IMPROVING NATURAL GAS DISTRIBUTION AND MANAGEMENT IN NIGERIA

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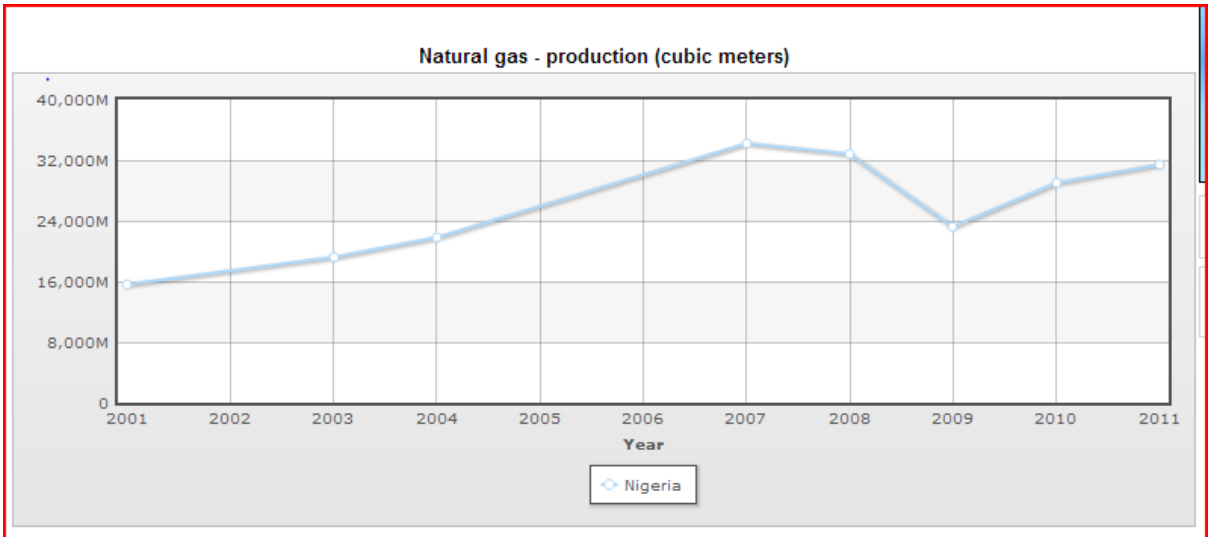
ABSTRACT: Gas is continuously flared in Niger Delta despite the efforts of the government and the oil industries to curb the menace of gas flaring. If this ugly scene must stop, oil production will be cut down to meet the flare – down target and remote gas field will be abandoned. To continue or increase the present oil and gas production, new market or new form of gas distribution will be created to improve gas utilization. Converting gas energy to electrical energy for local consumption and Natural gas hydrates (NGH) technology for international markets proffer a solution.

This paper reviews gas utilization in Nigeria and evaluates the future of natural gas hydrate technology in the management of natural gas in Nigeria. Natural gas hydrate is used to store and transport natural gas in form of hydrates at atmospheric pressure as a transportation option for marketing natural gas. It serves as a means of bringing stranded gas to the consumers.

Key words: Gas hydrate, Gas utilization, Natural gas transport, Niger Delta, Gas distribution, Gas management, Gas flaring.

INTRODUCTION:

Nigeria economy is majorly dependant on revenue from oil than gas but large deposits of gas reserve have been discovered both associated and non-associated. The gas industry has received little or no attention to actually develop and harness the gas resources. This has led to both economic loss and environmental challenges. There are several investment opportunities in the Nigerian gas sector. This ranges from local consumption to exportation of gas as liquid and/ or solid. According to Buresi (2003), Nigeria's gas reserve is currently estimated to about 188 trillion standard cubic feet (U.S, EIA 2012). This has placed Nigeria as the seventh endowed gas nation in the world and the first in Africa. Out of this reserve only about 2 trillion standard cubic feet (SCF)of dry gas is produced, ranking Nigeria as the world's top 30 largest Natural gas producers and was the world's fourth-largest exporter of liquefied natural gas (LNG) in 2015, (BP, Statistical Review of World Energy, 2015).Figure 1 shows natural gas production from 2001 to 2011. There was a drop in 2009 as a result of vandalisation of infrastructure which was reduced by the amnesty programme of the then government and the production has been on the increase since then. All the produced natural gas is not utilized due to constraint posed by lack of infrastructure hence most of the gas is flared. According to United States energy information Administration on the analysis of Nigeria's oil and gas sector, a significant percentage of Nigeria's gross natural gas production is flared because of lack of infrastructure in most of



Country	2001	2003	2004	2007	2008	2009	2010	20
Nigeria	15,680,000,000	19,200,000,000	21,800,000,000	34,100,000,000	32,820,000,000	23,210,000,000	29,000,000,000	31,360,

Source: CIA World Factbook (June 30, 2015)

the oil fields to capture associated gas. In 2013, Nigeria flared about 15% of the associate gas produced in 2013 (United State Energy Information Administration,2013).

