requirements set out in the relevant codes of practice, standards and regulations in the country of use should be known.
- xii. The filling and storage (other than temporary storage) of cylinders are operations that should not be undertaken within the same building.

3.2 HANDLING, SAFE STORAGE & USAGE OF LPG CYLINDERS

Cylinders containing compressed gases are heavy and awkward to move. Improper handling of compressed gas cylinders can result in sprains, strains, falls, bruises or broken bones. Other hazards such as fire, explosion, chemical burns, poisoning, and cold burns could occur if gases accidentally escape from the cylinder due to mishandling.

The following precautions should be taken to prevent an accident while handling gas cylinders:

- i. **Handling: Never do the following:**
 - Drag or slide cylinders, even for short distances
 - Drop cylinders or permit them to strike each other violently
 - Subject cylinders to mechanical shocks that may cause damage to their valves

- Use cylinders as rollers for moving material or other equipment
- Tamper with pressure-relief devices
- Permit oil, grease, or other readily combustible substances to come in contact with cylinders, valves or other equipment in oxidizer service
- Remove any product labels or shipping hazard labels
- Refill compressed gas cylinders by yourself because this has to be done only by qualified producers of compressed gases
- Lift a cylinder by its cap using a sling or a magnet
- Attempt to catch a falling cylinder

ii. Handling: Always do the following:

- Move cylinders using a suitable hand truck or cart
- Leave the valve protection cap and valve seal outlet in place until the cylinder has been secured in place and is ready to be used
- Secure cylinders when in storage, transit or use
- When returning cylinders to the supplier, properly close the cylinder valve, replace and secure any valve outlet seals and properly install the cylinder cap
- Use a cylinder cage or cradle to lift a cylinder
- Use the proper PPE for cylinder handling (safety glasses with side shields, leather gloves, safety shoes, and other appropriate equipment)
- While handling portable banks:
 - o Use extreme care and restrict the movement of portable banks to localized movement on clean, smooth, level stationary surfaces
 - o Use two people for localized manual movement of a portable bank
 - o Stay out of the bank's travel path
 - o Be aware of escape routes should the bank get out of control or start falling
 - o If a smooth, level surface is not available over which to move the portable bank, use a forklift, crane, or other appropriate moving equipment

iii. What to do when cylinders are in use

- All cylinders must be equipped with pressure regulators designed specifically for domestic LPG, which will regulate the internal pressure of the cylinder when subjected to heat, thereby preventing an explosion
- Use the correct regulator for the type of gas cylinder
- Always follow the instructions supplied when connecting the pressure regulator to the cylinder

- and do not open the cylinder valve or regulator tap until the pressure regulator is securely attached
- Never smoke while connecting the equipment and DO NOT check for leaks with a flame
- Examine the washer of the pressure regulator or valve before connecting each new cylinder. If the rubber looks worn or damaged, replace it

iv. Cooking

- Make sure the cylinder is upright
- Place the gas cooker and cylinder above ground level with the cooker positioned higher than the cylinder
- Ensure that the rubber hose does not touch the surface of the cooker
- Ignite correctly. The correct way to ignite a non-automatic cooker is as follows:
 - * Light a match
 - * Put the flame on the burner
 - * Turn on the cooker's valve
- When cooking, keep doors and windows open
- Do not rest hot cooking appliances on the cylinder
- Never subject the cylinder to excessive heat
- Turn off the valve or regulator tap when you have finished cooking
- If you will not be using the cylinder for a while, remove the regulator and seal the valve nozzle with the red safety cap provided
- Do not let children handle the cylinders or appliances

v. Safety Checks

- Regularly check your hose for signs of damage or cracking
- Check the hose connection for leakages by applying a soap solution. DO NOT test with a naked flame
- Hoses should be replaced every 2 years as they deteriorate over time. Hoses can be obtained from licensed LPG firms or their approved dealers

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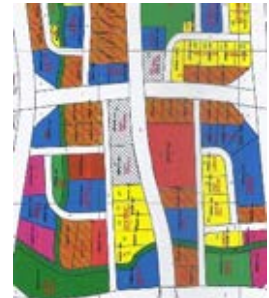
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Boskel was incorporated in August 1989 and commenced business immediately to provide Thermal Process Engineering and Environmental Management solutions. Boskel is wholly owned by Nigerians and operates with 100% Nigerian staff focusing on developing local solutions while maintaining international standards.

In January of 1991, Boskel embarked on the development of its patented passive Smokeless Flare System for the Oil & Gas industry. Shell Petroleum Development Company (SPDC) immediately became interested and after conducting several pilot tests on the Boskel Smokeless Flare system, began replacing its older smoky flare systems with Boskel Smokeless Flare system. The first commercial Boskel Smokeless Flare equipment was installed at Kokori flow station of Shell Petroleum Development Company in July 1992. Since then, over 400 Boskel

Smokeless Flare units have been built and installed for Shell Petroleum Development Company, AGIP, Seplat, etc in Nigeria and other locations including the Sultanate of Oman.

Following the success of the Smokeless Flare system, Boskel began developing Incinerators for treatment of hazardous and municipal wastes in 1995. Currently, we have designed and built several fully operational units for disposal of highly hazardous Industrial & medical wastes in various industries and disposal of municipal wastes for various government agencies. Today, Boskel operates and manages a fully staffed and equipped Waste Management facility complete with Rotary Kiln Incinerators, Thermal Desorption Units, Pyrolyzers and emission control monitoring units necessary for proper disposal operations. Boskel's headquarters is located on BOSKEL Road, Km. 17 Port-Harcourt - Aba Expressway, Port Harcourt, Nigeria.

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- 1991 DEVELOPMENT OF BOSKEL'S SMOKELESS FLARE SYSTEM
- 1992 FIRST FLARE SYSTEM COMMISSIONED IN SHELL
- 1996 DEVELOPMENT OF OIL SLOP BURNERS
- 1997 DEVELOPMENT OF BOSKEL'S INCINERATORS
- 1999 WASTE MANAGEMENT FACILITY SET UP IN P.H.
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- 2002 ADMISSION INTO HALL OF FAME (NIG. SOC. OF ENGRS)



Boskel High Temperature Rotary Kiln Incinerator for destruction of hazardous industrial and medical wastes

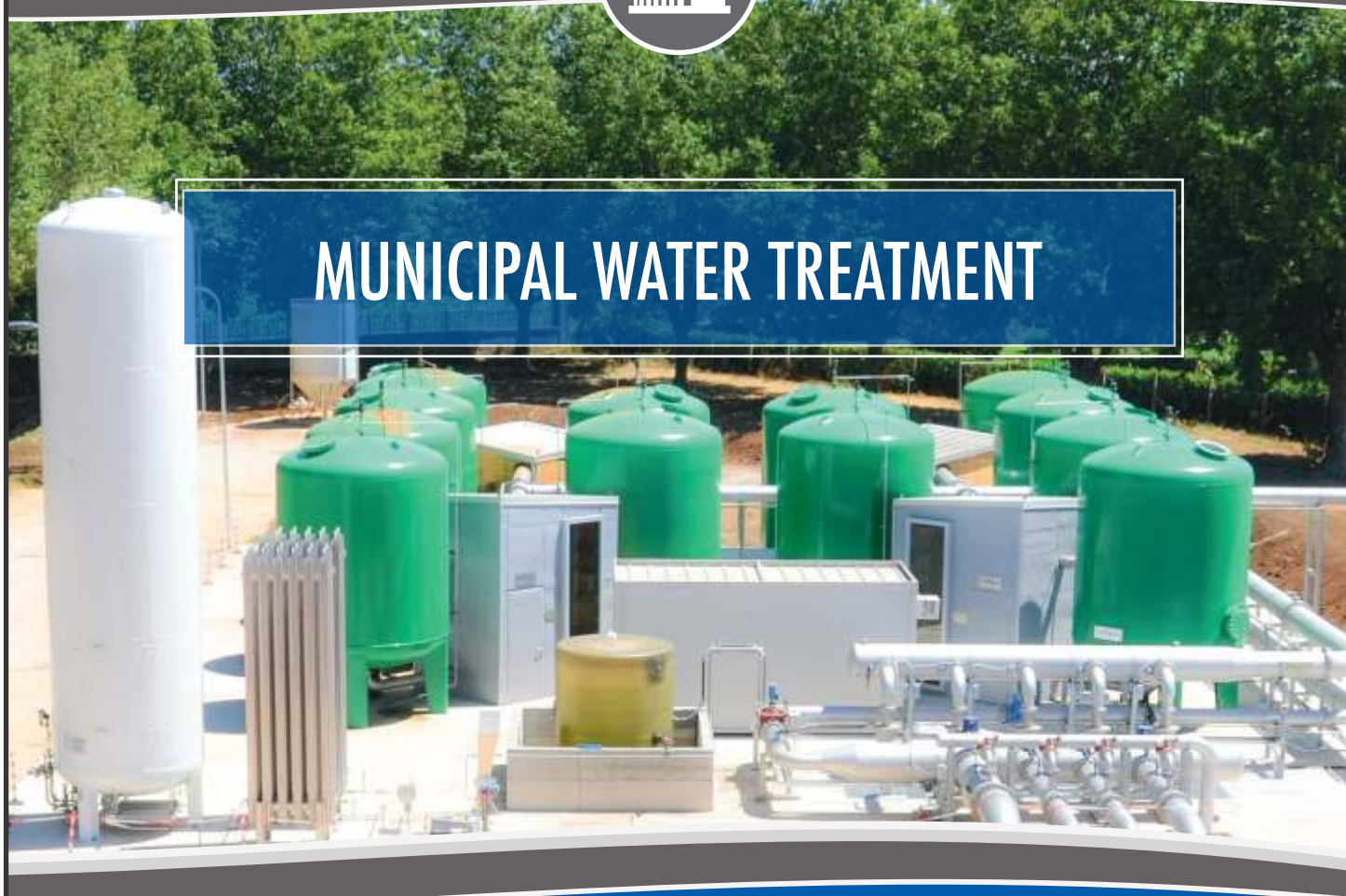


- 2003 NATIONAL HONOURS AWARD (MFR)
- 2004 DEVELOPMENT OF BOSKEL'S HIGH TURNDOWN FLARE SYSTEM
- 2005 FIRST FOREIGN ORDERS FOR FLARES RECEIVED FROM OMAN
- 2006 EXPORT OF FLARES START TO THE MIDDLE EAST
- 2007 FIRST FOREIGN FLARE COMMISSIONED IN OMAN
- 2007 FIRST ORDER FOR MED. WASTE INCINERATOR RECEIVED
- 2008 COMMISSIONING OF FIRST MED. WASTE INCINERATOR
- 2009 COMM. OF INCINERATORS AT LUTH, OWO, ILORIN AND ABUJA
- 2009 ORDER FOR INCINERATOR FOR NATIONAL HOSPITAL RECEIVED
- 2010 COMMISSIONING OF NATIONAL HOSPITAL INCINERATOR
- 2011 COMMISSIONING OF INCINERATORS AT ZARIA, GUSSAU, KATSINA ETC
- 2012 SECURED CONTRACT FOR INT. WASTES MGT FACILITY FOR ASABA
- 2014 STARTED TEST RUNNING OF THE ASABA WASTES MGT FACILITY
- 2018 DELIVERED OUR ROTARY KILN INCINERATOR FOR NLNG
- 2021 COMMISSIONING OF THE INCINERATOR FOR NLNG





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2021 ACEN AGM



(L - R): Past President of ACEN, Engr. K. A. Adeola, FNSE, FAEng; Vice President, Engr. F. Ajibade Oke, FNSE; Past President of ACEN, Engr. Y. O. Sagaya, FNSE, FAEng, MFR, OFR



Immediate Past President of ACEN, Engr. Charles 'Yele Akindayomi, FNSE; Honorary Treasurer, Engr. Kam-Selem Bukar, FNSE and a cross section of participants.



(L - R): ACEN President, Engr. George C. Okoroma FNSE, JP with Past Presidents, Engr. K. A. Adeola, FNSE, FAEng and Engr. (Mrs.) Mayen Adetiba, FNSE, FAEng; (back left) ACEN Managing Director, Engr. Kalejaiye Sunday, MNSE.



At the High Table, (L - R): Past President, Engr. (Dr) J. I Folayan, FNSE; President, Council for the Regulation of Engineering in Nigeria (COREN), Engr. Ali Rabi'u, FNSE; ACEN President, Engr. George C. Okoroma FNSE, JP and the Director, Environmental Assessment of the Federal Ministry of Environment, Mr. Abbas Suleiman, fnes.

INVESTITURE OF 19TH ACEN PRESIDENT



L – R: Engr. F. Ajibade Oke, FNSE in company of his wife, Mrs. Olabisi Oke, being presented as the incoming President of ACEN by the outgoing President, Engr. George C. Okoroma FNSE, JP and the ACEN Honorary Treasurer, Engr. Kunle Adebajo FNIStructE, at the event.



ACEN President, Engr. F. Ajibade Oke FNSE (2nd left) in company of his wife, Mrs. Olabisi Oke, being decorated as the 19th President by the 18th President, Engr. George C. Okoroma FNSE, JP and supported by the ACEN Honorary Treasurer, Engr. Kunle Adebajo, FNIStructE, at the event.



ACEN President, Engr. F. Ajibade Oke FNSE (3rd from left) flanked on the left by the ACEN Vice President, Engr. Kam-Selem A. Bukar, FNSE and Associate Professor of the Department of Business Administration, University of Lagos, Dr Sunday Abayomi Adebisi, representative of the Guest Speaker, Engr. Prof. Ayodele Francis Ogunye, FAEng, FNSChE, FNSE; and flanked on the right by former Minister of Works, Senator Adeseye Ogunlewe, representative of the Chairman, Senator Engr. Anthony Adefuye, FNSE; Special Adviser to the Governor on Works & Infrastructure, Engr. (Mrs.) Aramide Adeyoye, representative of the Guest of Honour, the Executive Governor of Lagos State, Mr. Governor, Babajide Olusola Sanwo-Olu; Deputy Chief of Staff to Oyo State Government, Hon. Wale Mogbonjubola, representative of the Guest of Honour, Oyo State Governor, HE Engr. Oluseyi Abiodun Makinde, FNSE and ACEN Honorary Treasurer, Engr. Kunle Adebajo, FNIStructE.



ACEN President, Engr. F. Ajibade Oke, FNSE, giving his inaugural speech.



ACEN President, Engr. F. Ajibade Oke, FNSE, presenting an award of recognition to the Chairman of the occasion, Engr. Senator Anthony Adefuye, FNSE, who was ably represented by former Minister of Works, Senator Adeseye Ogunlewe.



ACEN President, Engr. F. Ajibade Oke FNSE presenting an award of recognition to the Guest of Honour, the Executive Governor of Lagos State, Mr. Governor, Babajide Olusola Sanwo-Olu who was ably represented by the Special Adviser to the Governor on Works and Infrastructure, Engr. (Mrs.) Aramide Adeyoye.



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MODERN TECHNOLOGICAL CONCEPTS IN REFINERIES

BY ENGR. LASISI A. AYANSOLA



Engr. Lasisi A. Ayansola, FNSCh
(Chemical Engineer)

1.0 INTRODUCTION

The refining of crude petroleum owes its origin to the successful drilling of the first oil wells in Ontario, Canada in 1858 and in Titusville, Pennsylvania, USA in 1859 (Carruthers, 2019). Crude oils are complex mixtures of hydrocarbons, that is, chemical compounds composed only of carbon (C) and hydrogen (H). Petroleum provides a relatively cheap and convenient source of energy as compared to coal.

2.0 DEVELOPMENT OF OIL REFINING

Since the discovery of oil in northwestern Pennsylvania, there has been series of developments in the refining industry globally leading to the application of modern technologies. This paper focuses more on the modern technologies.

3.0 MODERN REFINERIES

Petroleum refineries are large, capital-intensive, continuous flow manufacturing facilities. Fig. 1 shows a schematic diagram of a refinery and Table 1 itemizes the physical and chemical transformations (processes) in refineries.

