



ISSN 2278 – 0211 (Online)

Optimum Utilization of Natural Gas from Marginal Oil Fields in Nigeria

Oruwari Humphrey Otombosoba

Ph.D. Student, Institute of Engineering Technology and Innovation Management,
University of Port Harcourt, Nigeria

Adewale Dosunmu

Professor, Department of Petroleum and Gas Engineering, University of Port Harcourt, Nigeria

Abstract:

Natural gas is a strategic asset from marginal oil fields which will bring about sustainable development of the Nigerian economy. The study investigates the factors influencing the optimization of natural gas from marginal oil field operations in Nigeria. The method of the study consisted of extensive literature review on utilization of natural gas from marginal field development was carried out and specifically a model of natural gas monetization from Asuokpe/umutu marginal field by Platform Petroleum was as used as a case study. The result of the study revealed that provision of adequate infrastructure and collaboration are some of the critical success factors, while barriers to optimization of natural gas are inadequate funding, monopolistic market structure, weak manufacturing and inadequate linkages. The study recommends adequate infrastructure in terms availability of finance and collaboration by marginal field operators and other stakeholders should provide enabling environment that will lead to optimization of natural gas.

Keywords: Marginal field, Natural gas, Monetization, Sustainable development

1. Introduction

Natural Gas as energy source is applicable for use in Residential, Commercial, Industrial and Power Generation. Gas has become very important in the global energy market & must be profitably harnessed. Total world natural gas reserve as at the end of 2014 is 6606.4 trillion cubic feet (187.1 trillion m³) with Reserve-to-Production (R/P) ratio of 54.1 years. Nigeria is endowed with abundant Natural Gas; Nigeria's reserve is placed at 180.1 trillion cubic feet ranking Nigeria 9th in world natural gas reserve table as shown in figure 1. *Global ranking of 9th and 25th in reserves and production respectively.* Nigeria is considered to be "a gas province with some oil" according to USGS.

Falobi (2009) posited that natural gas in Nigeria has not attained its potential as a major source of fiscal revenue in the domestic economy because of inadequate funding for infrastructure development, inept pricing of natural gas for domestic gas policy and regulatory framework. Due to unsustainable exploitation practices coupled with the lack of gas utilization infrastructure, Nigeria flares a substantial proportion of the gas it produces when compared with oil production in advanced countries, Nigeria lags far behind in terms of associated gas conservation and utilization. Natural gas reserves in marginal oil field can contribute to the sustainable development of Nigeria economy if properly harnessed. As with most oilfields in Nigeria, the designated marginal fields projects are produced with associated gas. But over the year's natural gas produced in associated field in Nigeria has been flared. Flaring imposes costs upon Nigeria, and potentially upon other countries as well. These costs include both opportunity costs – the cost of the best alternative foregone – and external costs. External costs are the costs imposed on Nigerians and others as a result of the activities of private oil companies (IOC and MFO), which are not currently factored into the cost of doing business.