As more oil reserves are been discovered the gas resource increase and more is anticipated. However, the problem facing the oil and gas industry is to combat the menace of gas flaring in Nigeria. Basically low gas market in our gas region, lack of infrastructure and low technological advancement in gas industry in Nigeria hinder gas utilization.

Power generation is offering the major source of developing domestic gas market in Nigeria. Pipeline supplies to international market are hindered by cost per distance as been very expensive and sporadic vandalism, options left are conversion of gas to electrical energy, liquefied natural gas technology currently in operation, Gas–to-liquid technology and Natural Gas hydrate technology.

ENERGY CONSUMPTION IN NIGERIA

Estimates have been made of Nigerian gas consumption in 2013 as shown in figure 2. It is noted that biomass and waste accounted for 74% of the energy consumed. More of the off-grid heating and cooking was done with biomass. ElA, 2013 states that about 45% of the Nigeria population use electricity.

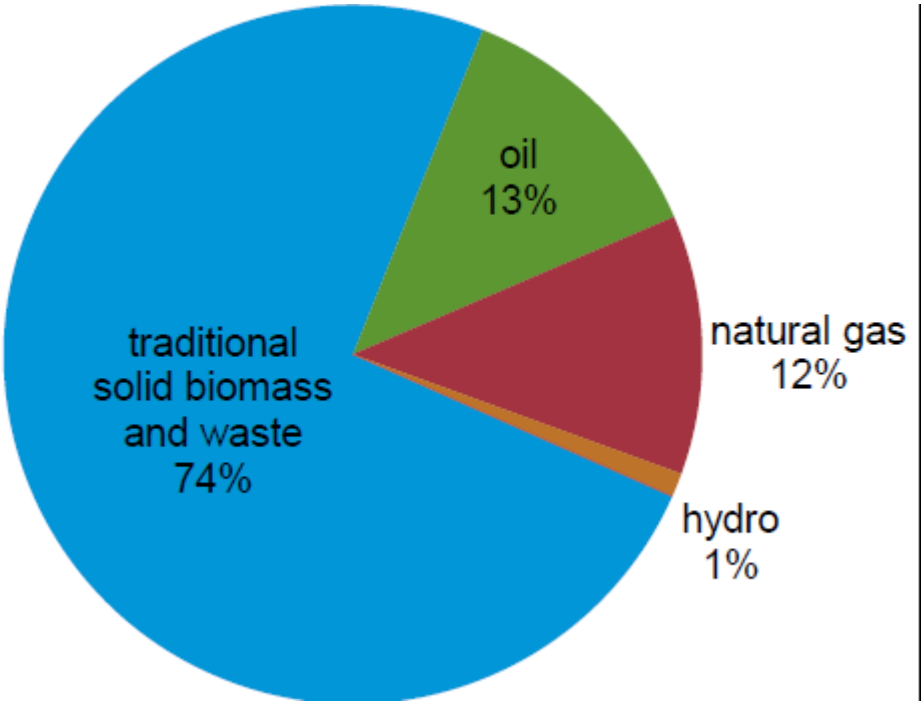


Figure 2 Nigeria's total primary energy consumption, 2013

The major infrastructure in place for the export of natural gas is the West African gas pipeline with installed capacity of 73 billion cubic feet per year (200mmcf/d) though activities of vandals has not allowed I to operate above one-third of its capacity. Another gas pipeline (2,500 miles) is the Trans-Saharan gas pipe line designed to supply gas to Algeria. Development and effective management of gas sector in Nigeria remains a strong channel for expansion and will generate opportunity for multiple revenues for Nigerian economy. Exploitation and monetization of stranded and associated gas will require the adoption of technologies focused towards development and commercialization of natural gas.

Harnessing associated and non- associated gas should become a thing of interest to the Government and oil industry. This will not only add value to natural gas but also monetize natural gas. Routine gas –flare could be a thing of the past if adequate measures are taken at the appropriate time

Out of the estimated 5Bcf/d associated gas production about 17% is re-injected, 33% used commercially and the remaining 50% of gas is flared (Ratcliffe etal 2001 and Alimi, 2014). Thus there is considerable room for further commercialization if this 50% (2.5 billion cubic feet per day) of unutilized gas can be converted to natural gas hydrate and electricity generation, the existing barriers of prohibitive transportation would not only be reduced but also gas flaring will be eliminated. Natural gas hydrate offers a reliable and viable means of storing and transporting natural gas in form of hydrates.

