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Petrochemical Technology Development: an Evaluation of the Nigerian Industry

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Abstract
Petrochemical resources have been exploited in sizeable quantities for the past fifty years in Nigeria. The discovery of Crude Oil and Natural Gas in Nigeria opened a floodgate of activities in the Petroleum and Petrochemical sectors. Four Petroleum Refineries have so far being built, with Warri and Kaduna Refineries having accompanying Petrochemical Plants. While the Warri Refinery has Carbon Black and Polypropylene Plants, the Kaduna Refinery has a Linear Alkylbenzene (LAB) Plant. Several other Petrochemical infrastructure have being built by government and private investment ever since. All these Plants were designed, installed and operated by foreign technology. After more than three decades of commissioning of the first Plant, local Engineers (expertise) can only operate and run these Plants. Basic redesign and maintenance of plant units and components are still referred offshore for technical support. There exists significant gap between Petrochemical infrastructure and in – country capacity in the industry. This paper therefore evaluates this gap with the aim of making useful suggestions in bridging it.

Keywords: Petrochemical, Technology, Industry

1.0 Introduction

Petrochemical as the name implies literarily means chemicals derived from Petroleum (which in this context includes Natural Gas). However, a common and contemporary definition of petrochemicals simply is; chemicals that are predominantly composed of hydrocarbons (Mall, 2007). Though, use of petrochemicals predates the discovery of Petroleum, its application is synonymous with the latter.

Petrochemical technology development and growth has changed the socioeconomic dynamics of the world since the early 1920s.

Every aspect of the daily life of man has something to do with petrochemicals. From shelter to clothing, household wares to cleaning etc., have major petrochemical products as indispensable inputs all over the world. Worthy of note is the rapid transformation of most domestic and industrial packaging products and services from the traditional metallic or wooden products to petrochemical derivatives. Almost every single packaged product hither done with other material can now have a convenient if not better replacement by a petrochemical product, thereby changing the face of global economy. Another sphere of critical application of Petrochemicals is the health sector for production of drugs, detergents, etc.

1.1 Petrochemicals' Production Process

The production of Petrochemicals follows the typical chemical process which comprises of physical separation processes interspersed with chemical reaction phases (Sinnott, 2005). For the purpose of this study which derives from the exploitation of Petroleum in Nigeria, the production scheme of Petrochemicals adopted shall be from processing of Petroleum commonly called Crude Oil and Natural Gas, as shown in Figure 1. There are no Rules of thumb in the processing of Petrochemicals as there are different pathways to arrive at a product, whence the figure below only presents a schematics of basic stages of producing common Petrochemical products from Petroleum without basic enabling details.