4.0 CLASSIFICATION OF REFINERIES BY CONFIGURATION AND COMPLEXITY

Each refinery's configuration and operation characteristics are unique. The term, configuration,

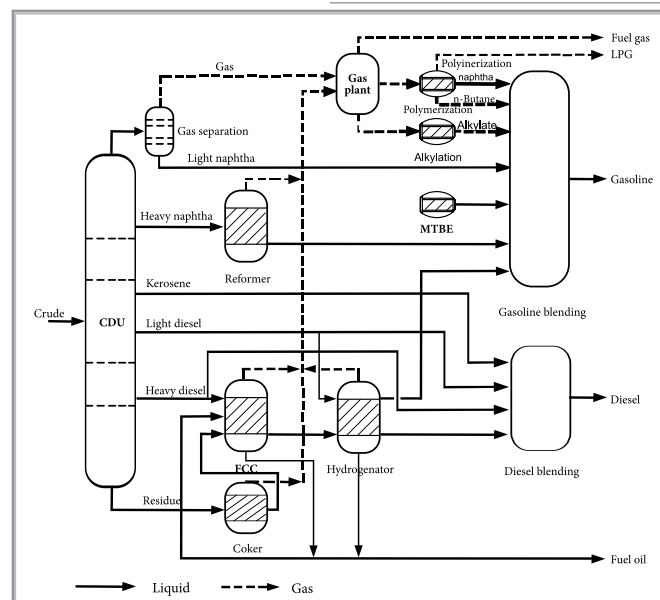


Fig. 1: Schematic diagram of a refinery

PHYSICAL	CHEMICAL	
	THERMAL	CATALYTIC
Distillation	Visbreaking	Hydrotreating
Solvent extraction	Delayed Coking	Catalytic reforming
Propane deasphalting	Flexicoking	Catalytic cracking
Solvent dewaxing		Hydrocracking
Blending		Catalytic dewaxing
		Alkylation
		Polymerisation
		Isomerisation

Table1: Physical & chemical transformations in a refinery

denotes the specific set of refining process units in a given refinery, the size, that is, throughput capacity, of the various units, their salient technical

1	SEPARATION	a. Distillation	b. Solvent Refining		
2	CONVERSION	c. Carbon Removal	d. Hydrogen Addition		
3	REFORMING	e. Catalytic reforming	f. Steam hydrocarbon reforming		
4	REARRANGEMENT	g. Isomerisation			
5	COMBINATION	h. Catalytic polymerisation	i. Alkylation		
6	TREATING, FINISHING, BLENDING	j. Gasoline, kerosene and diesel	k. Lubes and waxes	l. Asphalt	
7	PROTECTING THE ENVIRONMENT	m. Waste water treatment	n. Disposal of solids	o. Sulphur recovery	
8	STORAGE AND MOVEMENT OF OIL	p. Receipt of crude oil	q. Storage of crude oil	r. Storage of intermediates and finished products	s. Shipping of finished products

Table 2: Basic operations in modern petroleum processing

characteristics and the flow patterns that connect these units.

The term, complexity, has two meanings. One is its non-technical meaning and this implies intricate, complicated system consisting of many connected parts. The other is a term of art in the refining industry implying a numerical score that denotes, for a given refinery, the extent, capability and capital intensity of the refining processes downstream of crude distillation unit (CDU) which by definition has complexity of 1.0.

The higher a refinery's complexity, the greater the refinery's capital investment cost and the greater the refinery's ability to add value to crude oil by:

- Converting more of the heavy crude fractions into light, high-value products
- Producing light products to more stringent quality specifications. An example is ultra-low sulphur fuels (ULSF).

In general, all refineries belong to one of the four classes listed in Table 3 defined by process configuration and refinery complexity.

Configuration	Complexity	
	Ranking	Range
Topping	Low	< 2
Hydro-skimming	Moderate	2-6
Conversion	High	6-12
Deep Conversion	Very High	> 12

Table 3: Refinery classification scheme

4.1 BRIEF DISCOURSE ON REFINERY CLASSIFICATION

- Topping Refineries:** These refineries have only crude distillation and basic support operations. They have no capacity to alter the natural yield pattern of the crude oils that they process. They simply separate crude oil into light gas and refinery fuel, naphtha (gasoline boiling range), distillates (kerosene, jet fuel, diesel and heating oils) and residual or heavy fuel oil. A portion of the naphtha may be suitable for very low octane gasoline in some cases. They have no facilities for controlling product sulphur levels, hence cannot produce ultra-low sulphur fuel (ULSF).
- Hydro-Skimming Refineries:** They include not only crude distillation and support services but also catalytic reforming unit, various hydro-treating units and product blending unit. These

processes enable (1) upgrading of naphtha to gasoline and (2) controlling the sulphur content of refined products. Catalytic reforming upgrades straight-run naphtha to meet gasoline octane specification and produces hydrogen as by-product for the hydro-treating units. Hydro-Treating units remove sulphur from the light products including gasoline and diesel to meet product specification and/or to allow for processing crude oils having higher sulphur content.

- Conversion or Cracking Refineries:** These include not only all of the processes present in hydro-skimming refineries but also catalytic cracking and /or hydro-cracking units. These two conversion processes transform heavy crude oil fractions primarily gas oils, which have high natural yields in most crude oils, into light refinery streams that go to gasoline, jet fuel, diesel and petrochemical feed stocks.

These refineries have the capacity to improve the natural yield patterns of the crudes they process as needed to meet market demands for light products, but they still unavoidably produce some heavy, low –value products, such as residual fuel and asphalt.

- Deep Conversion or Coking Refineries:** These are, as the name implies, a special class of conversion refineries. They include not only catalytic cracking and/or hydro-cracking to convert gas oil fractions, but also coking. Coking units process the heaviest and least valuable crude oil fraction (residual oil) by converting it into lighter streams that serve as additional feed to other conversion processes. Such other conversion processes include catalytic cracking and upgrading processes such as catalytic reforming that produces the more valuable light products.

These deep conversion refineries with sufficient coking capacity process essentially all of the residual oil in their crude slates, converting them into light products. All new refineries being built are either conversion or deep conversion plants. It should be noted that, in general, product yields and quality depend on crude oil properties.

5.0 PETROLEUM PRODUCTS AND THEIR USES

5.1 LIQUEFIED PETROLEUM GASES (LPG)

Liquefied petroleum gases are usually mixtures of saturated and unsaturated hydrocarbons in the C3 and C4 range. LPG separated from heavier hydrocarbons by a straight distillation process contains only the saturated hydrocarbons whereas LPG obtained from conversion processes such as thermal/catalytic cracking, reforming and hydro-cracking contains unsaturated hydrocarbons as well. Although they are normally used as gases, they are stored and transported as liquids under pressure.

LPG is used as a domestic fuel, a fuel for internal combustion engine and a feedstock for the manufacture of various chemicals and olefins by pyrolysis. LPG is also used in many industrial applications or operations which include portable blow-lamps, soldering, brazing, welding, annealing, hardening and steel cutting.

5.2 NAPHTHAS

Naphtha is a generic name given to light hydrocarbons boiling in the gasoline range. It is a light distillate obtained from crude oil refining. If the naphtha fraction boils below 1000C, it is classified as light naphtha. Heavy naphtha boils above 1500C. For intermediate naphtha, the boiling range lies between 1000C and 1500C.

Light naphtha is used for gas making gasoline and special gasoline. Intermediate naphtha is used to make aviation gasoline, motor gasoline, marine gasoline, commercial solvents (rubber, lacquer and pesticide diluents), benzene, toluene, xylene, olefins and di-olefins as well as ammonia production.

Benzene, toluene, xylene, olefins and di-olefins are extracted from heavy naphtha, depending on the crude oil feedstock. Heavy naphtha is used in varnish and paint manufacture. It is also used as thinner for paints, varnishes, lacquers and mineral spirits.

5.3 MOTOR SPIRIT

It is commonly known as petrol or gasoline and is one of the most widely used petroleum products. Gasoline is employed in spark-ignition engines.

5.4 KEROSENE

Kerosene is a distillate fraction of crude oil in the boiling range of 150-2500C. It has to be in the form of vapour and mixed with the oxygen in the air in the correct ratio to form a combustion mixture.

It is used as domestic fuel for cooking and lighting. Whether it is used for lighting in lamps or in cooking stoves, it has to be first turned into vapour. This is done by using wicks or by pressure.

5.5 AVIATION TURBINE FUELS (ATFS)

ATFs are distillate fractions of crude oil in the boiling range of 150-2700C and consist predominantly of hydrocarbons. Paraffins and naphthenes are the major compounds in ATFs and their ratio varies with crude source. They are used in aircrafts.

5.6 DIESEL FUELS

Since straight-run diesel fraction for a given crude oil is fixed, varying amounts of selected cracked distillates from conversion processes such as fluid catalytic cracking, hydro-cracking, coking are used to increase the volume available to meet the growing demand of diesel.

Diesel fuels for automotive use need good ignition quality to ensure easy starting and smooth running. Sulphur content must be critically controlled to minimize environmental pollution, corrosion, wear and tear.

The hydrocarbons present in the diesel fuels include paraffins, naphthenes, olefins and aromatics and have a boiling point in the range of 150 - 4000C.

Certain agricultural wastes are being considered as a viable option to manufacture diesel fuels.

“Liquefied petroleum gases are usually mixtures of saturated and unsaturated hydrocarbons in the C3 and C4 range.”

5.7 FUEL OILS

Fuel oils are essentially made up of residues remaining after the removal of the lighter hydrocarbons in the course of atmospheric and vacuum distillation and conversion processes.

These are sometimes cut back with high boiling distillate to meet the finished product specification requirements such as the viscosity. The viscosity of residues can also be reduced by vis-breaking process. The finished blend of fuel oil may contain a number of components obtained from different sources. Residues from crudes differ considerably in sulphur and heavy metal contents. The specification requirements of fuel oil must be met by blending.

Fuel oils used in industrial furnaces and boilers have a significant amount of metallic constituents which concentrate in the ash in the form of oxides of these metals. These oxides have deleterious effect on the refractories and often decrease the strength. Additives have been successfully used to combat this effect by modifying the nature of the residual ash.

5.8 PETROLEUM HYDROCARBON SOLVENTS

Hydrocarbon solvents are volatile fractions derived from the fractionation of a petroleum stream. Their distillation range and composition are dictated by the various end-use requirements. Most of the important grades of hydrocarbon solvents are clear, water-white liquids, immiscible with water, but are completely miscible with other commonly used organic solvents.

They are used in a wide range of products and industrial chemicals. In the manufacture of paint, printing inks, polishes, adhesives, the hydrocarbon solvents comprise part of the finished product. In addition, they are used in many extraction processes such as the extraction of vegetable oils from oil seeds, minerals, pharmaceuticals.

In chemical processes, these solvents are used as an inert reaction medium or catalyst carrier. These may be used simply for clean-up and maintenance operations.

5.9 LUBRICATING OILS

Petroleum fractions having an average volatility lower than that of gas oil form the base of various

types of lubricating oils. These fractions constitute only 2 - 4 percent of the total crude oil processed. Lubricating oils are a blend of lubricating oil base stock and chemical additives that impart enhanced desired properties to the finished product.

They are used in a variety of applications in various grades of heavy duty to light duty range. They are referred to as lube oils/lubricants and are mainly used in cars, trucks, buses and railway engines.

5.10 PETROLEUM WAXES

They consist of normal and iso-paraffins and alkylated naphthenes in the range of C18 - C70. The commercial petroleum waxes can be broadly classified as paraffin wax, microcrystalline wax and petrolatum (Vaseline). Paraffin waxes constitute the major bulk of such waxes and the other two types are produced in comparatively smaller quantities and do command a good market because of their specific end uses. Paraffin wax is used for making candles, manufacturing of waxed papers and cartons. It is also used as sizing material to impregnate match sticks to give it a smooth burning property.

In addition, it is used to make fabric and leather acquire water-proof property in the production process. It is used as a modeling composition as well as the manufacture of crayons, glass pencils, coloured pencils, polishes and coating of fresh fruits and vegetables to preserve them from drying up and withering during transportation. dry cells of various types as well as cable marking. It is now being used as a raw material for the manufacture of chlorinated hydrocarbons, detergents of alkane carboxylate and primary or secondary alkyl sulphate types.

Microcrystalline waxes are used to dope paraffin wax needed in paper conversion and polishes. These waxes are used also as a substitute for expensive vegetable waxes required in specific uses such as sealing wax and in the electrical industry.

Petrolatum or petroleum jellies are almost universally referred to as Vaseline. These have value in use as salves and the highly refined white jellies find use in pharmaceutical and cosmetic preparations.

5.11 BITUMENS

Bitumens comprise a range of products derived from crude oils. They are essentially mixtures of hydrocarbon type molecules and exhibit

thermoplastic behaviour. It is black or brownish black in colour and possesses waterproofing and adhesive properties.

The excellent water proofing properties of bitumens coupled with the ability to act as strong adhesives support a large number of applications in road construction, building and other specialised industries. The major applications are found in paving for road and air fields, hydraulic use such as dams, water reservoirs, sea-defence works, roofing, flooring and the corrosion protection of metals.

5.12 PETROLEUM COKE

Petroleum coke is considered a valuable solid by-product of crude oil refining. It is produced in refinery coking units using residual oils, that is, heavy fractions of the crude oil as feedstocks. Good quality petroleum coke for electrode manufacture can be manufactured from high aromatic, high molecular weight petroleum stocks. There are three different types of coking processes – delaying coking, fluid coking and flexi-coking and their products are distinctly different.

The different types of petroleum coke are used as an industrial carbon in the manufacture of aluminium and as carbon source in steel manufacture. It also has use as inert electrical conductor in electric arc steel manufacture. It is used as a carbon source in the production of titanium dioxide and various steel alloys. It serves as a carbon anode in the production of direct-current batteries.

6.0 CONCLUSION

In Nigeria, the first refinery was a 38,000 barrels per stream day (bpsd) plant built by Shell-BP near Port-Harcourt and it was completed and commissioned in 1965. It was a simple hydro-skimming plant. It was debottlenecked in 1972 to 60,000 bpsd and a naphtha catalytic reforming unit (CRU) added.

Warri Refinery was completed in June 1978 and commissioned in September 1978 (100,000 bpsd plant). It was debottlenecked to 125,000 bpsd plant in 1987. The Kaduna Refinery was commissioned in August 1980 (100,000 bpsd plant) and debottlenecked to 110,000 bpsd plant in 1986. Lastly, the new Port-Harcourt Refinery came on stream in 1989 (150,000 bpsd plant). They are all conversion refineries owned by the Nigerian Government and operated

“It is designed to produce up to 50 million litres of gasoline and 15 million litres of diesel per day...”

by Nigerian National Petroleum Corporation. The refineries are currently down for turn-around maintenance after performing at abysmally low capacity utilization of about 20% for almost 4 years.

Dangote Refinery is an integrated refinery and petrochemical complex (deep conversion refinery) and is being developed on a 2,635 hectare (ha) space on the Lekki Free Zone (LFZ) near Lekki, Lagos, along the coast of Atlantic Ocean. It is designed to produce up to 50 million litres of gasoline and 15 million litres of diesel per day – 10.4 million tonnes (Mt) of gasoline, 4.6 Mt of diesel and 4 Mt of jet fuel per year. It will also produce 0.69 Mt of polypropylene (PP), 0.2Mt of propane, 32,000 t of sulphur and 0.5 Mt of carbon black feed (raw materials to produce tyres) annually.

It is a 650,000 bpsd refinery and is expected to be Africa's biggest oil refinery and the world's biggest single train facility upon completion. The estimated cost is about \$19 billion upon completion. Nigeria's Federal Executive Council (FEC) approved the acquisition of 20% minority stake in the project by state-owned NNNPC Limited for \$2.7 billion in August 2021.

As a point of note, Dangote Refinery will be a game changer by the time it comes on stream as it will double Nigeria's refining capacity and meet the increasing domestic fuel demand while generating foreign exchange through exports. It is expected to generate 9,500 direct and 25,000 indirect jobs.

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“THE CONSULTING ENGINEER” PERSONALITY

ENGR. VINCENT NNADI FNSE, FNSChE FIDA, FNIM, FIPS

(CHAIRMAN/CEO, METIERFORTE LIMITED)

Engr Vincent Nnadi retired from the services of TotalEnergies EP Nig. Ltd in 2020 as Executive General Manager, Corporate Social Responsibility, after 35 years of meritorious services to the company.