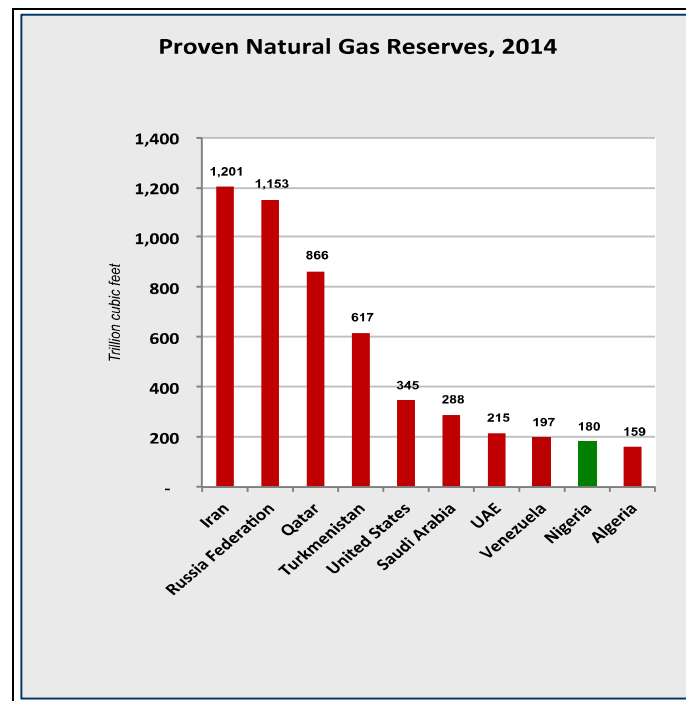


Figure 1: Proven natural gas reserves Source: BP Statistical World Energy Review - 2015

1.1. Statement of Problem

Despite policy initiatives in promoting marginal oil field development, the utilization of natural gas from marginal oil field has not been fully successful. The main problem against the optimum utilization of natural gas from marginal oil field operations in the country is the inadequate infrastructure and lack of appropriate pricing structure to support the economics of natural gas utilization. As a long term strategy for the utilization of natural gas in Nigeria, the Federal government of Nigeria has put in place the gas master plan policy frame work. Also the marginal field development programme was initiated in 2001 to boost oil and gas production and utilization.

1.2. Objectives of the Study

The objectives of the studies are to highlight the various development support strategies for viable utilization of natural gas from marginal oil field operations and make some recommendations for policy makers.

1.3. Research Questions

What are the infrastructure required for the optimization of natural gas from marginal field operations in Nigeria?

How can synergy between marginal field operators and investor in natural gas be promoted for the optimum utilization of natural gas?

1.4. Benefit of the Study

1.4.1. The Benefits of the Study Are

- Increased marginal field operator's revenue from gas sales
- Reduced importation of liquid fuels through substitution with natural gas
- Reduced Gas flaring
- Improved Corporate Image for marginal field operators
- Increased employment in the country

2. Literature Review

2.1. Introduction

The world energy council (WEC) of which Nigeria is a member share a common belief that guaranteeing a sustainable supply of affordable energy is one of the best ways to address poverty, inequality and environmental degradation everywhere on the planet. According to Kammen, (1997) over 3 billion people in the world rely on wood, charcoal, and other biomass (i.e. plants, human and animal waste) for most of their household energy needs and without access to modern energy services including electricity, it is nearly impossible to lift people out of poverty. Natural gas utilisation from marginal field operations can contribute to the use of modern energy service for example small scale gas turbine.

- The above is in line with Anthony (2006) submission that: “The country is about to initiate pilot projects on how to use the gas from marginal oil fields to produce power and LPG to achieve social objectives and guarantee financial viability. The pilot project will be used as a model for private sector led utilization of gas from marginal oil fields for power and LPG. He noted further that the World Bank is planning a study under the Global Gas Flaring Reduction programme for Small-Scale Use of Gas. Since gas to power project presents the missing link between Nigeria vast resources on the one hand, and successful, broad based economic development on the other.

In its current form the, Nigerian gas infrastructure will be unable to deliver this strategic intent of the government and World Bank. This will significantly hamper the nation ability to exploit the market potential of marginal field and the natural gas rapidly and broadly as required.

2.2. Viable Utilization of Natural Gases Options

According to the special adviser on petroleum matters “There are potential for gas utilization opportunities in Onshore/Marginal fields, which comes in Micro/Mini/Small Scale LNGs, Modular Liquefied Petroleum Gas and Power Generation and Agro-based opportunities. Alawode and Olusegun (2011) reviewed some of the projects of gas monetisation technologies or options among which are Liquefied Natural gas (LNG), Gas to Liquid (GTL), compressed natural gas (CNG), Gas to power (GTP), and Gas to solid (GTS), Studies by Daniel (2010), Sani (2006) and Hurton (2003),) have shown that plants ranging upwards from 2,500 b/d could be economic on a stand-alone basis. This economic calculation obviously depends upon a number of factors such as facility size, cost of gas, distance to market and produced products. Small offshore plants can be economic if they release crude oil and gas that otherwise could not be produced. Options for handling either produced gas or developing stranded gas from marginal fields in offshore areas, whether in shallow or deep water, are now such that an operator has a number of choices. Obviously the first choice, if available and economic, would be a pipeline to shore, but that unfortunately is not always possible.