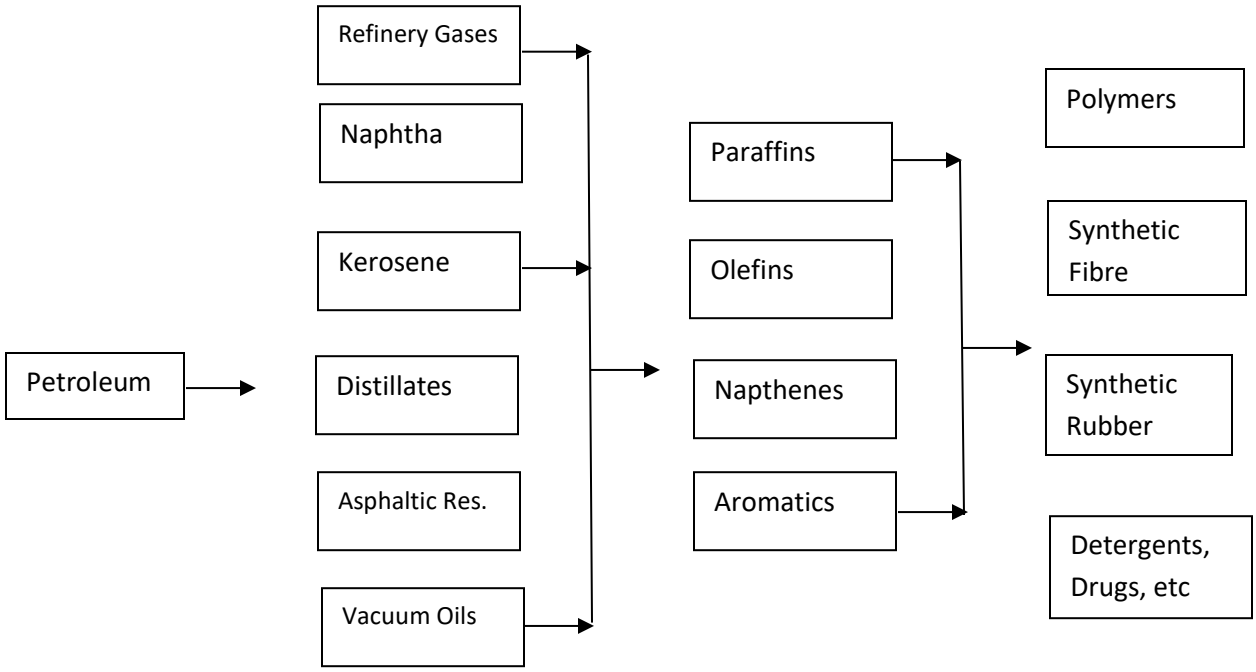


Figure 1: PFD of a Typical Petroleum Based Petrochemicals Plant

1.2 Objectives of Study

After over five decades of Petroleum and Petrochemicals development in Nigeria, there exists a considerable gap between in – country capacity and Petrochemical infrastructure. This paper therefore seeks to evaluate existing Petrochemical resources in Nigeria and the level of exploitation compared to available in - country capacity or technology in developing and harnessing these resources. Specific attention shall be given to the acquisition and/or transfer of such technology (Blomström and Sjöholm, 1999).

2.0 Methodology

2.1 Petrochemical Milestones of Nigeria

Petrochemical technology arrived in Nigeria upon the discovery of Petroleum in commercial quantities in Oloibiri of Bayelsa State (in then, mid- Western State in 1956) and the subsequent establishment of the first Petroleum Refinery of Nigeria at Port Harcourt in 1965. Earlier, Petroleum exploration activities had commenced in 1908 by the German Bitumen Corporation in present day Ondo State, even though the prospect was short-lived due to the outbreak of World War I. Later in 1937, the Nigerian

Government granted the Anglo – Dutch Consortium, Shell D'Arcy (later Shell Petroleum Development Company) sole concession for exploration of Petroleum which was only reviewed in 1959 when some more companies: Mobil, Gulf, Agip, Statrap (now Elf), Tenneco and Amoseas (now Texaco/Chevron) were granted similar rights (Chima, 2002). By the 1980s, substantial oil reserves have been recorded as shown in Table 1.

Table 1: Nigeria's Proven Crude Oil Reserves (Billion Barrels)

Year	Reserve	Change
1980	17	NA
1990	16	0.00%
2000	23	0.00%
2010	37	2.78%
2015	37	0.00%

Adapted from: www.indexmundi.com

A Second Petroleum Refinery – the Warri Refinery and Petrochemical Company (WRPC) was established in 1978, with a total crude processing capacity of 125,000bpd. The steady growth of the industry led to the establishment of two more Refineries in Kaduna and Port Harcourt to meet local and foreign demand for the products. Table 2 gives production capacities of the Petroleum Refineries in Nigeria.

Table 2: Production Capacities of Petroleum Refineries in Nigeria

S/N	Refinery	Capacity bpd
1	Port-Harcourt Refinery I	60,000
2	Port-Harcourt Refinery II	150,000
3	Kaduna refining and Petrochemical Co.	110,000
4	Warri refining and Petrochemical Co.	125,000
	Total	445,000

Source: ***www.nnpcgroup.com***

To effectively harness the benefits of the fast growing Petroleum industry, the Government of Nigeria established the Nigeria National Oil Corporation (NNOC) by Decree No. 18 of 1971. It gave basic regulatory authority to the body in the Petroleum sector. This was in response to the need to guide and control the activities in the sector which was completely in the hands of multinational companies. At the onset, there was only little and mostly menial local participation in the industry.

