



## Sustainable Infrastructural Development in Oil and Gas Sector: Challenges and Prospects

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### Authors' contributions

*This work was carried out in collaboration between all authors. All authors wrote, read and approved the final manuscript.*

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### ABSTRACT

Nigeria, though blessed with more natural gas than any other country in Africa, has very little capacity to put it to good use. The country lacks pipelines, processing facilities, petrochemicals plants and much of the other infrastructure needed for a thriving sector. As a result of this, Nigeria is the world's number two practitioner of flaring-burning gas when it comes from wells instead of trying to put it to use. Only Russia flairs more gas on an annual basis than Nigeria. With few supply bottlenecks removed, a clear legislation and an end to the sabotage and kidnapping common in the Niger Delta region, Nigeria's gas could be the catalyst for economic growth: new businesses, jobs and the removal of millions out of poverty level. The recent global crisis in oil prices has brought us to the need to note that this over-dependence on the oil creates needless shocks and thus, the need for diversification of the nation's resource base and long term growth path. Nigeria still has a long way to go, to solve its many problems in the Oil and Gas sector; and that most of it has to do with infrastructural decay.

**Keywords:** Infrastructure; refinery; oil and gas; flaring; pipelines; offshore; onshore.

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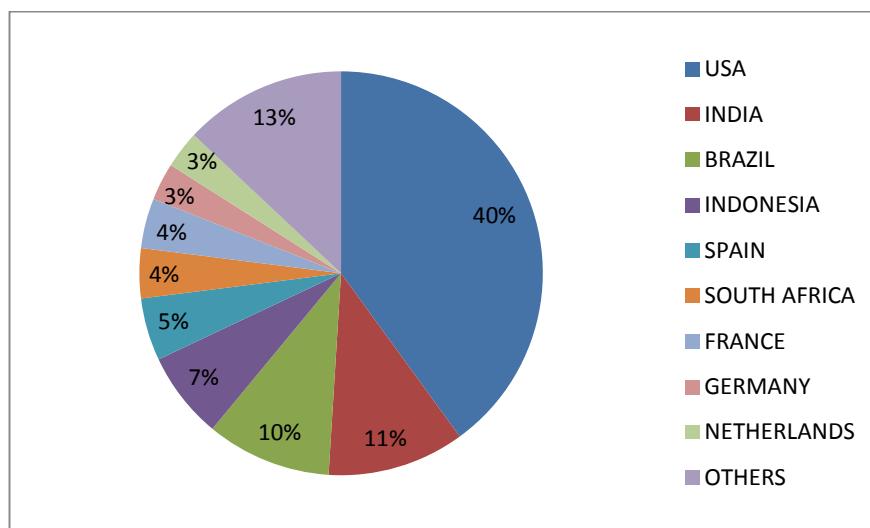
## 1. INTRODUCTION

Nigeria is the 11<sup>th</sup> largest oil producer in the world and the largest in Africa, until recently that she was overtaken by Algeria [1]. Nigeria's production currently stands at an average of 2.5 million barrels per day. However, Nigeria has set for herself striving targets of achieving 4 million barrels of production by year 2020. Nigeria's maximum production so far was between year 2004 and 2005, when more than 900 million barrels of crude oil was produced [2]. Between 2008 and 2009, the country recorded the least production, a little above 750 million barrels was produced as shown in Fig. 2. It should be noted that this period was that of global economic and financial crunch. In 2013, a total of a little over 800 million barrels of crude oil and condensate was produced. More than half of Nigerian's oil production was exported to the US in 2008-slightly less than 2 million bpd, making Nigeria the fifth-biggest supplier to the US market. Fig. 1 shows the statistics of oil exportation by different countries in year 2009.

More than 50 years after Nigeria got independence and had started graduating her own talented Engineers, the country still has challenges with infrastructure in many areas, especially in the oil sector of the nation's economy. This is one topic that has been agitating the minds of many professionals who are involved in developing infrastructure. It has

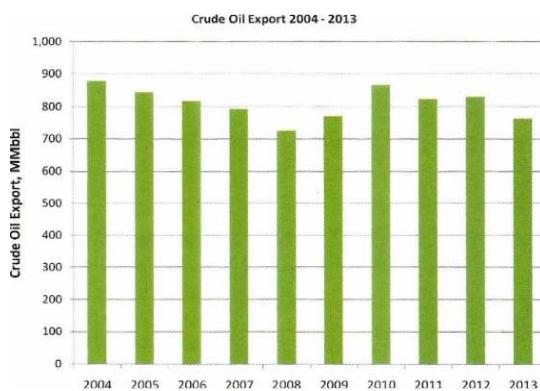
been the theme of many engineering conferences and annual general meetings in the past. There was a time the Federal Government set up an Infrastructure Concession Regulatory Commission to focus on strengthening infrastructure development through Public Private Partnerships (PPP). With this, the country still has significant infrastructure deficits that it is struggling to adequately address. This has been a problem for engineers in various fields of endeavour. It is a known fact that, there is epileptic power supply, public water is in short supply, the poor state of roads in the country has made transportation and distribution costs in Nigeria to be among the highest in the world. Sequent to this project development costs for oil and gas infrastructure are almost prohibitive and many projects are suffering delays in making final investment decisions.