Koso and Onwuachi-Iheagwara (2013) posited that: The options for viable utilisation of natural gas from marginal fields are varied but four of these may be said to be paramount, namely

- Gas sales: produce it and pipe it to the market: The ideal situation for a gas discovery is an available local market for the gas at a reasonable or competitive price.
- Liquefied petroleum gas (LPG): liquid extraction gas plant. This could either be individual components, C₃H₈, C₄H₁₀, or the mixed components – the mixed LPG. This product is presently imported since our refineries are not working. The refineries will definitely not meet future demand. At present, ChevronTexaco produces mixed LPG from their Escravos EGP project. This LPG and that from the NLNG at Bonny are exclusively for exports.
- Methanol: The potential for Methanol in Nigeria is enormous. There are presently no major methanol plants in Nigeria. A few are being planned. The marginal field companies can initiate the production of methanol from their fields. Synergy between fields in the same OMLs is ideal.
- Ethane: The petro-chemical plant at Eleme, Port Harcourt, is marginally functional because of shortages of ethane. We posit that the natural gas – associated and non-associated, in the marginal fields should be processed into various components, especially C₂H₆, ethane.

Other solutions that are now being offered to the industry are compressed gas tankers, floating liquefied natural gas (LNG), floating gas-to-liquids (GTL) and even floating electric power facilities with high voltage DC transmission to the beach.

2.3. Natural Gas based Projects in Nigeria

NNPC and other major E & P operators are currently embarking on several gas utilization projects. The major existing and future projects are:

2.3.1. Export Oriented Gas Utilization Projects

- Escravos gas project by Chevron producing LPG.
- Oso NGL project by Exxon mobil at OSO field
- LNG project by Nigeria LNG Ltd. (NNPC/ELF/Agip/Shell/Sotogas/Sobagaz
- The West African Gas Pipeline (NNPC/SHELL/CHEVRON JV) Project (WAGP): This project would transport gas from Nigeria to Ghana, Benin and Togo. The \$400-million WAGP traverse 620 miles (1,033 kilometers) both on and offshore to its final planned terminus at Effasu in Ghana and initially transport 120 MMcf/d of gas to Ghana, Benin and Togo beginning in 2004.

2.3.2. Belema Gas Injection Project (NNPC/SHELL JV)

SHELL JV Belema Gas Injection project is aimed at reducing flares in five flow stations by-re-injecting some of the gas, some for gas lifting, and some for use as fuel by local industries and the excess for backing out NAG that is currently used to meet various existing contractual obligations. About 80 MMcf/d of gas is expected to be utilized.

2.3.3. Trans-Saharan Pipeline (NNPC/SHELL/CHEVRON JV)

Nigeria underlined its determination to penetrate the European gas market when it signed preliminary agreements with Algeria in October 2001 on a planned Trans-Saharan Pipeline running through the North African country. The project would seek to connect the Nigerian gas field with that of Algeria, to the European market.

2.3.4. Expansion of Domestic Gas Distribution Network (NNPC/SHELL/CHEVRON JV)

Currently gas is being supplied by the Nigerian Gas company (NGC) and JV partners, for power generation, as a source of fuel or as feedstock to cement plants, fertilizers plants, petrochemical plants, glass manufacturing industries, food and beverages manufacturing industries. Several distribution schemes are planned to help promote Nigerian consumption of natural gas.

2.3.5. Independent Power Plant Projects

The Gregu, Omotosho Papalanto and Aloji (GOPA) projects have been completed in order to improve the electricity supply situation of the Nigeria power sector by utilizing the abundant natural gas in the country. This could positively improve gas utilization in Nigeria and impact the development of some marginal oil field by way of utilizing the gases from such fields with the right infrastructure. The major problems confronting the electricity sector in Nigeria are summarized below: Capital scarcity, economic inefficiency, lack of basic industries, debt and deficit: Power sector is not big enough (just about 4 GW of gas-fuelled power plant Capacity).