The Nigeria National Oil Corporation was merged with the then Ministry of Petroleum Resources to form the Nigeria National Petroleum Corporation (NNPC) by Decree No. 33 of 1977. The NNPC was mandated to oversee and monitor all activities in the upstream, midstream and downstream sectors of the oil industry in Nigeria and operated the Nigerian Government's 55% equity in Joint Venture Partnerships with Multinationals (NNPC, 2017).

Major investment in the Petrochemical industry came with the establishment of the Warri and Kaduna Refineries and Petrochemicals. Thereafter, the NNPC established the Eleme Petrochemical Company in Alesa, Eleme in Rivers State. Though fully privatized now with Indorama of India as new owners, the Plant was the biggest Petrochemicals investment in Sub – Sahara Africa at the time and produced Polyethylene, Polypropylene, and Polyvinyl chloride (PVC). Table 3 gives some major Petrochemical milestones of Nigeria.

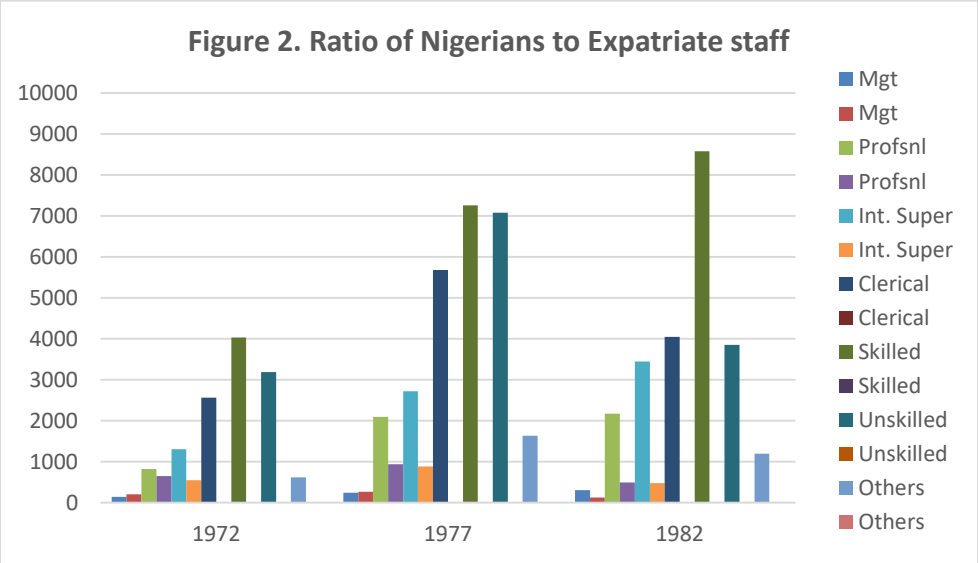
Table 3: Petrochemical Milestones of Nigeria

S/N	Name of Plant	Location	Date	Ownership
1	Port Harcourt Refineries 1	Eleme	1965	NNPC
2.	Warri Refinery and Petrochemicals	Warri	1978	NNPC
3.	Kaduna Refinery and Petrochemicals	Kaduna		NNPC
4.	Eleme Petrochemicals Company	Port Harcourt	1990	Fed. Govt
5.	National Fertilizer Company of Nigeria	Onne	1988	Fed. Govt
6.	Nigeria Liquified Natural Gas (NLNG)	Bonny		NNPC JV
7.	Brass LNG (Yet to take – off)	Brass		NNPC JV
8.	Olukola LNG (Yet to take – off)	Olukola		NNPC JV
9.	Chevron Gas–to–liquid plant	Escravos		Chevron
10.	Viva Methanol Plant	Lekki		
11.	Axinova Polyolefins Plant			
12.	Methanol Plant (License Acquired)*	Lekki	2000	Eurochem Tech.
13.	Polypropylene Plant (License Acquired)*	Anambra	2008	Emerald E & P
14.	Polyethylene (License Acquired)*	Unknown	2010	CCECC/NNPC
15.	Dangote Refinery (under construction)	Lekki	2018	Dangote Group
16.	Approval of Refinery Licenses by Govt.	NA	NA	NA

Source: Compiled, * Ajevu et al. [15],

2.2 Domestication of Petrochemical Technology by Nigeria

There was little or no in - country expertise in Petrochemical technology at the beginning of petroleum exploitation in Nigeria. Expatriate staff dominated every aspect of the industry ranging from installation to operation and maintenance of these facilities for the first several years. All major Petrochemical Plants of the country were designed and fabricated overseas. Even the installation, operation and maintenance were supervised and directed by expatriate staff and companies. Local professionals were few at the time and still needed specific trainings to meet the requirement of the Plants. A staff data of Nigerians to Expatriates in the Oil sector in the late 70s and 80s is represented in Figure 2.