A section of the Professional group believes that the challenge of sustainable development of infrastructure in Nigeria is really the approach and not the infrastructure itself. Energy infrastructures materializes through the services it provides us [3]. This simply implies that more energy infrastructure will be required as we embrace more energy intensive practices which then puts pressure on the provision of more services that are energy dependent. Notwithstanding the type of infrastructure that is required in any field, robust design and maintenance strategies are always



**Fig. 1. Oil exports by country**  
(Source : US Department of Energy (DOE), 2009) [4]

needed to keep the infrastructure in the best operational conditions. There is a new approach now being used for pipeline infrastructure development, it is called Asset Integrity Management (AIM). The objective of Asset Integrity Management is to outline the ability of an asset to perform its required function effectively and efficiently. While doing this it will at same time be able to protect the health and safety of the environment [5].



**Fig. 2. Crude oil export (2014)**

Specifically, Oil and gas infrastructure is made up of the following; oil processing facilities, power utilities, pressure vessels pipelines, wellheads, flow lines piping, and pipeline manifolds, and, pigging facilities, water injection systems, fire protection systems, telecommunications and so on. The offshore facilities are similar to that of onshore; the major difference between them has to do with the environment in which they operate. Onshore facilities are laid in trenches deep enough to protect them from damage such as mechanical impact. Those of the offshore are laid on the seabed and are held down by their own weight or the weight of the fluid they carry. The greatest challenge of the offshore is the environment in which they operate. Storms and hurricanes are frequent occurrences offshore, and they can easily tear down a steel platform, if it is not well structured. But then any service disruptions will undoubtedly be expensive and possibly catastrophic. The more reason while offshore facilities must be robust in design and construction; otherwise the consequences of service disruptions could be very devastating.

## 2. REFINERIES IN NIGERIA

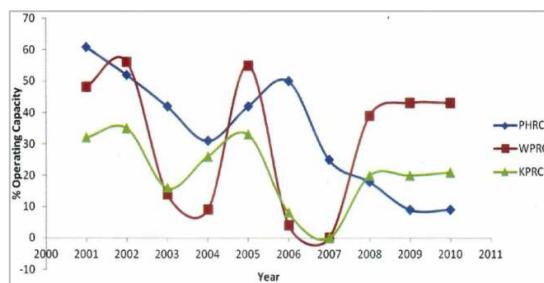
The NNPC had established and operated four refineries with combined installed refining

capacity of 445,000 barrel of crude petroleum oil per day. All the refineries had been operating sub-optimally because of poor maintenance. They all had suffered from the same lack of turnaround maintenance. In the last ten years, the refineries were jointly producing at less than twenty percent of installed capacity [6]. Crude oil by itself in an unrefined form has little or no direct use. Its value as a commodity is only realised when its many different hydrocarbon components are separated out, broken down or combined with other chemical in a refinery to provide products that can be marketed. A crude oil's value, therefore, is directly related to the yield of useful products each barrel will produce as it is passed through a refinery [2]. Nigeria currently has four refineries. The one in Port Harcourt, the old refinery inaugurated in 1965 has a capacity of 60,000 barrels per day. The new refinery inaugurated in 1989 has an installed capacity of 150,000 barrels per stream day. The other two refineries are in Warri and Kaduna. The Warri refinery was established in 1978 to refine 100,000 barrels per stream day(b/psd), and was expanded in 1987 to 125,000 b/psd. The Kaduna Refinery was commissioned in 1980 with a nameplate capacity for 110,000 barrels per stream day. Table 1 shows the total refining capacity of the existing refineries. The refineries have on many occasions suffered from irregular Turn around Maintenance. While TAM is required once in every two years, the refineries have been without TAM for almost two decades and this has caused serious problem for their operations. Invariably, lack of maintenance culture on our refineries and petro-chemical companies led to fuel imports. Domestic consumption of Nigerian crude oil is low – about 200,000 bpd, or around 15% of total petroleum products consumed—because Nigeria lacks the refinery capacity to refine its petroleum resources at home. At no point have all the four refineries worked at full capacity concurrently, due to infrastructural decay.

