Gas –To – Power and The role of Gas Compression in the Nigerian Energy Industry: Current challenges, strategies and solutions for sustainable development

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Abstract

Every industry in every country of the world is dependent on electricity to remain operational; therefore it is not a surprise that the frequent power cuts are having devastating effects on Nigeria's industrial sector. The electricity shortage in Nigeria is undeniably related to many of the key issues occurring in Nigeria today. The underlying causes of power shortages and regular interruptions – black-outs and brown-outs - vary from failures to bring on new capacity to coincide with the demands of economic growth, low investment and structural issues.

In this paper, the writer presents current challenges facing the gas compression industry in Nigeria. These include security concerns, supply chain issues, 'big crew change', corruption, business environment and infrastructural issues, poorly managed construction contracts, pipeline vandalization, gas supply disruption concerns, the absence of institutional framework and in recent times oil price volatility.

Dealing with these issues, the writer believes, will involve the provision of basic amenities in the oil and gas communities, competency development and improvement of supply chain and construction contractors personnel, training and technology conferences to address the 'big crew change', pragmatic enforcement of the law against corruption, appropriate monetary and fiscal terms to attract foreign direct investment, involvement of indigenous oil and gas companies, revival of moral awareness of the populace, formation of regional gas companies, development of fallow wells, adequate risk assessment by operators and service providers, quick passage of the Petroleum Industry Bill (PIB) and an enduringly strong political will on the part of the government.

Key words: Gas Compressors, Gas Compression, Nigerian Electricity Market, Nigerian Energy Industry, Security, Corruption, Risk Assessment, Infrastructural Issues, Training

Introduction

Nigeria has an abundance of natural resources especially hydrocarbons. Nigeria has the world's 9th largest proved natural gas reserves at 182 trillion cubic feet (Tcf) as of January 2013. The country produced about 1.2 Tcf in 2012 ranking it as the world's 25th largest gas producer (EIA, 2013).

It is projected that there will be 300 million new urban residents in Africa by 2030. This will generate a massive need for more services, housing, security, schools, medical facilities and transportation which in essence all require electricity (Mubila, 2012:7). These concerns are even more peculiar to Nigeria, if not disturbing, considering the vast potential the country is endowed with.

The lack of electricity is a major constraint in continuing business; maintaining standards of living, and increasing economic development in Nigeria. Most economic activity is not possible without energy, and no country in modern times has substantially reduced poverty without massively increasing its use of energy.

Background

The petroleum industry is usually divided into three major components: Upstream, midstream and downstream. Midstream operations are usually included in the downstream category.
The upstream oil sector is a term commonly used to refer to the searching for and the recovery and production of crude oil and natural gas.
The upstream oil sector is also known as the exploration and production (E&P) sector.
The upstream sector includes the searching for potential underground or underwater oil and gas fields, drilling of exploratory wells, and subsequently operating the wells that recover and bring the crude oil and/or raw natural gas to the surface.

The downstream oil sector is a term commonly used to refer to the refining of crude oil and the selling and distribution of natural gas and products derived from crude oil. Such products include liquefied petroleum gas (LPG), gasoline or petrol, jet fuel, diesel oil, other fuel oils, asphalt and petroleum coke.

The downstream sector includes oil refineries, petrochemical plants, petroleum product distribution, retail outlets and natural gas distribution companies. The downstream industry touches consumers through thousands of products such as gasoline, diesel, jet fuel, heating oil, asphalt, lubricants, synthetic rubber, plastics, fertilizers, antifreeze, pesticides, pharmaceuticals, natural gas and propane (Wiki, online).

Most midstream and essentially all downstream compression equipment is part of large industrial facilities, owned and maintained by major operators. In recent years, a few more midstream – mostly gas processing – plant operators have tended toward contract compression equipment than in the past. Nonetheless upstream, at or near the wellhead, in today's market, reveal more compression equipment being leased than owned by operators.

Historical estimates indicate that contract/rental compression equipment account for about a third of the total gas compression horsepower used in the gas industry from upstream to downstream. High –speed (<700rpm) natural gas engine or electric motor driven reciprocating compressors predominate upstream and most midstream natural gas compression applications. High-speed compressor packages are usually provided by a packager. The packager purchases the compressor, driver and other major components from individual manufacturers and incorporates them on fabricated I-beam skid (CompressorTech2, 2014).

Many Nigerians know only too well that the deregulation and privatization of the upstream and downstream oil and gas industry will bring the much needed sustainable industrial development in the country (Noruwa & Christopher, 2012:16).