Source: Adapted from NNPC Annual Report

Although the figures appear somewhat balanced, a critical analysis reveals strong presence and dominance of the sector by Expatriate Staff even as against the expatriate quota law (Legalforms, 2017). This situation was across both upstream and downstream operations. While the Multinational Companies were comfortable with the situation of acute lack of local expertise as it benefited them, the Nigeria government was not to wait for long before reversing the trend. A major policy trust that the foregoing was anchored on was the nationalization policy of the Nigerian Government (Biesteker, 1983). Other specific actions that were taken by the

Government to address domestic capacity lack in the sector was establishment of the following :

2.3 Nigerian Engineering and Technical Company (NETCO)

The Nigerian Engineering and Technical Company (NETCO) was established in 1989 as a subsidiary of the NNPC to correct the seeming manpower deficit in the Petroleum Sector. The company was to acquire and develop in - country capacity in the Petroleum and Petrochemicals sector as a joint venture between the NNPC and American Bechtel Inc. Bechtel Inc as partners were specifically to midwife the young company technically and thereby transfer technology in the long run. This noble objective was however not fully achieved as Bechtel Inc. pulled out of the JV in April, 1997. Today, NETCO is wholly owned by the NNPC with staff strength of about 412 Nigerians out of which are about 330 Engineers of various fields (NNPC, 2017). A select few of the several projects executed by NETCO are given in Table 4.

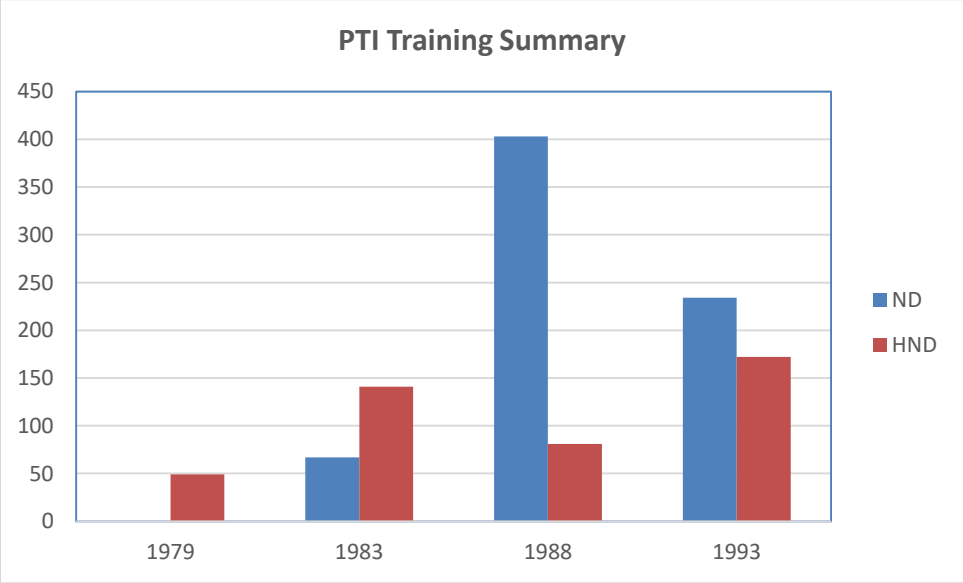
Table 4: Highlight of NETCO'S Experience