**Table 1. Domestic refining capacity, 2009 (Bpd)**

Refinery	Refining capacity
Port Harcourt Refinery	60,000
Kaduna Refinery	110,000
Warri Refinery	125,000
Port Harcourt (Alasa-Eleme) Refinery	150,000
<b>Total</b>	<b>445,000</b>

Fig. 3 shows the individual percentage operating capacity of the refineries in Nigeria and their combined percentage production capacity. As observed from the plots it can be seen that the combined production capacity of the four refineries has never exceeded 40% since the year 2000 [5].



**Fig. 3. Combined production percentage of installed capacity**

Source: NNPC Annual Statistical bulletin, 2011

### 3. NEW REFINERIES

The federal government of Nigeria as part of its effort to boost the local production of petroleum products issued 23 licences for the construction of new refineries. While 20 of these went to private investors, the government entered into partnership with some Chinese investors to build one refinery each in Kogi, Lagos and Bayelsa States. Only the 1,000 bpd private refinery

owned by the Niger Delta Petroleum Resources (NDPR) has commenced production [7]. It produces 120,000 litres of diesel per day using crude oil from its country's flow station. It produces only diesel which price is not regulated by government. The company utilizes some portion of the diesel for its internal consumption and invests the excess into the national output. All others failed to take off for various reasons. Some of which included: capital; the huge upfront start up fee mandatory requirement which most of the investors could not afford and the failure of government to accede to investors' demand for a free market pricing policy that would eliminate subsidies.

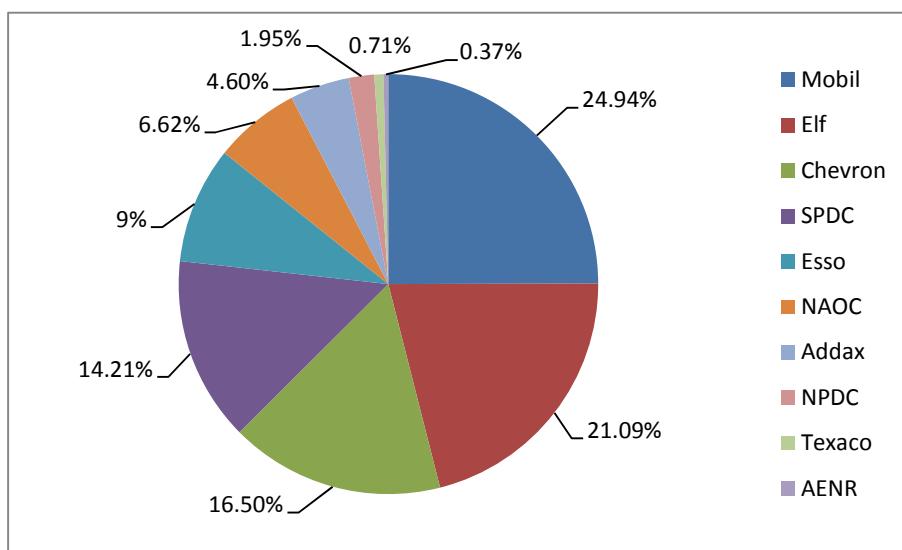
### 4. NATURAL GAS DEPOSITS

Though it has plenty of oil left, Nigeria's future may actually be more closely associated with natural gas [8]. The country has the ninth-largest gas reserves in the world, at about 4.2 trn cubic metres. Like its oil, Nigeria's gas is high quality and low in sulphur. Of the total, an approximately 2.7 trn cu metre is associated gas—that found mixed in with oil deposits. Natural gas is the fastest growing energy source and its consumption is projected to rise by almost 70 percent by 2025 to about 156 trillion cubic feet. The electric power sector makes up 50% of the total growth in world natural gas demand. The greatest increase in demand for natural gas is

**Table 2. Refineries in Africa**

Country	No of refineries	Capacity (bpd)	Capacity utilization (%)
Algeria	5	303,700	94
Angola	1	63,000	59
Cameroon	1	45,000	88
Congo	1	21,000	64
Egypt	9	774,000	81
Gabon	1	23,000	63
Ghana	1	45,000	45
Ivory Coast	1	84,000	85
Liberia	1	15,000	N/A
Libya	5	380,000	87
Morocco	2	170,000	68
<b>Nigeria</b>	<b>4</b>	<b>445,000</b>	<b>18</b>
Senegal	1	25,000	52
Sierra Leone	1	5,000	N/A
South Africa	4	545,000	85
Sudan	2	147,000	65
Tunisia	1	34,000	N/A
Zambia	1	12,000	77

Source: OGJ refineries survey 2011

**Fig. 4. Oil production- % OF total, first quarter 2009**

Source: NNPC Bulletin 2009 [9]

expected to occur among the emerging economies [4]. Gas is a close substitute to other fuels in electricity generation, a complement to crude oil in revenue earning, a feedstock for fertilizer and petrochemical industries and environmentally more friendly, being cleaner than crude oil and coal.