Given the inadequate state of infrastructure in Nigeria particularly power, there is the need to expedite action on the full deregulation of the power sector to promote adequate service delivery. The foundation for industrialization and enhancing linkages is the availability of good infrastructure especially electricity and transportation as put by Oyejide and Adeolu (2011). This is because the related or support industry aid the effective utilization of natural gas from marginal oil fields. For example, the volume of crude oil and gas supplied through operation of some marginal field will depend on the level of industrialization and related support industries.

2.4. Marginal Oil Field

In 2001, the Federal Government of Nigeria launched marginal fields programme and invited bids from indigenous companies for the 24 out of the 116 identified fields. Twenty-four (24) of the identified 116 marginal fields were awarded to 31 indigenous companies in an openly contested bid round in 2003. So, in 2003 when the Federal Government handed over the operations of these fields to local hands, many had welcomed the development with the hope that the confidence of local experts would be bolstered in oil exploration and production activities. However, by the end of June 2013, less than 30% of the awarded fields are producing petroleum assets, crude oil and or natural gas and its derivatives (Koso and Kelani 2013). Table 1 shows the producing marginal fields.

No	Fields	Company
1	Umusadege	(Midwestern Oil & Gas)
2	Umusati/Igbuku	(Pillar Oil)
3	Ibigwe	Waltersmith petroman oil limited)
4	Asuokpu/Umutu	Platform Petroleum limited)
5	Obodugwa / Obodeti	Energia Petroleum / Oando)
6	Ajapa	Britania-u
7	Ogbelle	Niger Delta
8	Ebok	Oriental Energy
9	Uquo	Frontier oil
10	Stubb Creek field	Universal Energy resource

Table 1: Producing marginal fields

Source: Wood Mackenze 2012, business day report (2013) and news Nigeria24, (2015).

According to Koso and Onwuachi-Iheagwara (2013): Many of these marginal fields are characterized by:

- Low reserves of crude oil (Less than 20 million stock tank barrels of crude oil),
- Low crude oil daily production rates (Expected or producing less than 4,000stb/day),
- Economic life of about eight to fifteen years,
- Low to moderate net present values (NPVs), and
- Low natural gas reserves (less than 100 bscf: AG and NAG).

In the area of gas optimization and utilization, Table 2 illustrates the available gas production and utilization figures by marginal field operators in Nigeria. It shows the total gas produced 10,571,327(MMSF), utilized (6,789,193 MMSCF) and flared (3,782,134MMSCF) by marginal field operators in Nigeria. Of the total production above 30% is flared which result in negative externalities in the operating areas. Marginal field development should be carried out in line with international best practice.

Marginal fields companies	Gas produced	Gas used as fuel	Gas sold to third party	Gas sold to NGC	Gas reinjected	Gas for LNG/NGL as feed stock	Total gas utilized	Gas flared
Energia Ltd	1,755,000	332,523	-		89,400	-	421,923	1,333,077
Midwestern oil and gas	398,150	19,792	-			-	19,792	378,358
Oriental energy	1,423,583	283,856	-			-	283,856	1,139,726
Niger Delta petroleum	5,482,999	92,426	1,976,349	20,862		2,910,295	4,999,932	483,067
Platform Petroleum	180,609	12,625	-		47,740		60,365	120,244
Walter smith	990,594	189,530	-		753,429	-	942,957	47,635
Brittania	-	-	-			-	-	-
Pillar	180,609	12,625	-		47,740	-	60,365	120,244
Prime exploration	159,782	-					-	159,782
Sub-total	10,571,327	582,976	1,976,349	20,286	938,309	2,910,295	6,789,193	3,782,134

Table 2: Gas production and utilization (MSCF) by Marginal field operators

Sources: NNPC statistical bulletin 2014

2.5. Performance of Marginal and Gas Field Operators

Since the effective take off of marginal field programme in 2003, the number of marginal oil field has grown from 1 to 9 in 2014. But how have these operators fared?