Date	Project Title	Client	Country
2001	Project Specification for NLNG Plus	TSKJ	UK
2001	Detailed Engineering of Bonga FPSO Topside Project	AMEC	NGR
2001	Detailed Engineering of Bonga FPSO Pipeline/ Flowline & Riser	ACERGY	NGR/FRN/US
2002	Detailed Engineering of Fractionation Unit, NLNG Plus	TSKJ	NGR
2002	Detailed Engineering 0f ExxonMobil's Erha FPSO EPC -1 Project	SAIPEM S.A	NGR
2004	FEED for QIT Gas Flare Elimination	MOBILE	NGR
2005	Detailed Engineering (Part of Agbami FPSO)	KBR	US/ NGR
2005	FEED for Brass LNG Project	BECHTEL	NGR
2006	Detailed Engineering of Condensate Stabilization Unit, NLNG (Train 6)	Entrepose	NGR
2006	FEED for Olukola LNG Gas Supply	KELLOG	NGR

Source: netco.nnpcgroup.com

2.4 Petroleum Training Institute (PTI)

Another step taken to develop in – country capacity in the sector by Government was establishment of the Petroleum Training Institute in Warri (PTI Act, 1973). The Institution was mandated to train intermediate manpower for the industry with high practical content. It was for this reason, PTI became domiciled as a parastatal in the Ministry of Petroleum Resources as against the Ministry of Education which traditionally houses Educational Institutions. The summary of PTI's training progression given in Figure 2 gives a glimpse of how well petrochemical technology development has fared in Nigeria.



Source: Adapted from PTI Annual Report (1996)

2.5 Petroleum Technology Development Fund (PTDF)

The government in 1973 established the Petroleum Technology Development Fund (PTDF) by Decree No. 25 but actual operations of the Fund started in the year 2000. The PTDF is saddled amongst other things with the following responsibilities (Adekalu et al., 1999).

- To provide scholarships and bursaries to Students in Universities,

Colleges and other higher institutions at home or abroad.

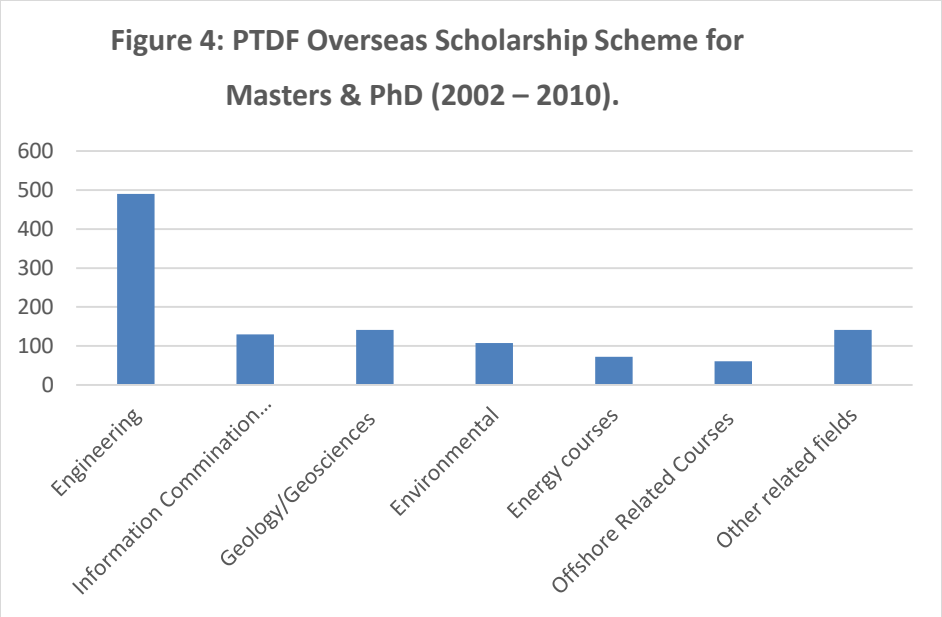
- To maintain, supplement or subsidize their education as mentioned above.
- To make suitable endowments to Faculties in Nigerian higher institutions as approved by the Minister.
- To make available suitable books and training facilities in the aforementioned institutions.
- For sponsoring requisite visits to oil fields, Refineries, Petrochemical Plants and also arranging the attachments of personnel for any of the establishments connected with the oil and gas sector.
- For financing the participation of personnel in seminars and conferences pertaining to the oil industry in Nigeria and Abroad.