Industrial consumption of natural gas is also projected to rise over the next 10 to 15 years from 8 trillion cubic feet in 2003 to 10.3 trillion cubic feet in 2025 [4]. The largest increases in natural gas consumption from 2003 to 2025 are anticipated in petroleum refining, metal durables, bulk chemicals and food industries. Residential consumption is also projected to grow over this time period by nearly 1 percent [8]. Unfortunately the facilities are not available to tap these abundant resources.

**Table 3. Natural gas production, 2005-2009  
(bn cu metres)**

Year	Bn Cu metres
2005	22
2006	28
2007	34
2008	24
2009	24.5

Source: BP Statistical Review (2008) [9]

## 5. PROSPECTS

Resource extraction in Nigeria has never been simple, straightforward or efficient, but as the

most important economic activity in Africa's most populous state. Nigeria's energy sector is a story that matters to the country and to the people far beyond its borders [7]. These opportunities have resulted in the following: A steady development of indigenous skilled manpower; an increasing confidence by the Oil majors in the ability of wholly owned Nigerian companies to deliver quality services and; a significant improvement in the Nigerian economy.

## 6. CHALLENGES

The oil sector has been overwhelmed by various problems which destabilized its optimal development over the years. In general terms, the oil sector of the Nigerian economy is faced with many challenges, amongst which include; ageing oil production facilities built in the early and mid-seventies, gas flaring and environmental pollution issues; building indigenous technology capability in complex deep-water environments. The barriers to sustainable energy development in Nigeria were analysed to be in three folds viz; cost and pricing, legal and regulatory and market performance [10]. Another challenge is security aside from the usual engineering design considerations. Offshore facilities however have significant challenges imposed by the environment [2]. For example erecting a platform offshore is not the same as digging a foundation and building a processing facility offshore. Storms and hurricanes are not uncommon offshore and they can easily tear down a steel

platform if it is not well engineered. In addition is the differential in commercial rates for Nigerian engineers and expatriate engineers. Communal disturbances, fraudulent domestic marketing sharp practices, cost of environmental remediation from pipeline vandalism are some of the problems confronting infrastructural development in oil and gas sector. Insurgent groups began to form in the early 1990s and in 1995 the execution of a local activist, Ken Saro-Wiwa, who has pushed for greater local participation. From the non-violent approach of Saro-Wiwa, however the situation has deteriorated and since 2005 production has remained well below capacity, thanks to the disruptive abilities of the insurgents operating in the region.

## 7. DISCUSSION AND CONCLUSION

Energy plays a very important role in powering the economic engine of any nation [11]. In line with the federal government's aspirations, it is anticipated that the crude oil reserves will grow and be maintained at about 40bn barrels through the period 2020. Also it hoped that the nation will reposition the natural gas sector to support a greener, flare-free basis for economic growth. The adoption of Petroleum Industry Bill (PIB) will go a long way to reposition the nation, and ensure that Nigeria ranks amongst the global league of countries with the modern and forward looking petroleum laws. The upstream segment will have a new management system put in place with robust gas fiscal terms, while incentives will be available for the small fields. In the midstream, refining and petrochemicals industries will be provided with incentives [12] similar to those in the gas utilization, processing and infrastructure sub-sectors. In the case of downstream, full deregulation of petroleum products in the domestic market and market-based gas pricing will be the order of the day after the transition phase.

The Nigerian National Petroleum Corporation [13] will become a full-fledged commercial entity with a vision to becoming an international oil company with strategic autonomy [14]. The nation's refineries have on many occasions suffered from irregular turn-around maintenance (TAM). While TAM is required once in every two years, the refineries have been without TAM for almost two decades and this has caused serious problems [6]. One of the greatest challenges in the industry is that many engineers who qualified as Mechanical Engineers but who are employed

as Process Engineers, Structural Engineers, Pipeline Engineers, Piping Engineers or Corrosion Engineers [15]. There is however a noticeable awareness and increasing participation of Nigerian engineers in the development of infrastructure for oil and gas installations, in line with Nigeria Oil and Gas Industry Content Development Act. With the Nigerian Oil and Gas Industry Content Development (NOGICD) Law, which was enacted in 2010, the meaningful participation of Nigerian indigenous companies in the country's Oil and Gas industry was planted. The Nigerian Content Development and Monitoring Board (NCDMB) undoubtedly have created in addition, a window of opportunity for Nigerian engineers to participate in the Oil and Gas sector of the economy [16]. This enabling environment has attracted a lot of Nigerian engineers to come on board the Oil and Gas stage.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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