Engr Nnadi joined the services of the company on October 15, 1985. He occupied various positions enumerated below where he served excellently in his career with the company:



Engr. Vincent Nnadi

- i. **Laboratory Technologist** in OML57 (1985 – 1990)
Production Supervisor (1991 – 1994): He served as a member of the start-up team of the first Total's offshore field in Nigeria, OML100 and commissioned the first offshore well to commence production for Total in Nigeria at Afia field.
- ii. **Production Superintendent** (1995 – 2000): He served as a member of the Commissioning, Start-Up and Production Team for the Obite Gas Plant.
- iii. **Head of Site of OML57** (2001 – March 2003)
- iv. **Head of Operations for OML99** for the start-up of Amenam/Kpono field (April 2003 – December 2003)
- v. **Project Manager**, Sustainable Development January 2004
- vi. **Deputy General Manager**, Community Affairs (2004 – 2006)
- vii. **General Manager**, Sustainable Development (2007 – January 2010): In this position, he supervised the design, reconstruction and construction of the temporary and permanent sites of the Institute of Petroleum Studies (IPS) among many other sustainable development projects.
- viii. **General Manager**, Sustainable Development & Public Affairs for the Port-Harcourt District (Appointed in February 2010)
- ix. **General Manager**, Special Duties (Appointed in August 2011): In this position, he carried out the special task of negotiating the company's agreements with communities.

Engr. Nnadi was the metier (professional head) representative for CSR and the Country Program Manager for the Affiliate Employee Volunteering Program (ACTION). He placed the company on top of its peers with the company winning many laurels. He has a knack for project delivery in record time. In the period 2017 - 2020, over 80 impactful infrastructural projects were delivered across all geopolitical zones of the country. In fact, he

is still popularly known all over the company as ACTION EGM. In consideration of his immense knowledge of the company, he was saddled with the task of producing the History of Total in Nigeria.

Engr Nnadi is well trained and holds several professional qualifications. He is a Fellow of the Nigerian Society of Engineers (FNSE), a registered engineer with the Council for the Regulation of Engineering in Nigeria (COREN), Fellow of the Nigerian Society of Chemical Engineers (FNSChE), Fellow of the Nigerian Institute of Management (FNIM), Fellow of the Institute of Development Administration of Nigeria (FIDA), Fellow of the Institute of Petroleum Studies (FIPS), Alumnus of the London Business School and Member of the Governing Board of the Institute of Petroleum Studies (IPS), A member of the Board of the Oil Industry Post Amnesty Organization, among several others.

He is a very active member of the Port-Harcourt branch of the Nigerian Society of Engineers. He also facilitated the formation of the Omoku branch and delivered the inaugural lecture. He was also the inaugural lecturer of the Nigerian Society of Engineers annual dinner in 2017 in Abuja. He holds a master's degree in chemical engineering of the Rivers State University of Science & Technology (now Rivers State University), Port-Harcourt. He is married to his dear wife, Comfort and they both have children. He has established his company called **METIERFORTE LTD** where he is serving as the Chairman/CEO.

He loves reading, writing, research, football and golf.

Let me use this opportunity to address young engineers. By young engineers in this context, I mean persons who have passed through or are passing through the necessary training in tertiary institutions with the required qualifications prescribed by the Council for Regulation of Engineering in Nigeria (COREN) and Nigerian Society of Engineers (NSE) to be identified as an engineer or are having this in view. In this category, you may be a young graduate, a youth corps member or in your final year of study. By your training as an engineer or prospective engineer, you are expected to use scientific

and mathematical principles to design or develop structures, machines, manufacturing processes to solve societal problems.

Engineering is indeed a noble profession. My choice to become one came quite early. I grew up in an oil & gas environment. While still in primary school, I made up my mind to become an engineer after seeing people using tools to manipulate systems to cause a change of state.

Soon after my graduation and youth service, I was engaged in the oil & gas industry. My training as an engineer afforded me many opportunities. An engineer is very versatile and could indeed work anywhere. Back in the 1980s and early 1990s, engineers were sought after for employment even in non-technical organizations, including banks. The downturn in the economy has resulted in shrinkage of opportunities for employment. This situation has necessitated self-employment option for graduates. Engineers require some discipline to rise from pupilage to expert status. What young engineers need to imbibe are the following:

- i. **Be a Professional:** To practise engineering, you must be affiliated to the Nigerian Society of Engineers (NSE). This is the umbrella body for engineers in Nigeria. It offers several categories of membership. The requirements are published in the NSE website: <https://www.nse.org.ng>. Each of you is also expected to register as a member of your branch of engineering bodies

A WORD FOR YOUNG ENGINEERS

BY ENGR. NNADI



Engr Vincent G. Nnadi, FNSE, FNSChE, FNIM

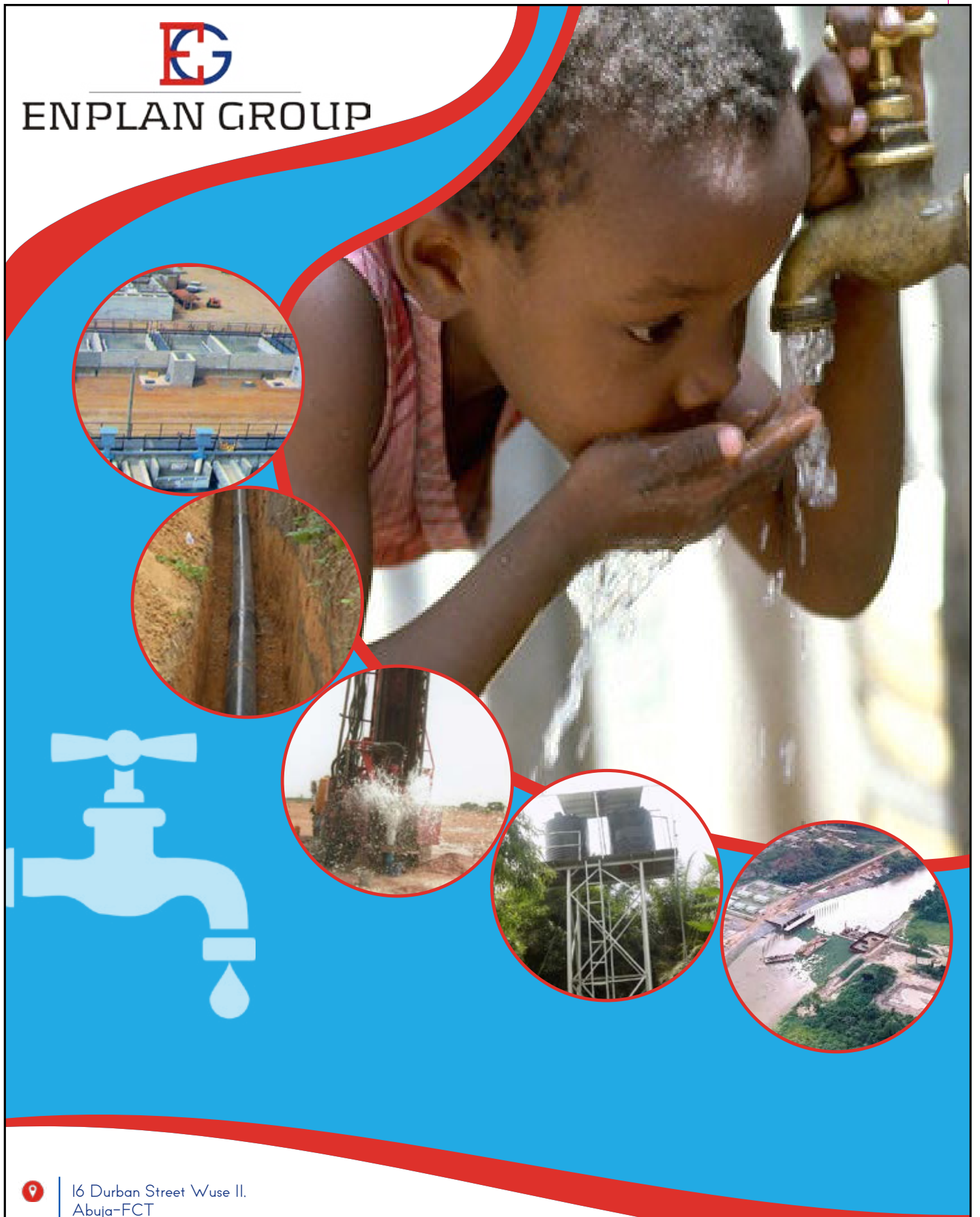
such as Civil, Mechanical, Chemical, Electrical, etc.

- ii. **Be conscious of Ethics:** Every engineer is expected to abide by a code of general conduct to uphold and enhance the dignity of the engineering profession. The guiding codes of conduct are contained in the NSE's Memorandum & Article of Association (MEMART).
- iii. **Embrace Mentorship:** Mentorship is one possible way of improving yourself as an engineer. Your mentor should be a senior colleague who has interest in your progress.
- iv. **Acquire Skills:** Skills make you more versatile and marketable. In this context, information & communications technology (ICT) is very vital among other special skills in your branch of engineering.
- v. **Protect the Environment:** Every engineer must strive to improve the environment around him. Think outside the box to provide waste management and renewable energy solutions in your environment.
- vi. **Be Part of Team Building Groups:** I advise young in any locality to organize themselves into small groups. Do not be isolated. When the Chinese economy was down, the numerous engineers who could not find jobs engaged themselves in little designs. This is how we started seeing toys being exported across the world. Make sure you belong to the local NSE branch close to you and be part of membership of a recognized division of NSE.
- vii. **Learn as a Lifestyle:** As young and prospective engineer, you should not stop learning. Learn from the seminar ones, books, internet and every available material including even non engineering subjects. Engage yourself in self-development. The easiest way to become a mediocre as an engineer is to stop learning.

These pieces of advice are not exhaustive. You must realize that the present situation of the economy is a challenge for you to innovate as an engineer.



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DEEPENING INDIGENOUS PARTICIPATION IN OILFIELD CHEMICALS DELIVERY IN NIGERIA

BY DR. N. JOHN ERINNE



Dr. N. John Erinne, FNSChE, FNSE, FAEng
(Managing Consultant, Chex & Associates, Industrial & Energy Consultants, & Past President, Nigerian Society Of Chemical Engineers)

1.0 INTRODUCTION

1.1 THE OIL & GAS INDUSTRY

In a sense, the Oil & Gas Industry may be segmented into three sectors, namely:

- Upstream Sector
- Midstream Sector
- Downstream Sector

As is well known, the Upstream Sector essentially caters to the exploration and production (E & P) activities which lead to the production of Oil & Gas while the Midstream Sector is concerned with the handling and processing of the produced crude oil and natural gas. The Downstream Sector, on the other hand, entails all the activities in the distribution and marketing of products obtained from the Midstream Sector. Further details of the segmentation are presented in Table 1.1

UPSTREAM	MIDSTREAM	DOWNSTREAM
EXPLORATION	TRANSPORTATION	BLENDING/ MANUFACTURING/ PACKAGING
DRILLING	REFINING	DISTRIBUTION
OIL PRODUCTION	GAS PROCESSING	MARKETING
	GAS PRODUCTION	PETROCHEMICALS

Table 1: Oil & Gas Industry segmentation

1.2 INDIGENOUS PARTICIPATION

It is pertinent to clearly define the concept of indigenous participation in the Oil & Gas Industry in Nigeria. In this respect, an indigenous company is considered to be one which is registered and operating in the country and in which majority shareholding and interest are retained by Nigerian nationals. Indigenous participation by consequence reflects the involvement of the indigenous companies in the activities of the industry.

It may also be noted that though a foreign company registered and operating in Nigeria may be deemed to be a local company it does not qualify to be considered an indigenous concern, for this purpose.

2.0 OILFIELD CHEMICALS

Chemicals are necessary and are used at different stages in the oil and gas value chain to achieve varied goals and purposes. The spectrum of oilfield chemicals relevant to the Oil & Gas Industry is wide and may be classified as follows:

- Drilling Chemicals
- Completion/Work-Over Chemicals
- Cementation Chemicals
- Stimulation Chemicals
- Production Chemicals
- Enhanced Oil Recovery (EOR) Chemicals

These chemicals are applied essentially in the Upstream Sector to enhance production efficiency as well as overall performance. Some other categories of Oil & Gas Chemicals such as Process Chemicals, Water Treatment Chemicals and Fuel Additives which find use in the Midstream Sector and the Lubricating Additives which are used in the Downstream Sector, may, however, not be strictly considered as Oilfield Chemicals.

Demand for the Oilfield Chemicals has maintained an impressive average growth rate of about 4 - 5% per annum over the years, with an estimated aggregate global demand value of \$28.4 billion in 2018.2 The contributions of the various types of Oilfield Chemicals to the aggregate demand value are illustrated in Table 2.2

#	TYPE	DEMAND	%CONTRIBUTION (\$million)
1.	Drilling Chemicals	10,338	6.4
2.	Stimulation Chemicals	5,992	21.1
3.	Production Chemicals	5,652	9.9
4.	Cementing Chemicals	2,897	10.2
5.	Workover/Completion Chemicals	2,442	8.6
6.	EOR Chemicals	1,079	3.8
		28,400	100.0

Table 2: Global oilfield chemicals market

It may be noted that the Drilling Chemicals, Cementation Chemicals and Completion/Workover Chemicals broadly find use in the exploration and drilling side of the Upstream Sector while the Stimulation Chemicals, Production Chemicals and EOR Chemicals broadly relate to the oil & gas production aspects of the sector.

Given the considerably wide spectrum of chemicals in the Oilfield Chemicals mix it is deemed most auspicious for the purpose of this discourse to limit consideration to the more impactful categories. In this regard, the Drilling Chemicals are highlighted, representing the exploration/drilling half of the sector while the production chemicals represent the Production half.

2.1 DRILLING CHEMICALS

2.1.1 Functions/Range

Drilling Chemicals are the largest product segment of the Oilfield Chemicals, accounting for over 36%

of total demand of Oilfield Chemicals globally, as illustrated in Table 2.2 This dominant feature derives mostly from increased drilling in the deepoffshore and other tight locations globally, including Nigeria. These Drilling Chemicals are basically the various chemicals which go into the formulation of drilling muds or drilling fluids used in well drilling operations for the purposes of:

- Lubrication of the drill bit
- Removal of cuttings generated
- Removal of heat generated
- Controlling formation pressures
- Maintenance of wellbore stability
- Sealing permeable formations
- Minimizing formation damage

Typically, drilling muds contribute between 5 and 15% of total cost of drilling an oil well which may be anywhere between \$1.0m for a simple, shallow well and \$100m, for the more complex wells in remote

locations or in austere conditions.^{3,4}

The Drilling Chemicals impart varying characteristics and serve different functions in the drilling mud. Details of the various types of Drilling Chemicals and their functions are provided in Table 3.

Evidently, these Drilling Chemicals may be further sub-divided into two categories, thus:

- Mud Base Chemicals
- Mud Additives

i. Mud Base Chemicals: These are mostly bulk, non-proprietary products used in relatively large proportions in drilling mud formulations to enhance specific gravity, weighting, viscosity, fluid loss control and formation protection properties. As illustrated in Table 3, they include Barites, Bentonite and Bromides (sodium, calcium, zinc). Barites are naturally occurring minerals composed mainly of barium sulfate with very high density. They are, therefore, used as weighting agents in drilling fluids for maintenance of hydrostatic head and wellbore stability while drilling.