Natural Gas hydrate (NGH) technology proffer attractive option in bringing stranded natural gas from remote fields to market. With reduction in the capital cost of hydrate production and transportation, NGH offers better alternative and most importantly will complement the existing technologies in meeting government target to completely stop gas flaring .NGH has wide application especially in stranded regions.

ENVIRONMENTAL CHALLENGES OF GAS FLARING

The impact of gas flaring ranges from health issues, economic to climatic changes. These gases are released into the atmosphere. Gas flaring causes acid rain and ozone depletion through the release of harmful gases like nitrogen, sulphur oxide, carbon dioxide and methane. Communities where gas is flared at lower efficiency experience environment pollution. It has been observed that gas flare in Niger Delta produce a lot of soots consequent upon lower flare efficiency. Abdulkadir etal, (2013) analysed the volume of carbon dioxide produced in some villages in Niger Delta. The result of the analysis show that carbon dioxide produced is above the critical threshold limit value of 30,000ppm. Apart from air pollution and the depletion of ozone layer, the heat released from such flares can cause rise in temperature which promotes the growth of pests, diseases and desertification. Residents in this area have complained of respiratory problems, eye irritation and skin rashes. They are compelled to live with noise, heat and excessive light from the flare stack which has led to deprivation of sleep. Experiments have shown the adverse effects of gas flaring on the soil texture and fertility in host communities. About 46.8 billion kilowatts of heat is released into the atmosphere (Uyigue, 2007). All these challenges from gas flaring threaten the life of people living in the Niger Delta area (Figure 3). The gas flare scene shown in Figures 3 and 4 requires immediate action to be taken to surmount these problems by protecting the environment, dealing with climate changes and survival of the people. Adequate reduction in gas flaring will reduce the economic waste encountered in the gas flare (figure 4). One of the technologies to alleviate this problem is effective gas distribution and management through Natural Gas Hydrate Technology and use of technologies that will enhanced proper gas utilization.

Figure3: Smoke From Giant Gas Flare showing air pollution

Figure 4: Numerous flare leading to loss of gas and revenue

VALUE OF NATURAL GAS IN A DEVELOPING ECONOMY

Lack of infrastructure and poor technological innovation has been a problem in the management of natural gas in third world and developing economy. Over dependence on hydropower supply as source of energy has increased the cost of running most equipment used in the industries. Currently, in developed economy, natural gas is used as source of energy in these strategic industries for constant and consistent operation. These industries are large users of natural gas and require the construction of extensive infrastructure to supply natural gas. Increased investment in this sector will not only increase the use of natural gas but also enhance capacity utilization so that the industries can be functional and operate commercially. Moreover gas turbines can be used in rural electrification. Typical example of these is gas distribution to industrial consumers at Aba, Port Harcourt, Ughelli, Sapele, Lagos and environs. Gas commercialization in Nigeria for many yearly has been hindered by lack of commercial market and infrastructure. Ratcliffe, in 2001 stated that the size of the connected gas market in Nigeria is over 0.6 billion standard cubic feet per day and that the local demand for gas in 2000 was 360mmscf/day due to poor maintenance and operation of the main consumers. It is estimated that PHCN consumes 70% to 80% of gas sold locally (Rezaiyan 1995). Manufacturing industry could increase their demand for gas. There is need to connect

the industries in the northern part of Nigeria to national gas grid to boost local consumption. Nigerian gas company piloted the use of natural gas for domestic purposes at the NNPC housing estate Ekpan, near Warri. The success of that project could have yielded similar projects in other cities.

GAS UTILIZATION AND MANAGEMENT IN NIGERIA

Gas management is one of the major problems facing oil and gas industries in Nigeria. Gas management is aimed at monetizing our vast undeveloped and stranded gas resource and to meet the government target to get rid of gas flaring. Gas management could go further to monetizing associated and non associated gas for economic growth in addition to social and environmental concern. The strategies used in the gas management are still not enough. These strategies are given below.

- Gas re-injection for reservoir pressure maintenance and gas conservation.
- Electricity generation with natural gas.
- Establishment of gas based projects.
- Establishment of the liquefied natural gas project (LNG) in Bonny.
- Establishment of gas – to –liquid (GTL) projects at Escravos.

Nigeria Agip Oil Company (NAOC) has two gas re-injection projects at Obiafu/Obirikom and Kwale/Okpai locations. Mobil Nigeria Unlimited re-injects 500mmscfd of gas to maintain pressure in Oso condensate field. Shell petroleum also re-inject gas at Oguta/Akiri location. Currently 80mmcfd of gas flared is used at Kwale by Nigerian Agip Oil Company to generate 480 mega watts of electricity which is added to the national grid. Also SPDC, an operator of NNPC, TENP and NOAC joint venture has intensified effort to improve local gas utilization by converting flared gas to 650 mega watts of electricity form Kolokoma and Afam gas plants.