Frontier Oil, the only company whose marginal field turned out to be a gas field, is supplying over 35 million standard cubic feet per day of gas (MMscf/d), transported through a 66 kilometre pipeline owned by AccuGas to the Ibom Power Plant in Ikot Abasi Local Government Area of Akwa Ibom State. Frontieier oil limited one of the marginal field operator was able to achieve 10-million-man hour on the 1st of September. This marginal field operator has a huge gas reserve. The company sells their crude oil to Exxon Mobil and supply gas to the following companies:

- Ibom Independent Power Producers
- Calabar cement industries
- Alaoji power plant
- Larfarge cement industry

According to the Cable report (August 2014):

- The Uquo gas project and gas processing facilities is one of the biggest projects of its kind undertaken by independent indigenous partners in sub-sahara Africa. The Uquo marginal field first awarded to frontier oil as part of the Federal Government's marginal programme in 2003, has been successfully developed by joint venture between two indigenous oil and gas company: frontier and Seven Energy. The result of the collaboration is this world class gas plant and a brand new domestic gas value chain, which has opened up the southeastern region of the Niger Delta for major industrial and commercial development starting with power generation. Frontier oil is the operation of the field, while Seven energy provide technical services and 100% of the funding.

2.6. Challenges of Natural Gas Utilization from Marginal Oil Fields Operation in Nigeria

2.6.1. Gas Flared Down

Nigeria has been compelled by a combination of historical, economic and geographic factors to flare gas they include the following:

In adequate Funding: The huge cost of developing major and interconnecting network of gas pipeline

- Limited no of appropriate reservoir conducive for gas reinjection/storage and economics of doing so
- Low technological and industrial base of energy consumption in the country. This may result in difficulties in local material sourcing (spares) and Shipping and customs clearing.
- Limited regional and international gas market
- Inadequate fiscal and gas pricing policies to encourage investment
- The difficult terrain of Niger Delta which hindered the gas gathering process and security issues

Because many of Nigeria's fields lack adequate infrastructure to produce natural gas, it is flared. The rationale for such waste is encapsulated in the argument that the utilization of associated gas depends on the capacity of the domestic gas market and on the economics of utilization vis-à-vis flaring as put by (Omorogbe, 2006). More over the marginal field operators lack the financial capability to develop such infrastructure.

However, Leye (2012) argued that the assumption that marginal field operators lack the fund to prosecute their gas development plan should not be entertained. They should come up with their plan before production which should be implemented within one or two years of production. There cannot be any exception to zero flare and so marginal field owners should look for ways of utilizing the produced gas either by selling their gases to other operators or look for small gas utilization project that will generate some funds to relief them of the cost to handle this. This is already happening in some industry where some company are now developing gas through toppling plant and gas production for sale. For example, according to the investor village report (2011):

- The company Britania –U a marginal field operator currently produces 2.2mmscfd of gas from its Ajapa field out of which 1.8mmscfd is reserved to power the production system on board the Floating Production, Storage and Offloading owned by the company, while the balance of 400scfd is small to be used for anything, rather the company fixed sonic flare tip, which is the latest technology ever to be used in the country, which cleans out the poisonous element and emits smokeless air into the environment.

2.6.2. Inadequate Gas Pipelines

According to a presentation of the Nigeria Gas Master plan by Yaradua (2008) it is posited that the Nigerian gas infrastructure is characterized by:

- Capacity constraints: Current capacity unable to support the anticipated growth in demand.
- Lack of connectivity: the network is composed of project centric infrastructure. The consequences are lack of flexibility and poor development of a liquid market where gas swaps can take place and excess capacity be flexibly deployed to market where there is shortage. More importantly, the gas rich eastern Niger delta is not connected to major locations where market growth is most rapid.
- Significant barrier to entry. Given the legacy of the Nigerian gas industry as an adjunct to its gas business, the existing infrastructure is dominated by a few major incumbents with limited scope for third party access and participation

Ibibia (2002) posited that a somewhat simplistic and often neglected measure is the construction of oil and gas depots. This could act as a price stabilisation measure during oil glut, avoiding waste and retaining excess for future use, apart from the fact that conserved petroleum can be very handy during national emergencies; it has the additional potential of sustaining rather marginal wells (oil and gas), which could have been abandoned during period of low oil price. Essentially, the object is economic and is advantageous to both marginal field operators and government. The temporary storage plinth, export tankers, shuttle tankers and low cost sub-sea tie back well are among the storage and export options to carter for the different requirement of marginal fields.