Bentonite is also a naturally occurring

	TYPE	FUNCTION
1.	Barites	Mud Base: Fluid weighting; Hydrostatic head maintenance
2.	Bentonite	Mud Base: Viscofier, Rheology modification; Formation protection
3.	Sodium Chloride	Mud Base: Fluid loss control; Well control
4.	Calcium Chloride	Mud Base: Fluid loss control; Well control
5.	Sodium Bromide	Mud Base: Fluid loss control; Well control
6.	Calcium Bromide	Mud Base: Fluid loss control; Well control
7.	Zinc Bromide	Mud Base: Fluid loss control; Well control
8.	Defoamers	Additives: Prevent or break foam
9.	Biocides	Additives: Kill bacteria in the drilling fluid system
10.	Corrosion Inhibitors	Additives: Protect against O ₂ , CO ₂ & H ₂ S corrosion
11.	Scale Inhibitors	Additives: Prevent Calcium & Barium scale deposits
12.	Dispersants	Additives: Remove solids from the drilling fluid; Maintain optimum drilling fluid properties
13.	Flocculants	Additives: Consolidate drill cuttings to facilitate removal and sustain drilling fluid properties
14.	Lubricating Agents	Additives: Reduce friction & facilitate cutting; Release stuck pipe
15.	Emulsifiers/Wetting Agents	Additives: Lower interfacial tension; Allow stable emulsion in oil & synthetic drilling fluids
16.	Surfactants	Additives: Provide detergency to prevent cuttings sticking to drill bit
17.	Shale Stabilizers	Additives: Coat shale fines to facilitate removal
18.	Alkalinity Control Agents	Additives: Adjust pH of water-based drilling fluids

Table 3: Drilling chemicals & functions in mud

mineral and a type of clay composed essentially of aluminium silicate. It has high water absorbent and adsorbent properties. In drilling fluid formulation, it is very useful as a viscofier, a rheology modifier and a sealant as well as a fluid loss control and formation protection agent.

The bromides, often referred to as brines, on the other hand, are water based solutions of inorganic salts used for drilling fluids loss control and well control. The most common brines used in drilling fluids are the sodium and calcium chlorides as well as the sodium, calcium and zinc bromides.

ii. Mud Additives: Unlike the base chemicals, the mud additives are predominantly specialty products used in small doses to impart specific properties on formulated drilling muds. They consist of a fairly wide range of product types with varying properties and capabilities as illustrated earlier in Table 3. Some of the more prominent additives include corrosion inhibitors, scale inhibitors, dispersants, anti-foams, biocides, flocculants, lubricating agents, emulsifiers/wetting agents, surfactants, alkalinity control agents, shale stabilizers, fluid-loss control agents and Secondary viscofiers among others.

3.4 BUSINESS MODEL NIGERIA

3.1 PROCUREMENT PATTERN

By the current practice in the Oil & Gas Industry in Nigeria, Drilling Chemicals are hardly procured directly by the international oil companies (IOCs) and the other Producers. Rather, they are procured indirectly as part of Mud Engineering and Drilling Fluids Contract Packages to support their drilling activities. Consequently, the Drilling Chemicals are mostly procured in the industry by the Mud Engineering/Drilling Fluids Service Providers.

Nevertheless, owing to their special concern about sustenance of drilling mud quality, the Producers often take keen interest in the sources and quality of chemicals used by their Mud Contractors in formulating the drilling muds. This interest has been accentuated lately by the compelling demands of the Nigerian Content Law.

3.2 MUD ENGINEERING/DRILLING FLUIDS SERVICES

The active Mud Engineering Service Providers in the industry are a mixture of international companies and local concerns. Amongst the international companies are world leaders such as MI-SWACO (Schlumberger), Halliburton Baroid and Baker Hughes. The local Drilling Fluids companies, on the other hand, include Hamilton Technologies, ANA Industries, OilChem Drilling Fluids, Librod Energy Services, etc. Participation in this aspect of the industry evidently requires strong technical know-how and capability, as well as heavy investment in mud blending plants and drilling fluid service delivery plants in addition to warehousing and logistics support facilities (*See Figs. 1 and 2*).



Fig. 1: Mud blending plant



Fig. 2: Section of field mud circulation plant on a drilling rig

3.3 MUD BASE CHEMICALS SUPPLIES

i. **Brine Chemicals:** With the exception of sodium chloride, there is no local production capacity for the brine chemicals. All requirements, except for sodium chloride, are imported into Nigeria mostly by the Drilling Fluids Services companies as well as the Stimulation Service Providers who also use large volumes of the chemicals.

- ii. Bentonite Clay: Mineral deposits of bentonite clay are available across the Nigeria. Proven reserves are estimated at about 700 million tonnes.⁶ However, none of these meet the requisite quality standards for use in drilling mud. They are essentially calcium bentonites rather than the more suitable sodium bentonite and particularly tend to be short on rheological and filtration loss control properties. Beneficiation and upgrade to meet the required standards have been demonstrated to be technically feasible but difficult to justify economically and commercially.⁷ Consequently, the requirements of the industry, estimated at about 50,000 tonnes per annum, continue to be sourced essentially from imports.⁸

While the quest for commercially justifiable beneficiation of local bentonite continues, there should be need for more intensive exploration for the more suitable sodium bentonite across the country.

- iii. Barites: There are also abundant mineral deposits of barites in Nigeria with proven reserves of over 20 million tonnes mostly in the North Central States of Nassarawa, Benue and Plateau as well as adjoining Taraba and Bauchi in the North East, Ebonyi State in the South East and Cross River State in the South-South.^{9,10}

The indication is that the reserves are a lot more extensive considering that only limited exploration has been carried out so far.

There is considerable activity spearheaded by indigenous companies in mining and processing barites for the Oil & Gas Industry. While many of these are able to meet industry requirements in terms of particles size, they are mostly marginal or short in respect of specific gravity (SG) and purity. In particular, industry standard requires a minimum SG of 4.1 whereas the prevailing SG range is about 3.6 – 4.4.¹⁰

The estimated barites processing capacity of over 450,000 tonnes in the country should be more than adequate capacity to meet the Oil & Gas Industry demand of about 120,000 tonnes per annum ¹⁰ by these local vendors. This will require improved mining and processing capability to meet the industry standard. Owing to the quality shortfalls, only about 10-20% of the industry demand is met from the local sources presently.¹⁰ The balance is unfortunately imported.

Lately, the Nigerian Content Development and Monitoring Board (NCDMB) certified four local barites suppliers, three of whom are indigenous companies, as acknowledged vendors to the industry in a bid to ensure compliance with specifications and maintenance of acceptable operational standards. Additional companies are expected to be certified as they adopt necessary measures to enhance their operations and ensure quality compliance. The overall intention is to create incentive and ramp up local supply to the industry while assuring requisite quality standards in order to close the supply gap. (See Fig. 3)



Fig. 3: Barites processing plant

Continued exploration effort for barites across the country should also be necessary in order to grow the reserves and ensure long term feed base for the industry as the quality issues are resolved.

3.4 Mud Additives Supplies

These specialties are mostly imported into the country by the Drilling Fluids Service companies. In-country production capability is limited to an indigenous concern in Port Harcourt, JEMMTEK Resources, which produces mostly emulsifiers and wetting agents.

Essentially, production of several of the additives entails blending of chemical concentrates and intermediates in solvent media. The solvents are often hydrocarbon solvents or even water which are readily available in Nigeria. This is, therefore, not a very demanding manufacturing process and consequently the lack of interest in local production is rather surprising.

4.0 PRODUCTION CHEMICALS

4.1. FUNCTIONS

The Production Chemicals are mostly proprietary specialty products applied to treat produced fluids

in the oilfields including crude oil, natural gas and produced water for the purposes of:

- Sustenance of product specifications, especially crude oil
- Flow assurance in production systems
- Facility protection and integrity assurance
- Regulatory compliance (e.g. effluent water)

4.2. RANGE

The range of Production Chemicals used in the Oil & Gas Industry includes demulsifiers, deoilers (Water Clarifiers), paraffin/asphaltene controllers, scale inhibitors, corrosion inhibitors, biocides, hydrogen sulfide scavengers, oxygen scavengers, defoamers flow improvers and hydrate controllers, among others.

Notably, several of these have similar chemistries and functions as the Drilling Fluid Additives even though there may be differences in details of formulation. They include scale inhibitors, corrosion inhibitors, biocides and defoamers.

4.3 TREATMENT SERVICES

These Production Chemicals are very specific in action and must, therefore, be selected very carefully to provide unique treatment solutions to oilfield production problems. The selection processes may be limited to bench scale, in situ testing and screening on site in the field or more detailed evaluation in the laboratory away from the field. Sometimes, they also entail plant scale trials and tests in the field.

Once selected, the chemicals usually require in depth technical support services for correct product application, performance monitoring and treatment optimization.

Effective production treatment solution delivery requires that the vendors are well kitted with requisite equipment and facilities which include:

- Field Test Kits
- Laboratory (See Fig. 4 and Fig. 5)
- Dosing Skids (See Fig. 6)
- Chemical Blending Plant (See Fig. 7)
- Warehouse/Storage Facility



Fig. 4: Chemical laboratory



Fig. 5: Production chemical screening



Fig. 6: Chemical dosing skid



Fig. 7: Chemical blending plant

4.4 GLOBAL MARKET

The global Production Chemicals market is estimated to be valued at about \$5.6 billion, accounting for nearly 20% of the total Oilfield Chemicals market of \$28.4 billion in 2018². This segment of the industry has also continued to witness fairly steady growth of about 4 - 5% per annum over the years, driven by the more intensive treatment requirements in the deep offshore as well as the increasing treatment needs of the ageing wells as they get depleted. Current projections suggest that the market will exceed the \$7.0 billion mark by 2023.²

The market is dominated by a few specialist chemical services companies with the peculiar research and development depth required to thrive in this segment of the industry. These include such known international vendors as: ChampionX, Baker Hughes, Schlumberger (MI-Swaco), Halliburton (Multichem), Clariant, Arkema, Coastal Fluids, REP, Anticorr, etc.

4.5 NIGERIA PRODUCTION CHEMICALS MARKET

The Nigeria Production Chemicals Market has been growing at a very impressive rate of about 6 - 8% per annum in the last 10 - 15 years, driven mostly by the rapid expansion in deep offshore oil & gas production.¹ Estimates indicate that the market is currently valued at about \$120m per annum.

The major international chemical service companies are virtually all present in the market, with some incorporated and operating directly while others participate through varied partnerships and representative arrangements with indigenous companies. The last decade or so has indeed seen the rise of the indigenous chemical services companies as active players in the market, gradually building up capability and know-how. These include Euniseil, GGI International, Librod Energy Services, Matrix Petro-Chem, Wellsworth Energy Services, etc.

As is the case in the Drilling Fluids Market, the players in the Production Chemicals Market are also expected to be backed by very substantial investment in laboratories, warehousing and blending plants. In fact, ownership of these assets is now mandatory for qualification to tender for major jobs in the industry on the insistence of NCDMB. The indication is that these indigenous vendors have responded very positively by investing massively in the requisite assets.

It should be noted that the IOCs and the other Producers procure production chemicals directly from the Chemical Vendors/Service Providers while Drilling Chemicals are procured indirectly through the Drilling Fluids Service Providers. This makes the current Production Chemicals business model in Nigeria to differ significantly from the Drilling Chemicals market.

Besides, it is curious that whereas there is ample local blending capacity and capability for a wide range of Production Chemicals, there is very little capacity or capability for local blending of Mud Chemical Additives, as noted earlier.

5.0 SWOT ANALYSES

SWOT Analyses on the indigenous Nigerian service providers and vendors in Drilling Chemicals (Mud Base Chemicals and Mud Chemical Additives) and Production Chemicals are shown in Tables 4 and 5 respectively.

<u>STRENGTHS</u> • Considerable Experience & Good Understanding of Industry • Investment in Barite Mining & Processing Assets • Ample Mineral Deposits of Barites & Bentonite
<u>WEAKNESSES</u> • Poor Quality Bentonite • Marginal Barites Quality • Very Low Additives Blending Capacity • Limited Technology & Know-How
<u>OPPORTUNITIES</u> • Barites & Bentonite Supply Gaps • Fairly Steady Growth Trajectory of Market • Nigerian Content Act • Petroleum Industry Act • Special National Gas Development Initiatives. • NLNG Train 7 Project • Amendable Funding Initiatives of NCDMB and the Development Banks
<u>THREATS</u> • Prospective Decline of Oil Industry • Multiple Regulation/Customs Harassment • Long Tender Cycles • Cyclic Nature of Demand in Line with Industry Ups & Downs

Table 4: SWOT: Drilling chemicals

In summary, the SWOT Analyses clearly reveal that enormous opportunities far outweigh the limited threats which the indigenous service providers and vendors face. The indication also is that their strengths are approximately counter-balanced by their weaknesses. These suggest that the meaningful strategic direction would be to deploy deliberate focus, effort and resources to exploiting the huge opportunities and addressing the inherent weaknesses identified.

5.0 RECOMMENDATIONS

5.1 DRILLING CHEMICALS

Arising from the SWOT Analysis, the following measures and strategies will be necessary and are recommended in order to boost and deepen the participation of the indigenous Drilling Chemicals Vendors in the Nigerian Oil & Gas Industry:

- i. There should be increased investment in Mud Additive Blending Plants by the vendors to enhance local production of the chemicals.
- ii. The vendors are also encouraged to consider partnerships and representative arrangements with reputable international providers of Mud Chemical Additives in symbiotic relationships. This will give them access to technology and know-how in the formulation and production of these chemicals.
- iii. Investment in necessary equipment and machinery should be undertaken by the vendors for increased mining and improved processing of barites in order to boost production and enhance product quality with a view to closing the prevailing supply gap between demand and local supply.
- iv. Introduction of improved work procedures, organizational structures and quality management systems by the vendors in their barites processing facilities is necessary. This will enable them deliver quality products which meet industry specifications and standards consistently.
- v. Sponsorship of more intensive research into the beneficiation and enhancement of locally available bentonite by NCDMB, the IOCs, other Producers and the research agencies are critical. This is to ensure the delivery of locally processed bentonite which meets industry specifications and performance standards, economically and competitively.

STRENGTHS

- Considerable Experience & Good Understanding of Industry
- Investments in Requisite Assets
- Availability of Adequate Local Blending Capacity
- Strong Affiliations with Global Leaders

WEAKNESSES

- Unavailability of R & D Support
- Limited Technological Know-How
- Limitation of Manufacturing Capabilities to Blending, Owing to Inability in Intermediate Chemicals Manufacture

OPPORTUNITIES

- Sustained Demand Independent of Cyclical Ups & Downs of Industry
- Steady Growth Trajectory of Market
- Ageing Fields Requiring More Intensive Chemical Treatment
- Nigerian Content Act
- Petroleum Industry Act
- Special National Gas Development Initiatives
- NLNG Train 7 Project
- Amendable Funding Initiatives of NCDMB and the Development Banks

THREATS

- Prospective Decline of Oil Industry
- Multiple Regulation/Customs Harassment
- Long Tender Cycles

Table 5: SWOT - Production chemicals

- vi. More intensive exploration for barites to increase reserves and for bentonite in search of the more suitable sodium bentonite grade should be spearheaded by the Federal Government (Federal Ministry of Mines & Steel) and with the active participation of the private sector.
- vii. There should be a review and streamlining of the multiple regulatory framework in place presently, involving NAFDAC, NESREA, SON and DPR (Split by PIA-2021 into NUPRC & NMDPRA), to facilitate smooth import processes for chemical intermediates, concentrates and finished products as well as storage and application of the products in the Oil & Gas Industry.
- viii. More particularly, a review of the rather oppressive and suffocating approach of the Nigerian Customs in the administration of tariffs is urgently required to create an atmosphere whereby vendors are able to meet their genuine Customs Duty obligations without bullying and intimidation and free from a feeling of

“...these measures, should go a long way to enable the noble objective to be achieved.”

strangulation.

- ix. There should be a reduction of the tender cycle from the current situation of over 2years duration on the average to less than 6 months by NNPC-NAPIMS, in order to make for greater certainty and assist the weaker indigenous vendors in planning.

6.2 PRODUCTION CHEMICALS

Similarly, deriving from the SWOT Analysis, the following strategies are recommended for deepening indigenous participation in the delivery of Production Chemicals to the Nigerian Oil & Gas Industry:

- i. There should be deliberate intervention, possibly spearheaded by NCDMB, to stimulate in-country manufacturing capability in chemical intermediates required for blending of Production Chemicals, by way of backward integration and enhancement of local value added, thereby encouraging the participation of the indigenous vendors.
- ii. Policy makers in the Nigerian Oil & Gas Industry should encourage R & D efforts in the use of locally available materials, especially hydrocarbon solvents from the refineries and the oilfields, in the formulation of Production Chemicals, requiring joint effort by the Vendors, NCDMB, the IOCs, the Other Producers and the Research Agencies.
- iii. Streamlining of the applicable regulatory framework, similar to the Drilling Chemicals situation is necessary.
- iv. Similar review of the Customs tariff administration approach should be looked into.
- v. Also, streamlining of the prevailing industry tender process for Production Chemicals, to suit the inherent peculiarities, as well as reduction in the prevailing 2 years tender cycle to 6 months, by NAPIMS will enhance overall productivity in the sector.