In exercise of its mandate, the PTDF has upgraded infrastructure in various Institutions especially the Oil and Gas related ones (PTDF, 2010). But most significant is the endowment of Professorial Chairs in some Nigerian Universities given in Table 5 and the Training Programmes through its Scholarship Schemes and others skills acquisition schemes shown in Figure 4 (Muttaqha, 2010).

Table 5: Universities having PTDF Professorial Chair

S/N	Beneficiary University	Course
1	University of Maiduguri	Geology
2	Usman Danfodio University of Sokoto	Petroleum Chemistry
3	University of Nigeria Nsukka,	Geological Sciences
4	University of Port Harcourt	Gas Engineering
5	University of Zaria	Chemical Engineering
6	University of Ibadan	Petroleum Engineering
7	University of Jos	Geology

Source: PTDF Mandate (2010)



Source: Muttaqha et al. (2010)

2.6 Petroleum and Petrochemical Engineering in University curriculum

Nigerian Universities introduced Petroleum and Petrochemical Engineering in their curricula to meet the demand of capacity in the sector. While Petrochemical Engineering was first introduced by the Rivers State University of Science and Technology, Port Harcourt, the first Universities that introduced Petroleum Engineering in Nigeria are given in Table 6.

Table 6: First Nigerian Universities with Petroleum Engineering

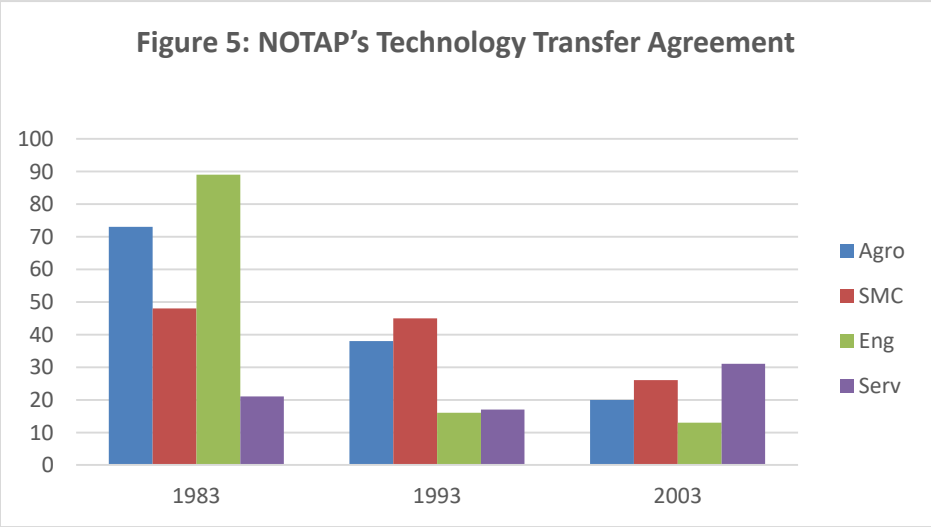
S/N	UNIVERSITIES	YEAR
1	University Of Ibadan, Ibadan	1972
2	River State University of Science & Technology, Port Harcourt	1995
3	Abubakar Tafawav Balewa University,	1998
4	Igbinedion University, Okada	2002
5	Covenant University, Ota	2004
6	Madonna University,	2004
7	University Of Benin, Benin	2006
8	Federal University Of Technology, Owerri	2007

Source: www.academia.com.ng and Universities portals

2.7 National Office for Technology Acquisition and Promotion (NOTAP)

The Federal Government Agency responsible for the acquisition and transfer of technology is the National Office for Technology Acquisition and Promotion (NOTAP), an Agency under the Federal Ministry of Science and Technology. It was established by Decree No. 70 of 1979 as the National Office of Industrial Property (NOIP). The Agency is saddled with functions such as valuation/Registration of Technology Transfer Agreements, Promotion of Intellectual Property, Technology Advisory and Support Services, Commercialization of R&D Results, Research Industry Linkage etc (Ekperiware and Adepoju, 1999)

The activities of NOTAP in the promotion of Petrochemical Technology development in Nigeria leaves much more to be desired as seen from the data in Figure 5 where Engineering, the bedrock of technology comes in a distant third place in total average.