For example, the bulk of our associated gas supplies lies to the east of the River Niger whilst the demand centres lie west of the Niger, the East- West link will therefore provide flexibility in supply and help in the elimination of Nigeria's gas flares in the east.

- Market structure is oligopolistic and under-saturated. There is very high barrier to entry. Early mover advantages are critical for potential indigenous players and marginal field operators. When the pipeline business is controlled by a single company like the Nigerian Gas Company NGC or several large companies, these companies may prevent other gas sources from entering the pipeline network, in this way they can suppress the emerging gas companies to maintain their competitive advantages Xiucheng et al. (2015).

Nigerian natural gas market is still highly monopolized and lack sufficient competitive market.

Furthermore, a monopolistic market may lead to a reduction in the operational efficiency of the market and a lack of development momentum for gas companies. Therefore, breaking up monopolies and diversifying market participants are very important factors in promoting gas industrial development.

2.6.3. Inequitable Gas Pricing

Natural gas price is still determined by the government. Under this pricing mechanism, the natural gas price is relatively low and it fails to reflect the real market value. The enforced low gas price will reduce profits of marginal field operators as well as creating economic hindrances. At the government controlled prices, there is very little or no incentive to marginal oil and gas companies to explore for or develop or utilize gas. According to Joint UNDP/World bank energy sector management report ESMP (2004), gas pricing in Nigeria is more complicated since there is no developed market internationally or nationally for its gas. Domestic gas prices are controlled by the government and so far have been set at levels which are generally considered to be uneconomic (\$ 0.30-\$0.50 MCF). There is the need for government to hands off gas pricing because the present gas pricing system was discouraging in the sector. Gas development in Nigeria is hugely untapped area with most of the field in question not within the proximity of existing gas lines. There are potential for gas utilization opportunities in onshore marginal fields which come in micro/mini small scale LNG, modular liquid petroleum gas and power generation and agro based opportunities. Pricing is flexible for domestic market.

2.6.4. Lack of Ready Market: Absence of Adequate Linkages and Weak Manufacturing

Koso and Onwuachi-Iheagwara (2013), Koso and Kelani (2013) stated from their study that low volume of natural gas asset characterized the marginal fields in Nigeria and that the effective monetization of these assets must be an integral policy of the marginal field operators. However due to small domestic demand gas intensive industries such as aluminium-smelting and petrochemicals are export-oriented and subject to international competition and trade volatility.

- Oyideji and Adeolu (2011) posited that: The dearth of linkages between the oil sector and the other sectors of the Nigerian economy is a critical developmental problem. One reason why there are no linkages in the oil sector is the capital intensive nature of oil sector activities and scarcity of capital as well as local expertise. The presence of effective linkages is necessary for a balanced growth of an economy, thus it is important that linkages exist between sectors so as to promote an all-round growth and development of an economy. This is a vital ingredient for utilization of natural gas from the operation of marginal oil fields.

2.6.5. Environmental Regulations and Securities Issues

Environmental regulations and security emergency management for industry have not been improved in Nigeria. The rapid growth of the gas industry has been coupled with substandard management and ecological concerns in recent years. For production and transportation of gas, there has been serious damage done to the environment due to legal deficiency. There is crude oil theft, and pipeline vandalism among others. The main challenges facing oil companies operating onshore in the Niger Delta in recent years have been presented by the activities of militants who attack the IOCs' and MOF oil facilities and kidnap foreign oil personnel as a way to bring their various grievances to the attention of the international community, or to receive monetary compensation from the IOCs, MOFs or the Nigerian government. Some of the indicators of the negative relationship between oil companies in Niger Delta include: Harassment of staff, hostage taking, vessel seizure, equipment destruction, barricade, sabotage, kidnap, pipeline vandalism and so on. This day report, 6th June (2013) posited that:

- Illegal bunkering had also remained another headache for the cluster of marginal field companies, noting that the clusters lost about \$72 million in 2012 alone to illegal bunkering, while Energia loses about 15 per cent of its daily injection to the illicit trade.