6.3 OTHER OILFIELD CHEMICALS

Even though the other categories of Oilfield Chemicals, other than Drilling Chemicals and Production Chemicals, have not been considered in-depth in this discourse, it can be safely assumed

that the factors impacting on them are not widely different. The high points of the above SWOT Analyses and the ensuing recommendations are, therefore, expected to be broadly applicable across the various chemical categories.

7.0 CONCLUSION

Various strategies have been highlighted and proffered, to assist in deepening the involvement of the indigenous vendors and service providers in the delivery of Oilfield Chemicals and Services to the Oil & Gas Industry in Nigeria. The active commitment of the vendors themselves as well as the other stakeholders including NCDMB, NNPC-NAPIMS, the IOCs, other Producers, the other Regulatory Agencies (NAFDAC, SON, DPR, NESREA), NCS, etc, to the implementation of these measures, should go a long way to enable the noble objective to be achieved.

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EXECUTED PROJECT PICTURES



RELEVANT CORPORATE EXPERIENCE

Project/Nature Of Works	Name Of The Client	Scope* Epcms	Year	Contract Manhrs	Contract Value (\$Usd)	Nature Of Contract	Jv Partners	Remark/ Reference Contact, Number
Escavos Export Pipeline System Project	Chevron	Feed & Ded	2009	15,000	0.6M	Sub Contract	Atlas Batelitin	Completed (Personel Supply)
Offshore - Accommodation Vessel Operations & Maint.	Addax Petroleum Nigria Ltd	Structural Engineering Design	2010	4,000	0.4M	Sub Contract	Petrostuff Nig. Ltd.	Completed
Ajaokuta-Abuja-Kastina	Ministry Of Petroleum	Feed And Detailed Engineering	2011	12,000	2.0M	Sub Contract	Atlas Engineering	Completed (Personel Supply)
Gas Supply To Omowood Industry Project	Nigerian Gas Comapany (Ngc)	Detailed Engineering	2012	4,000	0.5M	Sub Contract	Sail Petroleum & Gas Services Ltd.	Completed (Personel Supply)
Ogijo-Falcon City Gate Gas Spur Line Project	Nigerian Gas Comapany (Ngc)	Detailed Engineering	2012	2,000	0.65M	Sub Contract	Sail Petroleum & Gas Services Ltd.	Completed
Sonam Development Pipeline & Sonam-Okan Pig Receiver Platform (Prp) Project	Chevron Nigeria Limited	Feed	2012	6,000	0.3M	Sub Contract	Euroflow Design Ltd. / Sail	Completed
Ibafo-Mowe-Sagamu Gas Supply Project	Nigerian Gas Comapany (Ngc)	Ded	2016		1.05M	Sub Contract	Ajamy Oil & Gas Limited	Completed
6" X 1Km Gas And Crude Line ,4" X 1Km Low Pressure Gas Line From Otein-1 To Energy Park And 8" X 4.6Km Gas Delivery Pipeline From Energy Park To Elps Pipeline And Gas Processing Facility (Gpf) For The Duport Energy Park Project	Duport Midstream Nigeria Limited / Bablink	Feed	2020		\$0.5M	Sub Contract	Bablink	Completed
Pmc Of Assa North/Ohaji South (Anoh) – Ob3 Ctms Pipeline Project	Nigerian Gas Comapany (Ngc)	Pmc	2020		\$1.5M	Contract		Completed
Front-End Engineering Design 24" X 85Km Ogan – Asaba-Onitsha Bridge Pipeline Project (Phase 1)	Nigerian Gas Company (Ngc) & Fradro Nig Limited	Feed	2021		\$1.0M	Contract		Completed
Engineering, Procurement And Construction Of New Egbin Metering Station Project	Nigerian Gas Company Limited (Ngc)	Pmc	2021		\$1.5M	Sub-Contract	Line Pack Engineering & Consulting Services Limited	Ongoing

PETROLEUM PRODUCTS TRANSPORTATION THROUGH PIPELINES IN NIGERIA

BY ENGR. BENEDICT PETER AKPAN

1.0 INTRODUCTION

Transporting petroleum products through pipelines is cost-effective and reliable though challenges cannot be ruled out as are common in any human system. This mode of transportation promotes safety and saves time since large volumes in bulk carriage can be pumped within a short interval of time. It is more environmentally friendly, provided proper maintenance is carried out to prevent pipeline ruptures. It promotes energy efficiency compared to the use of trucks and trains. This means of transportation offers convenience since appropriate pressure levels are maintained at end-users' facilities.



Engr. Benedict Peter Akpan, FNSChE
(Chemical Engineer)

by an Area Manager. There are 21 depots connected to the network of products pipelines, namely, Mosimi, Ibadan, Ore, Ilorin, Satellite, Port Harcourt, Calabar, Aba, Enugu, Makurdi, Warri, Benin, Kaduna, Kano, Gusau, Minna, Suleja, Yola, Gombe, Maiduguri and Jos. There are also 17 pump stations to ensure good pressure levels at different destination depots at Warri, Abudu, Auchi, Lokoja, Abaji, Suleja, Izom, Sarkin Pawa, Kaduna, Zaria, Mosimi, Ibadan, Port

Harcourt, Enugu, Makurdi, Jos and Biu. Fig. 1 Fig. 2 show typical pump types.

There are 3 major petroleum pipelines systems emanating from products source refineries. One is System 2A/2CX which takes off from Warri Refinery down to Kaduna. System 2E/EX takes off from Port Harcourt Refinery down to Yola and System 2CX/2D/2DX takes off from Kaduna Refinery down to Maiduguri, Kano and Gusau. However, there is a system pipeline network that emanates from Atlas Cove that takes basically imported petroleum products to Mosimi and from there down to Ilorin.

2.0 TRANSPORTATION NETWORK

The construction of petroleum refineries in Warri and Kaduna necessitated the Nigerian National Petroleum Corporation (NNPC) to establish a network of petroleum products pipelines and storage depots strategically located nationwide and operated by her subsidiary, Pipelines and Products Marketing Company (PPMC). This was established in 1979.

The products pipelines have a total length of about 5,120 kilometers/ The products are moved through the pipelines by pumping using mainline and booster pumps.

A few pump stations complement pumping of products to desired destinations. The pipelines and storage depot system along with their mainline and booster pump stations and export/import facilities are administered under five zones known as Operations Areas. (See Fig. 1). Each operation area has as administrative office located within the area under its control and is headed

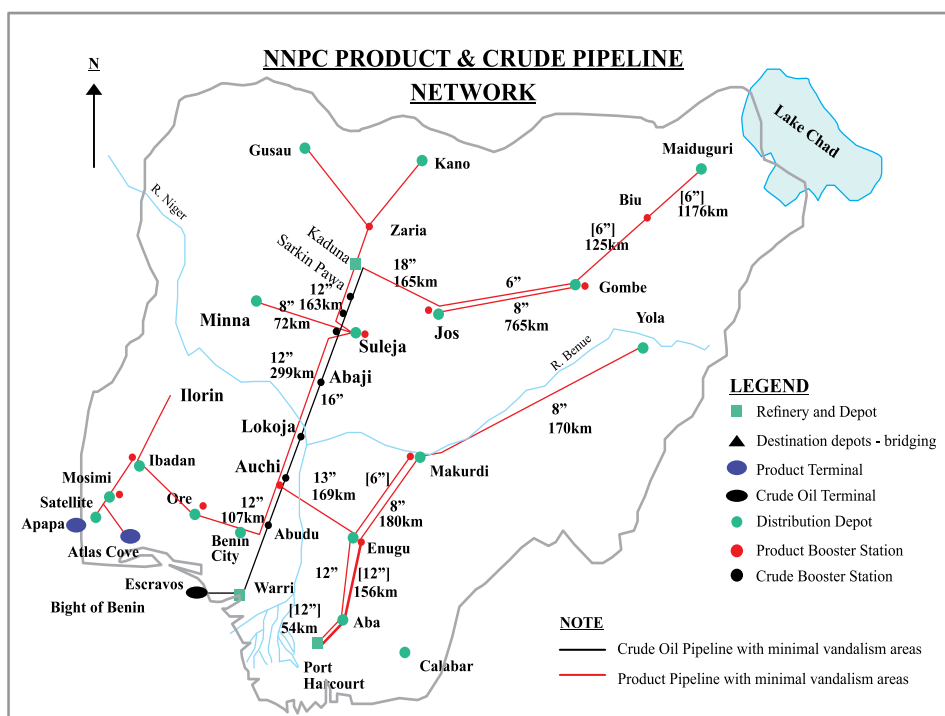


Fig. 1: NNPC product and crude pipeline network

To facilitate products movement, the various depots have API and ASME standards designed storage tanks with appropriate facilities to receive pumped products. Appropriate accounting meters are also provided at both ends of the pipelines system. Multiple petroleum products can be transported using the same pipeline with interfaces between products. The interface is usually sloped for subsequent blending and recovery.

Among petroleum products transported through the pipelines are premium motor spirit (PMS), dual purpose kerosene (DPK), automotive gas oil (AGO), aviation turbine kerosene (ATK) as well as the following slops: low flash interface (PMS/AGO, high flash interface (AGO/DPK).



Fig. 2: Diesel Driven Mainline Pump



Fig. 3: Electric Motor Driven Mainline Pump

“...annual losses of petroleum products recorded...N3billion.”

3.0 CHALLENGES OF PIPELINES TRANSPORTATION

Challenges of transportation of petroleum products through pipelines include vandalism, losses of products and fire accidents.

3.1 PIPELINES VANDALISM

In Nigeria, pipeline vandalism has attained an extreme dimension. The NNPC's experience is as shown in Table 1. In the year 2012, a total of 2,129 pipeline breaks were recorded on the entire products pipelines within the different area offices. Kaduna product pipeline had the highest vandalized points numbering 622 while Warri area followed with a total of 495 vandalized points. The nature of the pipelines vandalism includes cuts, pipe insertions, pipe boring etc. However, there were about 24 pipeline ruptures recorded in the Kaduna area. The vandalism incidents are primarily for economic reasons including a bit of sabotage. (See Figs. 4, 5, 6 & 7).

Cause of break	Gombe Area	Kaduna Area	Mosimi Area	P'Harcourt Area	Warri Area
Vandalism	241	622	479	292	495
Pipe rupture	0	24	0	0	0
Clamp failure/removal	0	0	49	0	0
TOTAL	241	646	528	292	495

Table: Pipeline breaks. (No. of new points) in 2012



Figs. 4, 5, 6 & 7 (Source: PPMC)

3.2 PRODUCTS LOSSES

Pipelines breaks result in petroleum products losses especially if other pipes are inserted on the main lines. Table 2 shows the experience

in NNPC in 2014. The combined annual losses of petroleum products recorded in the Mosimi/Atlas Cove-Idimu-Satelite Area was about 28,530m³, about 56.71% of total products pumped which amounted to about N3billion. The implications are financial losses and attendant downtime and

PIPELINE SEGMENT	PROD.	PUMPED (m3)	RECEIVED (m3)	VARIANCE			Amount (N)
				m3	litres	%	
A/COVE - MOSIMI & A/COVE-IDIMU-SATELLITE	PMS	188,530	170,948	-17,582	-17,582,000	-9.33	-1,541,238,120
	DPK	0	0	0	0	#DIV/0!	0
	AGO	23,105	12,157	-10,948	-10,948,000	-47.38	-1,510,386,080
KADUNA - SULEJA	PMS/H2O	0	2,046	2,046	2,046,000	#DIV/0!	179,352,360
	AGO/H2O	16	0	-16	-16,000	-100.00	-2,207,360
PH - ABA	PMS	3,962	5,493	1,531	1,531,000	38.64	134,207,460
	DPK	8,038	9,070	1,032	1,032,000	12.84	42,208,800
	AGO	9,754	8,174	-1,580	-1,580,000	-16.20	-217,976,800
WARRI-BENIN	PMS	0	0	0	0	#DIV/0!	0
	DPK	0	0	0	0	#DIV/0!	0
	AGO	0	0	0	0	#DIV/0!	0
TOTAL		233,405	207,888	25,517	25,517,000	-109.32	2,916,039,740

Table 2: PRODUCT PIPELINE PERFORMANCE: 2014.

Source: PPMC

disruption of operations schedules. It impacts negatively on any new business in the downstream sector of the industry. The Nigerian National Petroleum Corporation has been putting in huge efforts and investments to eliminate/reduce incidents of pipelines vandalism and there has been some measure of success. Figs. 8, 9, 10, 11, 12 & 13 show NNPC's efforts in pipelines maintenance.



Figs. 8, 9, 10, 11, 12 & 13: Vandalized pipelines maintenance efforts by NNPC

4.0 ENGINEERING PERSPECTIVES

The major steps in pipeline system design involve establishment of critical pipeline performance objectives and critical engineering design parameters such as required throughput (volume per unit time for most petroleum products), origin and destination points, product properties such as viscosity and specific gravity, topography of pipeline route, maximum allowable operating pressure (MAOP), hydraulic calculations to determine pipeline diameter, wall thickness and required yield strengths, number of, and distance between pump stations and pump station horsepower requirement.

Product pipelines usually are 12 to 24 inches in diameter but can be as large as 40 inches. Pigs are designed to clean accumulated sludge and

debris off the inside walls of a pipe or to monitor the pipe for conditions such as corrosion. Pigs used for corrosion monitoring are known as "smart pigs". They are introduced at launching facilities located along the mainline pipe right of way (ROW) often in conjunction with a pump station. Pipelines are monitored and operated using supervisory control and data acquisition systems (SCADA). SCADA systems regulate pressure and flow by monitoring and controlling pump operation and the positions of valves. SCADA systems also perform a variety of additional functions including alarm processing, leak detection, hydraulic analysis, pump station monitoring, throughput analysis and other functions deemed critical to the safe operation of the pipeline.

Corrosion control of pipeline network made of steel and other metals is critical to system integrity. Buried metallic objects will corrode (chemically oxidize) through electrochemical reactions if not adequately protected.

Corrosion control is accomplished through a variety of means. In most instances, paints and protective coatings are applied followed by wrapping and taping sections of mainline pipe prior to burial to isolate the metallic pipe and prevent electrochemical reactions. In addition, cathodic protection is provided through the use of an impressed current or sacrificial anode to counteract electrochemical reactions. Various polyethylene- or epoxy-based paints, some also including asphalt and/or coal tar, are used for buried pipes and valves.

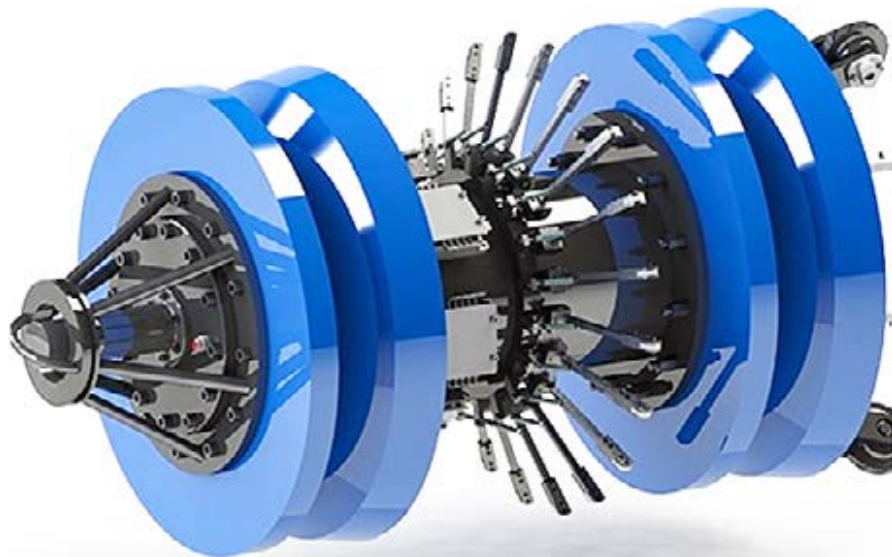


Fig. 14: DTAIC Inspection Equipment (Suzhou) Company Limited

5.0 PIPELINE MONITORING

Pipeline vandalism is a major threat to pipeline integrity. It brings about critical business financial losses and environmental risks. Hence, there is absolute need for any organization in Nigeria, that ventures into the downstream sector with the intention of petroleum pipelines transportation, to invest optimally in cutting edge pipelines monitoring technology that will detect and analyze threats along the entire pipeline with accuracy. The following methods are used for monitoring and inspecting petroleum product pipelines.