Source: NOTAP Annual Report, 2011

2.8 Nigerian Content Development and Monitoring Board (NCDMB)

The Nigerian Content Development and Monitoring Board (NCDMB) commonly referred to as Local Content Board was established to encourage domestic participation in the Petroleum sector. Though quite recent in establishment, the

Board is creating quick consciousness on the need for Nigerians to take ownership of the industry. While a number of successes have been achieved by the NCDMB in ownership of businesses and skills development especially in welding and fabrication, the Petrochemical technology is yet to record any concrete achievement. The effect of the record 26% local content milestone (NCDMB Conference, 2017) is yet to impact on Petrochemicals.

2.9 Engineering Professional Bodies

Finally, **The Council for Regulation of Engineering (COREN)**, the **Nigerian Society of Engineers (NSE)** which is the umbrella Organization of Engineering Professionals in Nigeria and its subsidiary bodies in the Petrochemical subsector **(the Nigerian Society of Chemical Engineers, NSChE and the Society of Petroleum Engineers SPE)** have worked tirelessly to improve local expertise. This they do by organizing regular Engineering Conferences and Workshops and sundry other activities aimed at improving petrochemicals technology. But rather sadly, these numerous efforts have not added up to any visible and concrete achievement in the development of Petrochemical technology locally.

3.0 Existing Petroleum Technology Gaps

1. Although there are few indigenous Engineering Companies that are into the design and construction of Plants or Units of Petrochemical Plants such as NETCO, this is mostly in collaboration with international partners and often not in core process units like reactors, distillation columns etc. The attainment of only 26% Nigerian Content after over fifty years of Petroleum exploitation is a sad commentary.
2. There are yet no internationally recognized Nigerian patents in the Petrochemical subsector.
3. There is still high and prohibitive dependence on foreign expertise for maintenance of Petrochemical Plants (such as TAM).
4. There is a painfully weak synergy between Academia and industry in coordination of research in this regard.
5. There is a disappointingly low Government's consciousness and sad indifference to the poor development of petrochemical technology in Nigeria even though investment in the sector is in Billions of Dollars.

Conclusion and Recommendations

In concluding this evaluation, it is worthy to note that tremendous effort has been made by the Nigerian Government to consciously develop technology in the Petroleum/Petrochemical subsector by acquisition or transfer but after over fifty years of Petroleum in Nigeria, the following grim situation still persists.

1. Total Privatization of the NNPC and its SUBs

The privatization of NNPC and its subsidiaries especially NETCO as was the case in the power sector is long overdue. It is a known fact that Nigeria being a capitalist economy cannot afford government control of businesses such as the NNPC. While it can retain regulatory duty, actual management for profit and growth including but not limited to the development of technology in the sector be given to the organized private sector as is the global best practice. The piecemeal deregulation of the sector by government is rather diversionary and counterproductive.

2. Insulation of NCDMB from Political Control

The meteoric rise in Nigerian content development in the Petroleum and Petrochemicals sector (from 0.5% to 26%) within a period of six years is a commendable feat by the NCDMB. However, this tempo can only be sustained and even improved upon if the agency is reasonably or totally insulated from political control. Quick measures to achieve the foregoing are not only desirable but expedient.

3. Repositioning of NOTAP

The law establishing the National Office for Technology Acquisition and Promotion (NOTAP) should be revisited with intent of making the agency more functional and result oriented. As a major factor in the promotion and transfer of technology, the agency has not lived up to its duties. It should be powered beyond mere registration of agreements as it currently does.

4. Revisit of Educational Curriculum

Osokoya (1987) contends that education is a distinctive way in which the society inducts its young ones into full membership. Technical education at the primary and post primary levels will inculcate these traits early in the young people. Unfortunately, the Nigerian society has an inexplicable propensity for tertiary education without due consideration for the substance of such

tertiary certificates that are paraded. A revisit of the educational policy and curriculum to discourage this culture is sure way to actualize technical and technological development. The same goes for University research and collaboration with industry

5. Government Policy

Finally, there cannot be any direction in society where there is no government. In everything that a society achieves, government provides the driving force. Consequently, greater government's commitment and engagement is an indispensable prerequisite for the overall attainment of the desired success.

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