Gas Compressors

Compressors are manufactured as positive –displacement, dynamic or thermal type depending on application. Positive types fall in two basic categories: reciprocating and rotary. Reciprocating compressors consists of one or more cylinders each with a piston or plunger that moves back and forth, displacing a positive volume with each stroke.

The compressor is the most essential constituent of any natural gas application. Compressors of various designs and manufacturers are used in many operations throughout the oil and gas industry. Compressors are used in some drilling operations, in many production operations, and extensively used in surface transportation of gas via pipelines. The gas compressor is a mover of compressed fluids, unlike pumps which are movers of basically incompressible fluids (or liquids).

The positive displacement class of compressors is an intermittent flow device which is usually a reciprocating piston compressor or a rotary compressor (e.g. sliding vane, screws, etc.). The dynamic class of compressor is a continuous flow device which is usually an axial flow or centrifugal compressor (or mix of the flow). Each of the two general classes of compressors and their subclass types have certain advantages and disadvantages regarding their respective volumetric flow capabilities and the pressure ratios they can attain.

In general, positive displacement compressors are best suited for handling high-pressure ratios (i.e. about 200), but with only moderate volumetric flow rates (i.e. up to about 10^3 actual cfm). Dynamic compressors are best suited for handling large volumetric flow rates (i.e. up to 10^6 actual cfm), but with only moderate pressure ratios (i.e. about 20) (Lyons, 1996).

Additionally, positive displacement compressors, particularly the multistage reciprocating compressors, are very insensitive to pressure ratio changes. These compressors will produce

their rated volumetric flow rates even when the pressure ratio approaches the design limit of the machine. The dynamic compressors, however, are quite sensitive to pressure ratio changes. The volumetric rate of flow will change drastically with changes in the pressure ratio around the pressure ratio the machine has been designed.

Thus, the positive displacement compressors are normally applied to industrial operations where the volumetric flow rate is critical and the pressure ratio is variable. The dynamic compressors are generally applied to industrial operations where both the volumetric flow rate and pressure ratio requirements are relatively constant.

In general, only the reciprocating compressor allows for reliable flexibility in applying variable volumetric flow rate and variable pressure ratio in an operation. The rotary compressor does not allow for variation in either. The dynamic compressors are designed for specific volumetric flow rates and pressure ratios and are not very useful when these design limits are altered.

Gas Compression

Gas from a pure natural gas wellhead might have sufficient pressure to feed directly into a pipeline transport system. Gas from separators has generally lost so much pressure that it must be recompressed to be transported. Whatever the source of the natural gas, once separated from crude oil, if present, it commonly exists in mixtures with other hydrocarbons; principally ethane, propane, butane, and pentanes.

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas to produce what is known as ‘pipeline quality’ dry natural gas. Thus, before the natural gas can be transported it must be purified (Lyons, 1996).

Nigerian Electricity Market

The demand for electricity in Nigeria far exceeds supply. This widely known fact informed the drive for major expansion of generation facilities by the Nigerian government. To this end, the Niger Delta Power Holding Company Limited (NDPHC) was established to implement the speedy execution of the National Integrated Power Project (NIPP).

The NIPP, a public sector funded initiative, is the principal tool being used to combat power shortages in the country. This project is expected to deliver significant new generation capacity to the electricity supply system including transmission and distribution and natural gas infrastructure throughout Nigeria (NIPP, online).

Challenges

Nigeria's gas to power sector is a very critical part of her ongoing power sector reform, which appears to be totally overwhelmed by various forms of challenges that experts in the country's energy sector consider too significant to be ignored by the federal government.

Several challenges confront the gas compression industry in Nigeria. These include:

Security

Host communities problems and its effects on the cost of doing business constantly stare at the face of operators and their service providers thereby slowing down development of oil and gas infrastructures. Local groups seeking a share of the wealth often attack the oil infrastructure forcing companies to declare force majeure on production. The perceived lack of transparency of oil revenues, tensions over revenue distribution, environmental damages from oil spills and local ethnic and religious tensions continue to create a fragile situation in the oil rich Niger Delta. Rising unemployment due to lack of progress in job creation and economic development in the Niger Delta also contribute to the insecurity experienced by the operators.

Supply Chain

Unpredictable import duty processing times resulting from intricate and cumbersome procedures that must be followed to get OEM equipment into the country is an issue operators and service providers battle with constantly in the industry. Product quality issues, inadequacy and sometimes outright unavailability of needed replacement parts are some other concerns related to supply chain facing business leaders in the industry.