5.1 REMOTE SENSORS THAT TRACK CHANGES IN PRESSURE, FLOW RATE OR TEMPERATURE

There are hyperspectral imagers (specialized video cameras) that can detect evaporated hydrocarbons through hyperspectral imaging. These cameras are sensitive enough to detect extremely low volumes of evaporated hydrocarbons within a two-kilometer radius of the camera. Fig. 14 shows a special pipeline inspection equipment.

Aerial light detection and ranging imagery created from airborne laser sensors are used to monitor geo-hazards such as landslides, earthquakes and river erosion in real time.

Fibre optic cables installed alongside pipeline can detect tiny leaks by sensing changes of temperature and vibrations caused by flow from a pipe. There are smart balls which can be placed in the pipeline to move with the flow and detect leaks. They have an acoustic data system that can detect small and even pinhole-sized leaks.

Smart membranes that turn the pipe itself into a sensing device are also used. The membranes are wrapped around pipelines which can sense leaking fluid and signal operators. Any changes are immediately transmitted to the control room, setting off alarms.

Helicopters and drones are used to observe pipelines from the air. Specially trained dogs are sometimes used to search for leaks as their ultra-sensitive noses can detect leaks that machines cannot. Advanced pipelines solutions that will detect within metres, analysing within minutes, alerting personnel within seconds are also in use.

Every day, the use of fibre optic sensors is an effective method to monitor pipelines and ensure safety. Distributed fibre optic sensors can be considered as integral parts of efficient pipeline installation and monitoring systems. When combined with a satellite-based monitoring system, it helps to locate the origin and identify the nature of a disturbance sensed in the fibre optic cable. Fibre optic sensors are resistant to electromagnetic interference, radio frequency interference and high temperatures and do not conduct electricity. Hence, they can be used for applications that involve highly inflammable material or high voltage electricity. Apart from being small and light-weight, the sensors are highly sensitive, have excellent range and multiplexing capabilities. It can detect temperatures, strain, vibration and sound with high location accuracy and absolute resolution. The system installed could detect a third-party activity including manual digging. By

“...to determine the effects and risk in construction, leakage and maintenance of pipelines on environmental components such as water bodies, plants, soil, etc.”

knowing the exact location of the event, immediate response can take place to prevent illegal tapping and consequential environmental pollution and financial loss.

In the satellite-based monitoring system, high-resolution satellite imagery (30 cm), ultra-high-resolution imagery (15 cm HD) are used to compile environmental maps (geological and technical features) to determine the effects and risk in construction, leakage and maintenance of pipelines on environmental components such as water bodies, plants, soil, etc. The map which shows the possible ways of oil accumulation in case of an oil spill can also be compiled. Remote sensing uses these compiled maps to monitor the condition of the pipeline. Ultra-violet and infrared sensors can be mounted on aircraft/drone (UAVs) for oil spill surveillance, as the oil absorbs solar radiation and emit thermal energy. Synthetic-aperture radar (SAR) imagery with aircraft surveillance is the most cost-effective method to monitor pipelines and detect leakage. Some technology experts have suggested the incorporation of deafening sounds and simulated explosions in case of third-party interventions such as digging.

It is worth noting that despite advances in technology, the aspect of sincerity and patriotism of the intervention operatives is of great importance. Hence, adequate remuneration and incentivization of the operatives is required. Pipeline security should be given a very high attention from the highest echelon of government, especially considering the contribution of the petroleum downstream sector to the economy of the country. Appropriate legislation should be put in place to ensure adequate penalties are meted out to pipeline vandals. A specially trained mix of security operatives should be attached to well-trained and highly motivated organization operatives to curb the menace of pipeline vandalism.

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MODULAR REFINERIES: TECHNICAL AND ECONOMIC PERSPECTIVES AND RELEVANCE TO NIGERIA

BY ENGR. STEPHEN IDIATA



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(Chemical Engineer)

1.0 INTRODUCTION

Nigeria is generally correctly described as being blessed with abundant crude oil resources including gas. This description is buttressed by its position as the 6th crude oil producing nation in the world and the 1st in Africa. Nigeria has 4 crude oil refineries located in Port-Harcourt (I and II), Warri, and Kaduna with a combined nameplate capacity of 445,000 bpsd (barrels per stream day). However, the country is faced with a serious challenge of petroleum products importation due to several years of low capacity utilization in the refineries and the eventual shutdown of the 4 refineries for rehabilitation in 2019, among other numerous challenges.

One bold step to rescue Nigeria from the economic quagmire of total dependence on importation to meet petroleum products needs is the government's policy of encouraging private investors to build both conventional and modular refineries.

Refineries come in various sizes. They are in the range of small topping and reforming refineries to sophisticated complex refineries. They perform 3 basic steps which are:

- Separation (fractional distillation) of crude oil into hydrocarbon fractions of more related properties
- Chemical conversion (cracking and rearranging the molecules) of the separated hydrocarbons to more valuable and desirable products
- Treatment or purification of the products by the removal of unwanted elements or compounds

2.0 TECHNICAL PERSPECTIVE OF MODULAR REFINERIES

2.1 BASIC DESCRIPTION OF MODULAR REFINERY

Modularity is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use. A modular design can be characterized by functional

partitioning into discrete scale-able and reusable modules, rigorous use of well-defined modular interfaces and making use of industry standards for interfaces.

A modular refinery, as the name implies, is a refinery whose parts or units of equipment are constructed in modules designed to be transported quickly and easily to anywhere in the world. Modularization enables the major refinery equipment units to be prefabricated on skid-mounted steel structures prior to shipment to the proposed refinery location.

A modular refinery is also defined as a set of skid-mounted modules of small capacities, put together to achieve refining of crude oil at capacity in the range below 1,000 to 100,000 bpsd. However, most experts focus on small-size modular refineries designed for crude oil at capacity in the range of 1,000 to 30,000 bpsd or gas condensate in the range of 660 to 14,000 bpd.

2.2 MODULAR REFINERY CONFIGURATION

Modular refineries, typically available units, are topping refinery as shown in Fig. 1 or

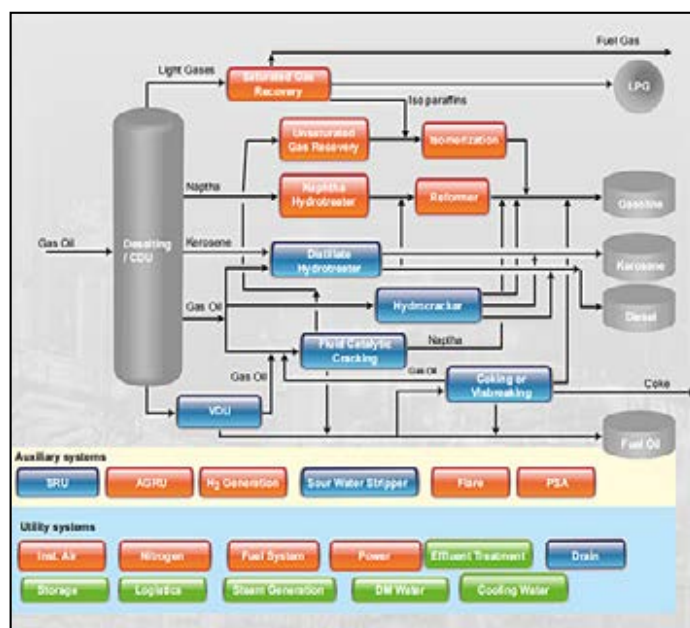


Fig 1: Block diagram of a typical conventional complex conversion refinery

hydro-skimming refinery as shown in Fig. 2. Their crude oil feedstock capacities fall in the range of 5,000 to 30,000 bpsd.

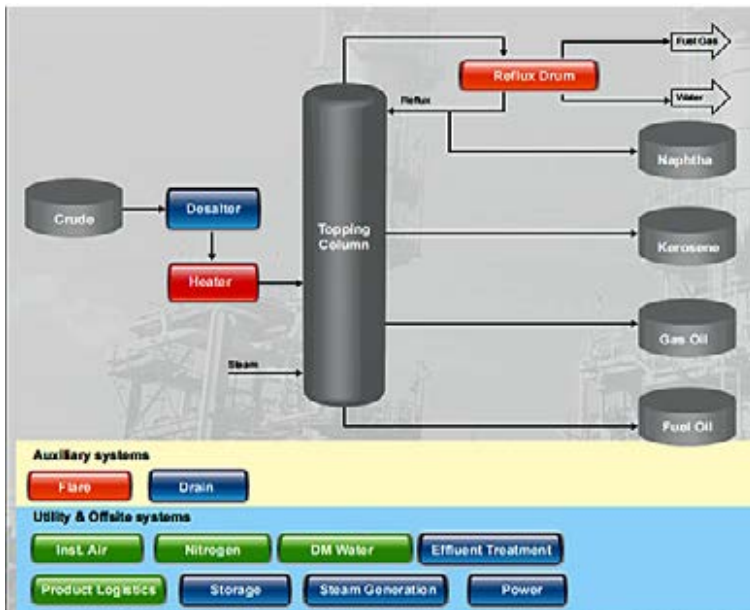


Fig 2: Block diagram of a typical topping modular refinery

Configuration tends to be simpler and can include process units such as a crude distillation unit (CDU), diesel hydro-treating (DHT), naphtha hydro-treating (NHT), reforming, isomerization, sulfur treating units, among others.

The different configurations available for modular refineries, with increasing degree of sophistication are:

- i. Atmospheric (Topping) Unit
This is a low capital cost crude distillation unit for diesel and/or kerosene production, with naphtha and fuel oil as by-products.
- ii. Naphtha Hydro-treating and Reforming Unit
Addition of reformer or hydrotreater, which entails higher capital cost, makes production of high octane unleaded gasoline and LPG possible. This configuration may include an isomerization unit to boost total octane

rating of gasoline and produce more premium unleaded gasoline.

- iii. Vacuum Distillation (Cracking) Unit
Vacuum distillation unit distills the atmospheric tower residue into a clean vacuum gas oil (VGO), which can be used as diesel blend and heavy residual oil.
- iv. Hydro-Cracker Unit (Full Conversion Unit)

The hydro-cracking unit has high capital cost. It converts light and heavy gas oils to more valuable lower boiling point products. The yield across a hydro-cracker may exhibit volumetric gains as high as 20-25% for light end products from fuel oil, making it a substantial contributor to refinery profitability.

3.0 CONVENTIONAL VERSUS MODULAR REFINERIES

Some comparative analysis between modular refineries and conventional refineries include the following:

- i. Modular refineries are constructed off-site in a specialized fabrication shop built to high quality, assembled and tested before shipping to site while conventional refineries are constructed on site.
- ii. Modular refinery modules installation is much faster compared to a conventional site building approach.
- iii. Conventional larger refineries have improved economy of scale and can produce a wider variety of refined products including integration into petrochemical operations.
- iv. Modular mini-refineries have lower investment costs compared to conventional refineries.



Fig 4: A typical modular refinery

- v. Modular refineries are sized for lower local demand and could be located in remote areas.
- vi. Modular refineries have shorter construction time than conventional refineries.
- vii. Modular refineries have easier possibility for future relocation. Fig. 3 shows a

typical modular refinery.

- viii. Conventional refineries produce a wide range of products while modular refinery products are very few.
- ix. Conventional refineries can process all crude types depending on processing severity while modular refineries feedstocks are mostly sweet crude oil and condensates.

4.0 ECONOMIC PERSPECTIVE, OPPORTUNITIES AND CHALLENGES OF MODULAR REFINERIES IN NIGERIA

Refineries have not been very profitable, as the industry has been plagued worldwide by historical low margins especially during the years of high crude oil prices in the neighbourhood of US\$100 per barrel. In that era, about 90 per cent of the operating cost in most refineries was simply cost of purchasing and delivering crude oil to the plant.

Nigeria consumes about 19.535 billion litres of premium motor spirit (PMS) annually, averaging 1.5 billion litres monthly. With about N241.00 currently paid on every litre as subsidy, this brings yearly subsidy to about N4.6 trillion. Therefore, producing fuel required within the country will go a long way in not only releasing the pressure on foreign exchange but also promoting enhanced economic growth and development.

Establishment of refineries to produce the fuels and other petroleum products required in Nigeria is indeed a good investment window that holds economic, social and development value for the country and potential investors. However, because of the general perception of unprofitability, establishment of modular refinery calls for the most skilled and detailed business approach to establish profitability. In what follows, we provide an analysis of some of the essential considerations of modular refinery establishment in the context of Nigeria's business environment.

Modular refineries have shorter construction time than conventional refineries. Modular refineries have easier possibility for future relocation. Establishment of reasonable numbers of modular refineries will contribute to Nigeria's transition from being an import-dependent country to a net exporter of refined petroleum products. If investment in modular refineries is well harnessed, it

will boost confidence in this aspect of the petroleum industry as well as bring about growth in the nation's GDP and increase in number of jobs. There are often two sides to the modular refinery debate. On the one hand, there is the argument that profit margins of conventional refineries are generally low and that of modular refineries are so low that most of them may not be economically viable. As of January 2020, the average net profit margin of refineries was 6.8 per cent, according to data from NYU (New York University) Stern School of Business.

Complexity is an essential factor in the viability of crude oil refining process. The profitability of any refinery is related to its Nelson Complexity Index (NCI) or complexity. The refineries with more complex conversion plants like catalytic reformers and fluid catalytic crackers (FCCUs) or residue fluid catalytic crackers (RFCC) which are able to convert the lower value heavy bottom products (atmospheric residue and fuel oil stocks) to higher value light products like diesel, PMS and LPG are more profitable. FCC unit is able to convert about 50 - 60% of atmospheric distillation residue (heavy gas oil) to highly priced, high octane number gasoline and the remaining 40% to petrochemical (decant oil for carbon black), propylene for polypropylene and alkylation (butane) plants feed-stocks, refinery fuel (fuel gas) and small fraction of light cycle oil as diesel blend. However, while the economics of modular refineries such as topping or 'hydro-skimming' plants are not comparable to a 200,000 bpd and above complex or 'full conversion' refinery with hydro-cracking, the relatively low capital cost and flexibility can make it a cost-effective product supply option in the right circumstances in Nigeria.

Some of the factors that erode modular refineries, like topping units' profits, are their inability to profitably process cheap heavy and sour crude oil and products slate of high yield (about 35%) of very low value heavy fuel oil (HFO) and low octane

"FCC unit is able to convert about 50 - 60% of atmospheric distillation residue (heavy gas oil) to highly priced..."

STREAM	VOLUME %
LPG	0.98
Light Gasoline	4.25
Light Naphtha	13.73
Heavy Naphtha	10.12
Kerosene	13.28
AGO (Diesel)	22.69
Residue Fuel Oil	34.95

Table 1: Distillation Yield for a 10,000 bpsd Hydroskimming Modular Refinery for Bonny Light with API 32.90

STREAM	VOLUME %
LPG	0.98
Light Gasoline	4.25
Light Naphtha	13.73
Heavy Naphtha	10.12
Kerosene	13.28
AGO (Diesel)	22.69
Light Vacuum Oil	16.81
Heavy Vacuum Oil	13.26
Residue Fuel Oil	4.96

Table 2: Distillation Yield for a typical complex conventional conversion Refining of Bonny Light with API 32.90

number naphtha (of about 8 - 10% yield) products which are of low demand to products of high demand (See Table 1 & Table 2).

The conditions (right circumstances) required to make investment in modular refinery workable will include: proximity and access to crude supply at a cheap or reduced price, proximity to sizable markets with logistics advantages, share of utilities or cheap source of utilities, project finance on preferential terms from development credit agencies and government incentives. A prospective investor should understand each of these elements as standalone forces as well as how they interrelate with one another in the context of the Nigerian investment environment.