The combination of these factors sub-optimizes Nigeria competitive position in a rapidly evolving and intensely competitive global gas business. The gas infrastructure blueprint aims to address these barriers and leverage a diversified industry player base to actualize this.

3. Platform Petroleum on Gas Flaring as a Driver of Investment. A Model of Natural Gas Monetization

According to platform petroleum website report (2012):

- Platform petroleum has demonstrated the monetization of natural gas in development of its marginal oil field the Asuokpu/Umutu field which lie in the Northern Delta Depobelt, in Shell's OML 38, Western Niger Delta. The field was awarded to Platform Petroleum Limited as a Marginal Field in 2003 after a competitive Bid Round. On April 01, 2005, following handover of the Field in November 2004, Platform executed a Joint Venture Agreement with Newcross Petroleum Limited resulting in a 60/40 Equity ownership of the Field with Platform remaining the Operator.
- The Phase I development of the Field was kicked off in August 2005, culminating in First Oil, achieved on December 01, 2007. This phase entailed the re-entry, testing and completion of two existing wells (Umutu – 2 and 4) as well as the construction and installation of a 10,000bopd Flowstation. 48 Kilometers of Export Pipelines was also installed in two segments (32km of 6" Pipeline from Umutu to the Umusadege Hub and 16km of 8" pipeline from the Hub to Agips' Kwale Facility).
- The Phase II development, as detailed in the Field Development Plan earlier approved by the department of Petroleum Resources (DPR) entails further development drilling and ramp-up of oil production as well as providing a gas solution. The Umutu Gas is quite rich in liquids. The gas solution is, therefore, designed to be in two parts:
 - A liquids stripping plant to produce LPG and NGL and
 - Sale of the lean gas to a third party off taker.
- Estimated gas reserves for the Umutu Field ranges from a low of 75bcf through a most likely of 180bcf to a high of 320bcf. About four additional wells will be required to firm up these reserves. Most instructive, however, are the yields for LPG, excess propane and NGL that have been calculated from the composition of the Umutu Gas. For input gas volume of 30mmscf/day, the yields are as follows: LPG - 1,200bbls/day NGL (condensate) - 500bbls/day Excess Propane - 350bbls/day Based on the most likely gas reserve of 180bcf, gas supply for a 30mmscf/day plant is guaranteed for sixteen (16) years.

By this achievement Platform petroleum has successfully registered another project under the United Framework Convention and Climate Change (UNFCCC) clean development mechanism, bringing the total registered product to four in the country. The project Asuokpu/Umutu gas recovery of the dry associated gas that is currently flared at the Asoukpu/Umutu marginal fields are delivery to the Nigerian domestic gas market for productive use as an energy product. Also the New CDM project has the potential to improve national resource management through full utilization of the energy resource produced at the field. The new CDM project activity will apart from contributing to the sustainable development of the nation by providing reliable gas supply to strength the national electricity system, resulting in greenhouse gas emission reduction. It would equally generate new employment opportunities.

Also on gas flaring, the Nigeria authorities would do well to take the advice of Vijay (2012), the director of the World Bank on Sustainable Energy Department, who says:

- "By reducing gas flaring, oil producing countries and companies are improving energy efficiencies and mitigating climate change. Instead of wasting this valuable resource, we now need to develop gas market and infrastructure so the associated gas can be utilized to generate electricity and cleaner cooking fuels."