Big Crew Change

In parts of the country affected by the ongoing Integrated Power Project (IPP) development, the demand for experienced compressor hands has reached critical proportions. The problem has been exacerbated by retirements in the current workforce, leaving many companies with a serious shortage of experienced workers and forcing them to recruit from each other and their service providers or to reach outside the industry.

Corruption

Corruption in the oil and gas industry is rampart and widespread. It is not restricted to the contractors alone but also thrives among the workforce. There are reported instances of delay in the process of awarding contracts attributable to unscrupulous demand for upfront gratification in cash or kind. The disturbing aspect of it all is when such behaviors are seen among the rank and file of those with oversight functions both in government and corporate organization (Okereke, 2013; Olugbenga et al, 2013:38). Recent scandal affecting anti-corruption agency further highlights limited government progress in tackling graft (Ibeh, 2014).

Business Environment and Infrastructural issues

Nigeria's natural gas sector is restricted by the lack of infrastructure to monetize gas that is currently flared. Incessant oil theft known as 'bunkering' often lead to pipeline damage that result in production loses forcing companies to shut in production. Equally worrisome, too, is

situation that all the existing mining leases for the hydrocarbon industry in Nigeria did not define gas but oil mining which reveals a lack of political will on the part of the federal government. The trend toward progressively tight enactment of Nigerian content requirements has implications across a range of issues - the ability to deliver projects on time and labor costs present risk.

Construction Contractors

Poor management of fixed –price contracts making it easy to operate over budget and with bloated variation orders along with cash flow issues. At the root of it all is the not too thorough planning embarked upon by the project team. The usual practice is the late involvement of the project manager from the early stages of the project – compounded by the in-house jostle for the role by eligible professionals. The impact of all of these is the drag in implementation of projects which often times meant hurried projects deliverables that are not quite fit for purpose – not maintenance friendly, incomplete work, repeat work and so on.

Pipeline Vandalization

Attack on oil infrastructure and pipelines force IOCs to shut in their wells, and sometimes IOCs are forced to declare force majeure which result in huge losses in revenue and the attendant repair cost utilizing funds that could have been channeled to beneficial developmental projects for society at large. Sadly, the presence of wireless sensors network would not deter vandalization of oil and gas pipelines and facilities in the Niger Delta (Obadoeze et al, 2012:65). Pipeline vandalization is a recurring phenomenon. 1000MW was lost to pipeline attack just recently as announced by the minister of power (Gas to Power, 2014A).

Supply Disruption

One critical challenge is low gas supply – the gap between gas requirement and gas availability – to power plants resulting from absence of appropriate structures including regulations and laws guiding the mining of gas resources – associated and non-associated gas inclusive.

Aging infrastructures and poor maintenance that result in all too frequent outages are a common phenomenon in the industry. These disruptions mostly stem from pipeline damages associated with oil theft resulting in shut-in of trunk lines. Failure of power plant owners to pay their bills to the gas companies also contributes to supply shortages. Nigeria currently loses 1,476MW to gas shortage (Gas to Power, 2014B).

Natural gas wastage

Aside from the well-known and documented wastage associated with gas flaring – Nigeria flares the 2nd largest amount of gas globally – a less well known phenomenon is the wastage at the power generation plants due to inefficient system processes and machinery coupled with behavioral issues of the human interface (EIA, 2013). A recent study of the Delta Four power plants revealed a huge waste of gas available for power generation (Oyem, 2013: 434, 443).

Falling oil price

The effect of oil price volatility on the implementation of new gas-prospecting projects is a cause for concern among operators especially those in Joint Venture (JV) arrangements. The common perception is that the NNPC often times would delay in remitting its share – the so called 'lack of partner funding'- to the arrangement, bearing in mind that Nigeria's budget is framed on a reference oil price of $77.5 per barrel (EIA,2013; PwC, 2014).

Absence of institutional framework

Regulatory uncertainty associated with the delay in the passage of the PIB resulting in less investment in the development of new natural gas projects. The absence in all the mining leases for hydrocarbon industry the definition for gas mining but oil mining expose the industry to unguided players predisposed to corruption.

Recommended Remedies

The following strategies are worthy of consideration by the Nigerian government, business leaders and practitioners in the Nigerian energy industry as they brace up to tackle the challenges.