The quality of products is a strong contending issue in investment in modular refineries. For instance, the maximum allowable sulfur in the products is specified by different regulatory authorities in different countries, so compliance is crucial. Invariably, investments in these extra product treatment units do bring additional costs that if not carefully controlled can erode the lean margins in modular refineries.

5.0 CONSUMPTION PROJECTION OF MODULAR REFINERY PRODUCTS

If there is a good market for automotive gas oil (AGO – diesel) and kerosene, it will be investment savvy to install a simple atmospheric topping plant, which comprises the distillation unit in its simple form to produce AGO, kerosene, naphtha and fuel oil. In Nigeria AGO consumption has been on the rise for over 30 years. Energy consumption projections also indicate even more increase in total national consumption between 2015 and 2035, according to Energy Commission of Nigeria (ECN). The consumption projections

and analysis provided by the (ECN) did not, however, factor the anticipated improvements in electricity supply which will lead to reduced demand for both AGO and premium motor spirit (PMS). Over 20 percent of the PMS and AGO consumption in Nigeria is used in the generation of captive electricity in households and industrial/commercial communities. This implies that a topping plant originally configured to maximize AGO production might soon need to include PMS in the desired product slate. An extra cost will be incurred for the installation of a cracking unit to further convert heavy/fuel oil to PMS. Consumption of AGO and PMS is also projected to rise exponentially between now and 2035. It shows very high percentage increases in each of the intervals between 2020, 2025, 2030 and 2035 according to International Atomic Energy Agency (IAEA) and Energy Commission of Nigeria (ECN) data. These are some of the fine considerations that must go into the feasibility work of a mini-refinery.

6.0 MODULAR REFINERIES RELEVANCE TO NIGERIA SITUATION

The establishment of modular refineries in Nigeria is very relevant to the nation's current need for petroleum products, security, environmental pollution mitigation, eradication of crude oil theft & pipeline vandalism, technological and socio-economic development. However, there is need for incentives and provision

“If there is a good market for automotive gas oil (AGO – diesel) and kerosene, it will be investment savvy to install a simple atmospheric topping plant, which comprises the distillation unit...”

of enabling business environment by government to encourage investment. Dependence on imported refined products has put much pressure on the Naira due to enormous foreign exchange requirements. Modular refineries establishment in Nigeria will enhance local production of premium motor spirit (petrol) in the country and reduce the menace of rising fuel imports. The setting up of modular refineries at strategic locations of demand in Nigeria will put an end to persistent shortages of petroleum products especially diesel and kerosene. It will reduce subsidies and products smuggling in Nigeria.

Modular refinery, which is ideal for stranded production fields and remote locations, can be sited in the riverine areas or other areas where accessibility to the petroleum products presently seems to be very difficult due to transportation and other logistics problems. This will allow the dwellers in such areas to purchase the products at cheaper price compared to what is obtainable at present. Different modular refineries can serve different markets in specific locations economically.

The establishment of modular refineries in Nigeria will bring about rapid production of feedstocks for downstream petrochemical plants leading to creation of millions of jobs for the nation's youths. This will not only solve the national poverty problem but also ameliorate the insecurity of life and properties in Nigeria.

The people in the communities with modular refineries can become key stakeholders as joint venture partners. This will promote peace and security in these communities. There will be drastic reduction in environmental pollution associated with illegal refining activities.

7.0 CONCLUSION

There is urgent need for massive investment in the Refining & Petrochemicals (R&P) industrial sector in Nigeria. The development of this sector has not been given the right attention in this country leading to the unpalatable and catastrophic socio-economic effect of the importation of the required petroleum products in the nation. It is important to reiterate the fact that modular refinery can be profitable though

“There is urgent need for massive investment in the Refining & Petrochemicals (R&P) industrial sector in Nigeria.”

it is not as profitable as the full-conversion complex refinery. It simply means that certain conditions which favour profitability should be considered such as closeness to source of raw materials as well as closeness to the market for the products.

Secondly, it is essential to carry out a detailed bankable feasibility study with various configurations of the process units, taking into consideration the type of crude oil to be processed and the expected internationally/nationally acceptable products quality. This type of study is a complex one involving diligent technical, economic and financial analysis to finality by experts for informed investment decision.

While this process is viewed from a business perspective, it should be noted that government incentives can serve as ‘game changers’ in setting up modular refineries because of the socio-economic needs of the people. Nigeria, in particular, should have modular refineries to fill the socio-economic gaps.

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Actolog Solutions Limited Launches “The Customer is King” Campaign

Customer service in action

The triplet of good product research, promptness and customer satisfaction has put Actolog Solutions Limited ahead of competition as far as power backup and UPS in Nigeria is concerned. As a one-stop Company for reliable power backup solutions for critical loads like elevators, escalators, large-scale manufacturing machines, hospital equipment, ICT, telecommunication, etc. in Nigeria, Actolog is offering its customers the benefit of a research-based breakthrough for prolonged equipment lifespan as well as excellent service which is second to none anywhere in Nigeria.

The Company's operational theme for 2022 “The Customer Is King” did not come as a surprise because the most important person in Actolog is not the

CEO but the customer. A simple evidence of the assurance of the firm's excellent services is the fact that Actolog has continued to provide power backup solutions for some top-rated companies for about 20 years. This is because Actolog does not just give customers the manufacturer's warranty; it also gives local guaranty to cover the equipment if it breaks down within a year,

Actolog will replace it at no cost to the customer in liaison with the manufacturer. So, the hassles and pain are completely taken off the customer in any part of Nigeria. Actolog believes that the first assignment is to make the customer's equipment work, profit is only a byproduct of excellent customer service.

Without any doubt “Customer is king”, as the Company's campaign slogan stipulates, refers to the customer-centric philosophy which points to the customer as the No. 1 citizen in Actolog's business trajectory. So to keep



Mr. John Akadu
(CEO, Actolog
Solutions Ltd)



A staff working on an Uninterruptible Power Supply, UPS, system



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the customer pleased, Actolog is intentional about pushing the boundaries of customer satisfaction beyond today's feats by innovating for the future. That is why Actolog's business executives and engineers offer an exceptional prompt response to customers' needs. Actolog's CEO echoes this: "We carefully debrief the customer, fully understand their problems and get to the site with solutions (in any part of the country) faster than any other competitor in the market."

To be sure, promptness is one of the core values of the Actolog brand as it strives "to add value and redefine service delivery by providing the highest quality of



*Makelsan Online UPS Kkg Unkaynagi
 Boxer Serisi 10-40 KVA*

service at the shortest possible time and at the most cost-effective price. With this business approach, we have been building long-lasting relationships with clients."As we go out to deliver our products and services on time, it does not end there. At the very core of excellent customer service is quality products. Actolog's UPS products come with unbreakable and unequalled warranty which leaves the customer reassured even in an energy-challenged country like Nigeria. Actolog is the major stockiest of a wide range of European standard products made by MAKELSAN in Istanbul, Turkey, The manufacturer offers excellent on-sale and after-sales services which are best described as

‘try-once-and-get-hooked’.

This enviable niche in the market did not come by chance. Actolog places high premium on staff training, expertise and research. In terms of staff qualification, the lowest entry prerequisite in the Technical department is a National Diploma in Electrical/Electronics discipline while some staff possess B.Sc. in Power Engineering and Masters in Electrical Engineering. The successes of the Company are also attributed to its assiduous approach to training, research and knowledge acquisition.

The obvious inference from our operational philosophy is that Actolog Solutions Limited sits in a class of its own offering critical power backup solutions to Nigeria's teeming business communities across sectors in manufacturing, financial services, hospitals, ICT, elevators, etc. This Company has come of age and recently released rare research findings which offer solutions to users of inverters working with batteries of undesirable short lifespan.

The data from Actolog's breakthrough research has demystified the problems associated with inverter batteries with the introduction of lithium batteries. Actolog is offering lithium batteries which can last up to 10 years compared to that of an average lead-acid

battery which lasts for 2 to 4 years depending on the number years of uninterrupted usage.

In the world of batteries, lithium is the durable component in phones and electric vehicles' batteries which enable them maintain smaller but efficient frames. So, Actolog's introduction of the slimmer lithium batteries as replacement for the bulky lead-acid batteries is pitching efficiency and durability over size and inconvenience.

Speaking at an exhibition recently, Mr. John Akadu, Actolog Solutions Limited CEO, explained that “unlike the regular batteries that are built with 100AH (Ampere Hours) from which you can only draw 50% (50AH), this new invention offers you 95% of the capacity for the whole weighted 100AH. This implies that you can utilize almost the full capacity of lithium batteries repeatedly without damaging the battery cells”.

He further explained that regardless of the number of times customers charge it, their lithium batteries would require no replacement until after 10 years. Again, the normal battery is built to operate at not more than 25oC, but the Nigerian climate sees temperature climbing up to

35oC and above and this adversely affects the life and functions of the battery. However, Lithium battery is



384 Aytemiz Makelsan Boxer S-Serisi 10-15-20 KVA



LevelUP UPS

designed to function optimally in temperatures of up to 60°C and is therefore suitable for the Nigerian weather which can rise in excess of 35°C without the need for cooling.

As part of its sterling services to its esteemed customers, Actolog constantly provides information and training for users of their equipment because they believe that bridging the knowledge gap will ensure better management of supplied equipment. This is the reason why Actolog flew in her Turkish manufacturers to share knowledge while training staff of some clients.

The workshop revealed that there are three levels of uninterrupted power supply (UPS) protection, otherwise called UPS topology. The first gives the end user the power from the grid regardless of the sags or brownouts without filtering the power and when power goes off, it switches to battery. Overtime, the lack of power filtration destroys the equipment. In the middle level technology, power outage is delayed by some milliseconds but is not enough to sustain it. The last stage is the continuous uninterrupted power for critical equipment which cannot allow a break in power. This is used for servers and critical life-support equipment. With this crucial knowledge, customers are guided on what is best suited for their equipment.

Overall, Actolog is always a step ahead of competition and is fast becoming a major stakeholder in the Nigerian power sector. The Company expanded rapidly by moving to a new corporate office in Lagos, and opening an office in Abuja in 2020 despite

the effects of COVID-19 pandemic on businesses. In 2021, it opened its doors to the public in Port-Harcourt which is an important business hub.

This Company has rightly earned its reputation and is not shy to tell customers and prospects that where competitors offer 1 year manufacturer's warranty, Actolog is offering a total money-back/equipment replacement guarantee, 10-year design life on its UPS/inverter equipment and a 25-year design life for its solar panels. This is the best power backup services company you can find anywhere in Nigeria.

Actolog Solutions Ltd. has deployed UPS solution to over 1000 locations across Nigeria and the West African subregion to power heavy-duty equipment like elevators, manufacturing plants, hospital equipment as well as regular ICT loads. With great after-sales support, our UPS solution has performed exceptionally where other UPS brands have failed.

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THE CONVERSION OF NATURAL GAS TO ELECTRIC POWER: ENGINEERING PERSPECTIVES

BY ENGR. SIMON EKEDEGWA AGADA

1.0 INTRODUCTION

Globally, electric power has become the main concern in the economy of all nations. Consequently, countries strive to seek and secure a reliable source of power to guarantee stable economy. All over the world, natural gas is considered as a better source of power because it is cleaner than coal. The engineering principles deployed in the conversion of natural gas to power have to be applied in a cost-effective manner. Therefore, engineers employed in power generation companies need to strive to optimize these principles so as to improve the bottom line.

There are different designs of natural gas power generating machines, depending on the technology. In this paper, we would use a case study of GE, Frame 6 machine without going into power distribution aspect.

2.0 THE COMPONENTS OF TURBO ELECTRIC POWER GENERATOR

2.1 THE GENERAL ASSEMBLY DRAWING

Fig. 1 shows the general assembly drawing (GAD) of the gas turbine engine (GTE) deployed to convert natural gas to electricity.

The gas turbine engine (GTE) is a turbo-machine that converts natural gas to mechanical energy in the turbine while the electric power generator (EPG) utilizes the mechanical energy of the turbine

to produce electricity. The coupled entity of GTE and EPG is called turbo electric power generator (TEPG).

2.2 THE COMPONENTS OF THE GAS TURBINE ENGINE (GTE)

Natural gas is utilized in GTE for combustion to generate heat which is converted to mechanical energy in the turbine. This mechanical energy turns the shaft of the generator for the generation of electrical energy. Each of the components of this turbo machinery (GTE) plays a specific role in converting the natural gas to provide mechanical energy in the turbine as described hereunder.

- i. **Output Shaft and Gear Box:** As shown in Fig. 1, the compressor, combustor and the turbine are connected to a single, centrally positioned shaft which extends outward at the compressor and turbine ends. The extension of the compressor is connected to a prime mover (e.g diesel engine) using the accessory gear box and the torque converter. During start-up of the TEPG, a direct current (DC) battery provides power to the diesel machine to give initial turning of the main shaft. The turbine drives the generator, thus transforming its mechanical energy into electrical energy by electromagnetic induction.
- ii. **The Compressor:** In this case study using GE Frame 6, Model MS 6001B, 17 stage axial compressor is deployed. This provides the air for the combustion of the natural gas. It compresses atmospheric air from suction pressure of 1.032kg/cm²g to a maximum pressure of 11.8 kg/cm²g. It is this compressed air that mixes with the natural gas in the combustor to produce hot gas according to equation 1.

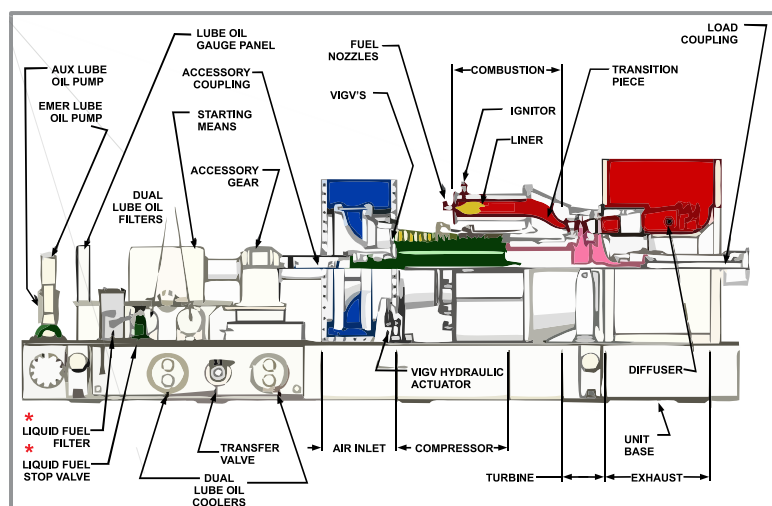
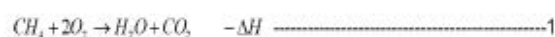


Fig. 1: A general assembly drawing (GAD) of the gas turbine engine



- iii. The Combustor: The combustor is where the mixture of the natural gas and the compressed air is burned to produce hot gas. In GE frame 6 Gas Turbine, there are 10 combustion cans that make up the combustor unit.
- iv. The Turbine: The centrally positioned shaft at the end of the turbine is coupled to the shaft of the electric power generator (EPG) using a gear box. As the hot gas leaves the combustion chamber, it creates mechanical energy in the turbine which turns the shaft of the EPG to generate electricity.
- v. The Exhaust: The exhaust is the passage way that guides the hot, combustion gas out of the turbo-machine. It is the product of the combustion reaction between the natural gas and the compressed air in the combustor. The hot gas leaves the combustion chamber at 11.80 kg/cm²g to the turbine and exits to the atmosphere via the stack at about 1.0818kg/cm²A.

3.0 THE COMPONENTS OF THE ELECTRICAL POWER GENERATOR (EPG)

Basically, the GTE only uses the energy of the natural gas to provide mechanical energy to the turbine. It is the EPG that generates the electricity. Fig. 2 shows the electric power generator (EPG).