4. Research Methodology

An extensive review of gas utilization schemes and economic development of marginal field in Nigeria was used were carried out. Specifically gas monetization by platform petroleum one of the marginal field operators was use as case study

5. Result and Discussion

The following factors were identified as militating against the optimization of natural gas from marginal oil fields operations are

- In adequate infrastructure
- Inequitable pricing
- Market structure
- Lack of capital for gas utilization projects
- Lack of ready market
- Securities issues in Niger Delta

5.1. Improving Pipeline Connectivity and Adequate Storage Facilities

There should be joint use of infrastructure (cluster model) and no need to duplicate processing and transportation infrastructure. An efficient network of oil and gas infrastructure is crucial to the success of gas utilization from marginal field operation. In order words the development of common infrastructure for example pipeline, terminals export and refineries. Also gas utilization can be achieved from marginal oil field operation by tying in to an existing oil and gas infrastructure. By taking advantages of the extensive pipelines distribution in the Niger Delta where the marginal oil fields are located there is opportunity for marginal oil field to provide natural gas for investors in natural gas utilization.

5.2. Natural Gas Pricing Structure

It is difficult to utilize natural gas without the support of an appropriate pricing structure for two main reasons. First, the prospect of lower fuel costs is the major driving force in the acceptance of natural gas as an alternative fuel by industry operators. Hence, there must be economic incentive attractive enough to encourage investment in the gas sector.

Secondly, for the marginal field operators, the natural gas price must be such as to provide a reasonable return on the investment to promote the construction of gas projects. For these reasons, natural gas price must be set at a level that is acceptable to both the marginal field operators and the users of the natural gas. There should be flexibilities around the take or pay Gas sales purchase agreement (GSPA) especially for associated gas based projects.

5.3. Funding

As put by Offia, (2011) other ways that MOF operators can raise funds are by going to the capital market to raise funds. They can in the alternative involve private investors including foreign financial and technical partners through private issuance of shares. The MOF operators may also approach international banks, foreign equity partners, The World Bank, regional bank and financial institutions. Therefore, financing of marginal field project can be achieved as follows:

- i. Through the technical partners
- ii. Collaborative financing (public private partnership) approaches through banks and financial institutions coming together to form consortium or embark on loan syndication
- iii. Reserve based lending
- iv. Using investment house to raise funds in form of share, stock and bonds

5.4. Synergy for Promoting Natural Gas Utilization from Marginal Field

A strategic partnership between marginal field operators and the users of natural gas is critical to the optimum utilization of natural gas from marginal field. The formation of such strategic alliance will not only provide a common focal point but will also provide economies of scale for the development the natural gas market. The gas distribution companies being the links between marginal field operators and the market in the Gas Value Chain are critical to the success of natural gas utilization. A strategic partnership can be promoted between marginal field operators and the users of the natural gas through revenue sharing. Partnership and alliance could also be in the form of:

- a. Initiation of a long term relationship between the asset holder (marginal field operator) and the service companies (drilling contractor and equipment supplier). This includes the leasing of facilities for processing and monetizing of natural gas.
- b. Sharing of financial risks and rewards and is aimed at an improvement in efficiency and reduction of operating cost.
- c. Infrastructure sharing: This may involve sharing information and technical know-how among field operator. The basic sharing of existing platform concept is to improve the project economics by use of existing nearby infrastructure such as gas processing platforms and pipelines as opposed to building or buying a new facility. This strategy enables utilizing the benefit of economies of scale.

6. Conclusion

The study highlighted the strategies needed for optimization of natural gas from marginal oil field in Nigeria. Based on the analysis, the overall findings and conclusions are that the needed infrastructure are inadequate. Some of the suggestion made are: As an integral

policy of the marginal field operator is that gas monetization should be factored in to the cost of doing business in Nigeria. An attractive cost effective gas pricing is needed to create the incentive for marginal field operators and other stake holders in natural gas investment. Also there is the need for collaboration and cooperation by marginal field operators with stakeholder, third parties and support industries in the area of infrastructure.

It is worthy of note that the gas master plan infrastructure will aid in the effective monetization of the natural gas from marginal oil fields. For example, if the gas master plan is effective Opportunities available in LPG services include fabrication of LPG storage plant, LPG bottling plant, LPG distribution trucks, LPG filling station and LPG equipment. The outcome of adequate infrastructure and collaboration in optimization of natural gas asset from marginal field is economic sustainability in Nigeria.

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