Security

- *Provide basic Amenities*

For sustainable gas supply, oil and gas producing communities should be provided with basic amenities like pipe borne water, good roads, schools and hospitals and electricity as well from the gas mined in the area. Above all, there should be concerted effort to eliminate environmental pollution in these communities. These recommendations also apply to communities with crisscrossing oil and gas pipelines. Transparency of purpose and will is the key in all of these. There is no gain saying that the government alone can meet these needs, corporate consciousness dictate that corporate organizations should participate in the venture for societal good which they stand to benefit from in the long term.

Supply Chain

- *Competency development*

The growing pace of change sweeping across the Nigerian Customs requires that supply chain practitioners stay abreast in addition to bringing innovative solutions to internal and external processes to improve on the delivery times of original equipment manufacturer (OEM) parts and equipment.

Big Crew Change

- *Training*

Around the world, the compression industry is continuing to expand its capacity to satisfy demand for gas compression and processing equipment. Along with the continuing strong demand for compressors comes the need for more trained and experienced engineers, operators and maintenance technicians.

Recruitment and training should be urgent ongoing priorities for the development of the necessary workforce. Many upstream and midstream companies have expanded their internal training capabilities, and third-party training providers fill in some of the gaps. Regional colleges should develop entry-level compressor operator and maintenance training programs. Relevant agencies and professional bodies in the country should increase their focus on training for the near term and into the future.

- *Technology conferences*

Development of annual training and technology conference by relevant professional associations cannot be overemphasized. These events should focus on engine and compressor maintenance with intensive training track programs for compressor operators and maintenance technicians taught by industry experts. The topics covered at such training events should include environmental health and safety and original equipment manufacturer (OEM) training for gas engines and compressors and turbines.

Corruption

- *Dealing with the root causes*

Development of a strategic plan by government to deal with the root causes of corruption which include over-centralization of resources at the centre and social insecurity (Chete et al, 2014:30).

- *Pragmatic enforcement of the law*

The political will by the government to invest more resources on the enforcement and compliance with laws and regulations is mandatory in the fight against corruption. It must be mentioned that it is the enforcement of the laws – existing and new – that should be paramount to all stakeholders. There should be honesty in tackling corruption. A lack of high level political will to fight corruption forcefully, and a lack of institutional independence and capacity to effectively investigate and prosecute graft cases will continue to stall progress if not addressed.

- *Adopting the 'Name and Shame' Approach*

The time is rife with adopting the 'name and shame' approach as a tool in dealing with the menace of corruption in Nigeria. Equally important is the need to focus on proper conduct and celebrate it in the public domain. Some may argue that it would not matter a thing, but keep in mind that someday, such records could be useful in determining who qualifies to hold strategic public office positions in government or public companies in the country.

- *Adoption of robust anti-corruption policies*

Businesses engaging in regular interactions with public officials are particularly exposed to corrupt demands which underline the importance of having robust anti-corruption policies that are properly communicated to and implemented, including regular refresher anti-corruption training, by in-country staff. The importance of managing integrity risk is further accentuated by the increasingly stringent enforcement of international anti-corruption legislation and capabilities.

Business Environment and Infrastructural issues

- *Attract Foreign Direct Investment*

Relevant government agencies should continue to maintain the momentum to attract foreign direct investment in gas-prospecting by utilizing appropriate fiscal measures.

A recent press release by Petroleum Africa stated that the multi-stakeholder project driven by the US president Barack Obama christened 'Power Africa Initiative' aims to add more than 10,000 megawatts of electricity generating capacity with the ultimate goal of 'enhancing energy security, decreasing poverty and fostering economic growth.' The six initial partner countries are Nigeria, Ethiopia, Ghana, Kenya, Liberia and Tanzania. The lending bank, Standard Bank Group, well acclaimed as Africa's largest lender by assets, has provided funding over $400 million principally for Nigeria and Kenya (PetroleumAfrica, 2014). The judicious use of such funds will help in addressing the dearth of infrastructure in the energy industry.

- *Encourage participation of indigenous companies*

The Nigerian Content Development Management Board (NCDMB) should take the lead in encouraging local indigenous companies in the sphere by following through with its mandate by law.

Already companies are showing interest in the power sector. Oando, a publicly owned company in Nigeria, is planning to build a 400MW plant which will commence in mid-2015. The company gas and power unit currently operates 228-km network of natural gas pipelines – with plans to expand to 600-km - supplying power plants and industrial consumers in Lagos and Port Harcourt (PetroleumAfrica, 2014).