The basic components of EPG are:

1. The shaft or rotor
2. The Brush
3. The slip rings
4. The Stator

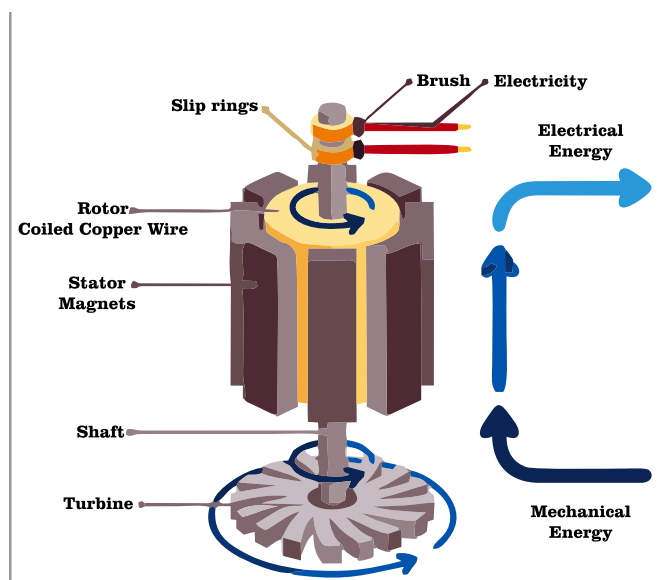


Fig. 2: An electric power generator

Other pieces of equipment required for the generation of power include:

1. DC Battery Banks
2. Exciter System
3. Transformer

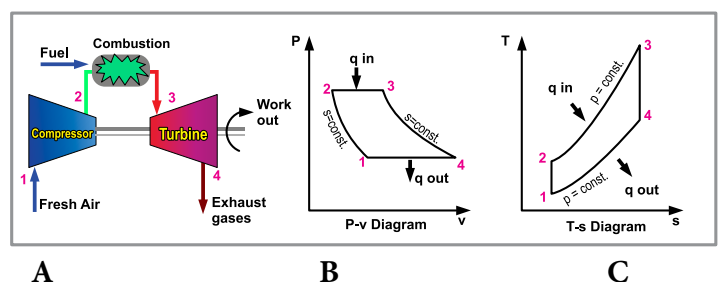
4.0 THE PRINCIPLES OF ELECTRICITY GENERATION

Electricity generation using natural gas requires the use of a gas turbine engine, electricity generator and an exciter. These three pieces of equipment are connected together with a shaft. The gas turbine engine is to help rotate the generator and exciter shaft. The starting point of the electric generation is the exciter where DC current is converted to AC current. The generator is connected to the exciter which provides it with AC current that induces an electromotive force (EMF) in the stator winding as soon as the generator rotor rotates. The stator windings are connected to the transformer which converts the 11KV generated to 33KV. In modern generator, brushes and slip rings replace transistors. Fig. 2 provides an illustration.

5.0 THE ENGINEERING PERSPECTIVES OF THE OPERATIONS INVOLVES IN CONVERTING NATURAL GAS

In this section, some engineering aspects of converting natural gas to power will be discussed using the Brayton Cycle. Figs. 3a, b, c show the Brayton cycle.

5.1 THE FUEL INGRESS TO THE COMBUSTION CHAMBER



Figs. 3a, b, c: The Brayton Cycle.

Fig. 3a shows the fuel (natural gas) entering the combustion chamber with air. As combustion reaction occurs, heat (q-in) is added to the process (See Fig. 3c).

In GTE, the chemical energy in the natural gas is changed from one form to another as shown Fig. 4. Fig. 5 shows the various processes that are involved

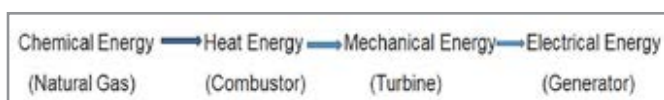


Fig. 4: Conversation of energy in natural gas

in the conversion of the chemical energy of the natural gas to MECHANICAL energy in the turbine. The source of the oxygen is the ambient air. In our

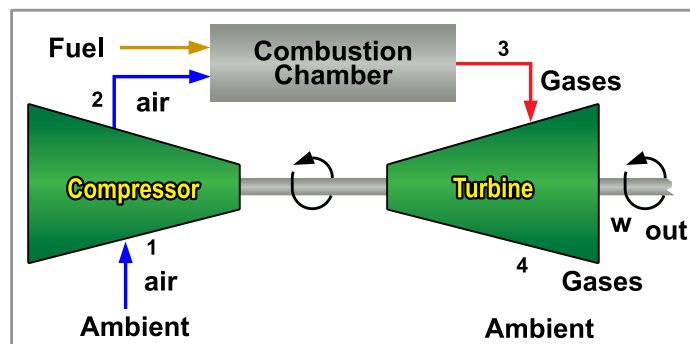


Fig. 5: The processes of converting natural gas to mechanical energy in GTE

case study (GE FRAME 6, MS 6001B), the air is filtered and fed into the axial compressor at point 1, gets compressed from ambient pressure, 1.0 barg to about 11.8 barg and exits at point 2 (See Fig. 5). The natural gas and compressed mix in a pre-mixing chamber and the mixture undergo combustion.

The combustion process (2-3) involves increase in volume but at constant pressure. The pressure of gas inlet to the turbine (P1) is 22- 24 barg. This is regulated by a gas stop ratio valve (SRV) to about 15 – 17.58 barg (P2) and finally by the gas control valve (GCV) to about 10 barg before entering the combustor. The ratio of the compressed air pressure and the natural gas pressure before mixing is about unity (1.5). The energy utilized from the natural gas depends on its low heating value (LHV).

The quantity of air and the natural gas to the combustion chamber is regulated based on the load. Fig. 6 shows the instrument on the natural gas pipeline to control and regulate the natural gas to the combustor.

Fig. 7 shows the distribution of compressed air from

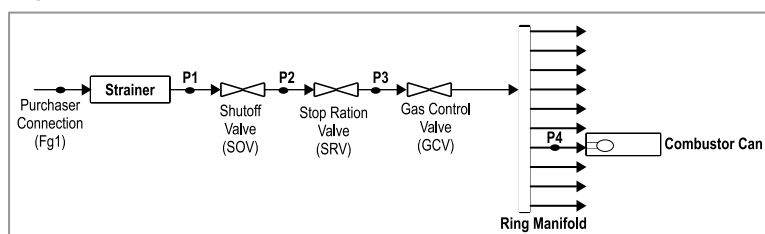


Fig. 6: Control of natural gas to the combustor.

the compressor. The combustion air at stage 17 of the compressor is premixed with fuel before the mixture is injected into the combustion chamber through a set of nozzle. The combustion air exits the compressor at point 2 at a temperature of about 300oC and increases adiabatically during combustion to a firing (combustion) temperature of about 1727oC at point 3 (See Fig. 5).

$\Pi = 3.6$) the temperature change may only K1.766C9.183C9About 15-20% of air is introduced around the jet of fuel in primary zone to provide necessary high temperature for rapid combustion. Some 20 % of the total air is then introduced through holes in the flame-tube in the secondary zone to complete the combustion, reducing the reaction rate in that neighbourhood

The turbine converts the energy of the flue gas (gas at combustion chamber outlet) into mechanical energy to drive the compressor, the turbine, the electricity generator and other accessories like the exciter. Fig. 5 shows the compressor and the turbine arranged on a single shaft. This shaft extends outward at the compressor and the turbine. The extension at the compressor is connected to a prime mover (for the case study, it is diesel engine), while that at the turbine is connected to an electricity generator.

At a satisfactory air flow from the compressor, the ignition is turned on and the fuel valves on the natural gas line are opened, and the central rotor begins to turn and increase in speed gradually. At a speed of 3,066RPM (60% of the maximum speed of 5163 RPM), the starter disengages and the hot gas produced from the combustion turns the turbine, sustains the speed and increases it gradually until the required speed is attained.

As seen in Fig. 5, the flue gas enters the combustion chamber at point 2 and exits at point 3. This exit temperature, called flame or firing temperature is about 1071oC, a value too high for the metallurgy

of the turbine materials. Therefore, prior to entering the gas turbine at point 3, it is diluted with secondary air from stage 17 of the compressor to attain the required turbine inlet temperature of 950oC (see Fig. 7). Fig. 5 shows the condition at the inlet to the turbine (Point3) and outlet of turbine (Point 4). The flue gas decreases in pressure from inlet to

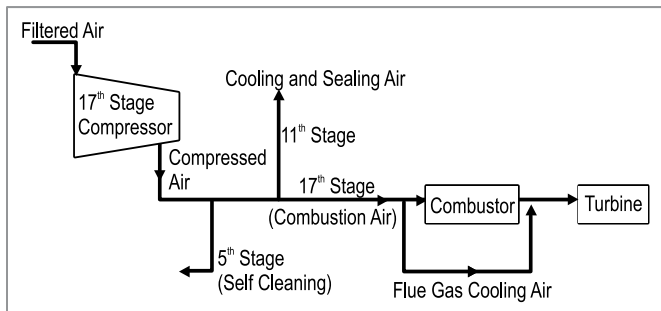


Fig. 7: The distribution of compressed air at the outlet of axial compressor

outlet and increases in volume. The temperature decreases but the entropy remains constant in line with the Brayton Cycle principle.

5.2 THE WORK DONE BY THE FLUE GAS ON THE TURBINE AND GENERATOR FOR GENERATION OF ELECTRICITY.

As seen in Figs. 5a, b, c, the gas (product of combustion), also called flue gas undergoes a unique process from point 3 to point 4: Pressure decreases; Temperature decreases; Volume increases; entropy remains constant. According to gas laws, the decrease in temperature of gas means decrease in kinetic energy (KE), decrease in pressure means decrease in pressure energy.

This means some portion of the kinetic energy and pressure energy in the gas are transformed to mechanical energy in the turbine. We do recall that the centrally positioned rotor carrying the compressor and the turbine is extended outward at the turbine. This extension is connected to the rotor of the generator and the exciter using a gear system.

Thus, as the turbine turns at a speed of 5163 RPM, the gear system reduces this speed to 3000RPM and causes the electric generator to turn, thereby generating electricity using the principle of electromagnetic induction.

Fig. 8 depicts the arrangement of gas turbine engine and electricity generator. The flue gas enters the

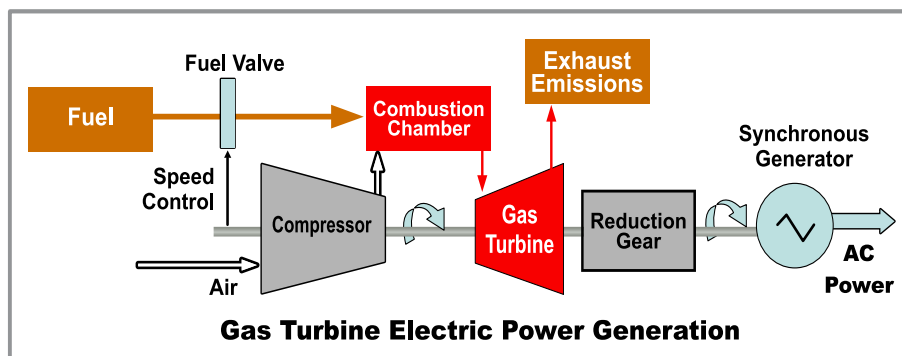


Fig. 8: Natural gas energy conversion to electricity

turbine at a temperature of about 950oC and exits at the outlet at about 599oC. The outlet temperature of the flue gas enables it to be used in the combined cycle to generate steam in the heat recovery and generator system (HRSG).

6.0 THE EFFICIENCY OF THE SIMPLE AND COMBINED CYCLE OF THE GAS TURBINE

The efficiency of the gas turbine in our case study (GE Frame 6, MS 6001B) is either evaluated as single cycle or combined cycle depending on whether HRSG is in service or out of service. The efficiency term is described as natural gas -to- power efficiency (Power generated / Total energy in gas).

Where,

$$\eta_{TSC} = \frac{P_{actual}}{LHV_{gas}}$$

η_{TSC} = Turbine efficiency using single cycle,

P_{actual} = Actual Electric power generated (KJ/s)

LHV_{gas} = Low Heating Value of the Gas utilized (KJ/s)

For a single cycle, the efficiency is about 20 -35%, but for a combined cycle, it is about 60%

7.0 CONCLUSION

The gas turbine engine, when coupled to electricity generator utilizes the energy of natural gas to produce electricity. The energy of the natural gas is converted to mechanical energy in the turbine which turns the electricity generator to produce electricity using the principle of electromagnetic induction.

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Engr. Enefiok Ubom, FNSChE

REVERSING THE 'DARK SIDE' OF THE OIL & GAS INDUSTRY

BY ENGR. ENEFIOK UBOM

1.0 INTRODUCTION

The first oil well in Nigeria came on stream in 1958 in Oloibiri in the Niger Delta region. The country has witnessed tremendous growth in the oil & gas industry since then with enormous growth of earned revenues. However, there is a 'dark side' to the industry, that is, environmental pollution and degradation of the ecosystem.

2.0 REVERSING ENVIRONMENTAL POLLUTION IN THE PETROLEUM INDUSTRY

Companies operating in the petroleum industry have the responsibility to evolve techniques to reverse environmental pollution and curb the damage to the ecosystem. This paper presents some techniques in the scope of tit-bits.

2.1 ENVIRONMENTAL AUDIT

Oil and gas field environmental health and safety audit is a very comprehensive review of all applicable environmental, health and safety laws, regulations and corporate environmental, safety and health (ESH) policies including ISO 14000 requirements. An ESH audit of an oil and gas field is a formal process that may last for days or weeks.

Audits of an oil or gas field should address air pollution control, water pollution, drinking water management, employee safety, industrial hygiene, loss prevention & emergency response and training policies.

The benefits of ESH audit include the following:

- Better compliance with governmental and production sharing contracts
- Adequate and relevant information transfer to stakeholders
- Reduction of potential ESH risks
- Reduction of incidents leading to fines and lawsuits
- Enhancements of policies and marketing image

2.2 ENVIRONMENTAL SITE ASSESSMENT

An environmental site assessment (ESA) is designed to address any past or present hazardous substances,

wastes or toxic chemicals that may have been present on the subject site, either on the surface or within the subsurface.

ESA can be categorized into 5 phases, namely record search & site investigation, sampling, remediation, monitoring and closure.

Record of oil spill in Nigeria started with the Ebubu-Elleme oil spill of 1967-1970. Since then, there has been numerous incidents of oil spills both onshore and offshore with disastrous consequences on the ecosystem.

The extensive damage to the rich mangrove forests/vegetation and marine ecosystem by oil spills on Ogoni land and indeed other parts of Niger Delta region cannot be disputed. For Nigeria, appropriate use of ESA techniques would apply to Ogoni land remediation efforts initiated by the Federal Government through the United Nations Environment Program (UNEP). Ogoni land degradation by petroleum production activities is just one of the examples of the 'dark side'. Fig. 1 shows a typical oil spill site.



Fig. 1: *A green swampy site degraded and darkened by an oil spill*

3.0 THE WAY FORWARD

This paper does not attempt to provide all the details of effective management of the petroleum industry with zero pollution. It suffices to state in general terms that the drive for environmental sustainability should be heightened through stringent legislation and the organizations involved in the oil & gas industry should ensure they achieve sound environmental performance through the control of the impact of their activities, products and services on the environment.

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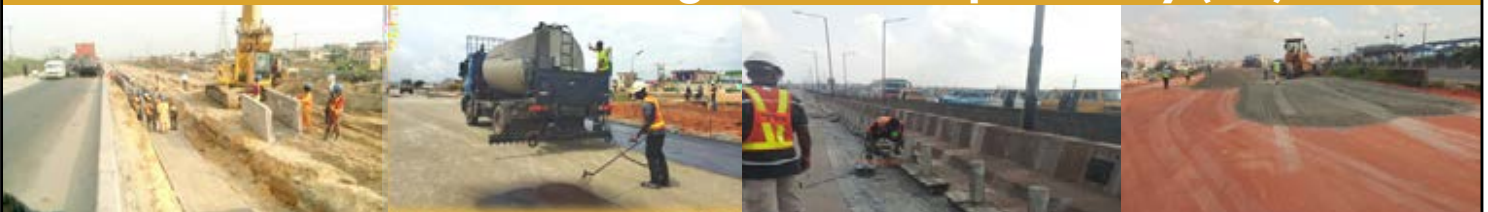
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