- *Unbundling of natural gas transmission networks*

Consideration should be given to the unbundling of natural gas transmission networks in future regulatory frameworks in view of its effects on the final customer prices. In particular, the government should follow through with the unbundling of the Nigeria Gas Company (NGC) – the transmitter of pipeline gas - to create room for better services and fair competition.

- *Opportunities in Nigerian content compliance*

Seek for ways to turn regulatory systems into opportunities for growth rather than an obligation.

Construction Contractors

- *Competency development*

It is highly recommended that construction contractors develop their competencies in all aspects of project management but especially project control and cost management. The difference that exists between the business organization – the permanent organization – and programs/projects – the temporary organization –which is by no means trivial, must be recognized and managed with the foreknowledge it deserves.

- *Project financing*

Construction Contractors live and die by cash flow. Access to funding should be made relatively easy, for the competent ones with good track record, by the relevant banking institutions (Oshodi, 2014).

Pipeline Vandalization

- *Revival of moral Awareness*

The need to revive a moral awareness among the citizens to protect public property like the gas transportation pipelines and associated facilities cannot be stressed enough. Adequate surveillance, arrest and prosecution of those caught vandalizing pipelines must be enforced by security agents.

Supply Disruption

- *Formation of regional gas companies*

The formation of a regional gas company in West Africa to help deal with the perennial shortage of the supply of natural gas in the sub region is a welcome development. A decision borne out of the need for these countries to work together to find lasting solution to gas supply disruption; Nigeria, Cote D'ivoire and Equatorial Guinea, with Ghana taking the lead, are all involved in the establishment of the strategic gas company (PetroluemAfrica, 2014).

- *Natural gas storage infrastructure*

The removal of infrastructure bottle necks must be prioritized in the ongoing reforms in order to secure a sufficient natural gas supply. The idea of building natural gas storage facilities should be considered.

- *Develop fallow wells*

Increasing the supply of gas by developing fallow wells identified in certain parts of the country where there have been proved gas availability is recommended. Noteworthy is the effort of Niger Delta Power Holding Company (NDPHC), the ministry of petroleum and the private sector. Recently, the federal government earmarked USD1billion to address the challenges of gas supply to power plants to boost electricity supply nationwide (Gas to power, 2014C)

Falling oil price

- *Adequate risk assessment*

The need for operators and service providers to conduct proper risk assessment cannot be over emphasized considering that the 'fall in oil prices, the 'low level export quantity (below benchmark) and low prices (nearing budget benchmark) would definitely result in inadequate revenue to fund the nation's budget' (Udemezue, 2014).

Absence of institutional framework

- *Quick Passage of the Petroleum Industry Bill (PIB)*

The PIB when passed into law is expected to change the organizational structure and fiscal terms used in governing the oil and gas sectors. Some belief, though, that the changed fiscal terms would make deep water projects that involve large capital expenditure commercially unviable. Negotiation of contracts with international oil companies (IOCs), change in tax and royalty structures, deregulation of downstream sector, restructuring of Nigerian National Petroleum Company (NNPC), concentration of oversight function with the Minister of Petroleum Resources, and a mandatory contribution of 10% of monthly net profits by the IOCs to the Petroleum Host Communities Fund are some of the aspects of the PIB considered to be the most touchy (EIA, 2013).

- *Political Will*

The principal instrument to meet the challenges thus can be summed up as robust political will, deliberate funding for gas production and institutional framework to drive all transactions relating to gas production, separate from oil. The passage of the long awaited Petroleum Industry Bill into law hopefully should address all of these concerns.

Conclusion

Introducing flexible, efficient and reliable gas compression and transportation and transmission solutions for the energy industry in Nigeria will result in long-lasting development and sustainable benefits, and in turn economic growth.

Exterran Nigeria specializes in rapid deployment of gas compression solutions including reliable and cost effective operation and maintenance services to meet these needs. Exterran's gas compression solutions coupled with these comprehensive services and flexible commercial

terms have established Exterran as a leader in the gas compression industry. With its expanding presence in Nigeria, Exterran offers a reliable and efficient solution to the current specific compression needs for power generation within Nigeria. In addition to its business of providing these world-class gas compression transmission solutions, Exterran also implements philanthropic projects at each plant location through its community development program, which aims to build and maintain close relationships with its neighbors through projects and donations to health & education. Exterran is a major supplier of production, condensate stabilization, compression, gas treating and processing equipment and other oil field services.

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