Currently, some oil industries like Shell and Agip have shown interest in rural electrification where gas turbines have been employed. Also these oil companies supply gas to NEPA for power generation. Projects for commercial extraction of LPG and NGL are equally in progress. Mobil processes about 600mmscfd gas in Bonny for the production of natural gas liquids. Chevron produces liquefied Petroleum gas (LPG) and (LNG) by processing about 280mmscfd gas in Escravos.

Contributions of Liquefied Natural Gas LNG Project

The NLNG project has contributed immensely to reduce gas flare in the Niger Delta. Before the advent of NLNG project in 1999 about 70% of total associated gas produced was flared (Uzukwu 1998).

Liquefied natural gas serves as the major mechanism for the export of natural gas in Nigeria. The major contributors and their equity share in the project are NNPC 49%, SPDC 25.6%, Elf 15% and Agip 10.4%. Successful completion of LNG's base project enabled Nigeria to diversify its economy, reduce gas flaring and its dependence on export of oil, develop its vast gas reserve and generate another major source of income. Trains I, 2 and 3 are designed to handle1500 mmscfd gas and NLG- plus (Trains 4 and 5) is to handle 670 mmscfd each (Rat cliffe etal 2001). This gives total plant capacity of 2840 mmscfd. For trains I, 2 and 3 gas supply by the shareholder are as follows. SPDC 450 mmscfd (about 60% non-associated gas and 40% associated gas.), Elf 390mmscfd and Agip joint venture supplies averagely 219 mmscfd to the plant. This gives a total gas supply of 1069 mmscfd.

According to the National Conference on gas Development and utilization in Nigeria, (2002), gas production at the end of 2001 was 1.8 trillion ft^3 or 5bcf/d, made up of 75.61% associated gas and 24.39% non associated gas. Gas used was estimated at 48.91% and gas flared stood at 51.05%. In 2011, Nigeria produced a total of 1 tcf of natural gas and also exported 17.97 million metric tons (875 Bcf) of liquefied natural gas (LNG). Currently NLNG exports 52metric tons of LNG per annum which places Nigeria as the 4th largest exporter of LNG in the world (U.S. EIA 2012). In the period of 1999 and 2012 NLNG has converted 3.3 tcf of gas going to the flare into LNG/NGL products for export. Current gas utilization as at 2011 is 14,750mmscf/d of which NLNG contributes 80% (Mundi, 2013)

Compressed Natural Gas

Natural gas is converted to compressed natural gas by compression. It is used as vehicular fuel because of its low pollution during its combustion process. The attitude of the industrialist, commercial and private motorist in the use of this new vehicle has been a disappointment to the invention. The cost of converting an old stock and limited facilities for refilling fuel tanks have scared private and commercial vehicle operators from patronizing the new technology. At present, about 60 vehicles have been converted to operate on CNG in pilot schemes mainly sponsored by NGC in Warri and Egbin (Wilcox 2000). There is need to

have more vehicle using compressed natural gas as vehicular fuel. It is environmentally friendly as less emission is encountered compared to use of petrol (PMS) and diesel (AGO)

Conoco Energy Services contributed in the development of Coselle compressed natural gas. This was developed to solve problems of ocean transport of stranded gas. It cubs the problems associated with pipeline distribution of gas such as sabotage, political dispute where the pipeline crossed national boundries and inability due to fixed infrastructure.

Contribution of Gas-To-Liquid Technology

Chevron Nigeria Limited and Conoco Energy Services embark on this new technology to build different GLT plants in Nigeria. The chevron's Escravos gas project phase 3 will supply residual gas to Escravos GLT plant. These GLT plants are to have in - let gas in excess of 800mmscfd. The expected total GTL capacity would be 33.8million barrel per day. This feed gas will produce 34,000b/d of GTL diesel, GTL naphtha and a small quantity of LPG.

Local and Regional Market Supplies

Nigerian gas company (NGC) owns majority of gas transmission capacity, it operates more than 1100km of pipelines serving major markets in the West and East of Nigeria. The Escravos to Lagos pipeline system (ELPS) has a capacity of 1100 mmscfd supplying gas to NEPA power plant at Egbin, cement plants at Shagamu and Ewekoro. Also through a 170km 24inch-diameter branch it supplies gas to Ajaokuta steel plant. SPDC in its 2-phase gas transmission project supplies gas to Agbara and Ota in Ogun State and Aba in Abia State. Other power stations supplied are Afam, Ugheli, sapele and Egbin. There are also industrial consumers in the southeast and Southwest as shown in Table 1.

TABLE 1: Local Distribution of Natural Gas in Nigeria

LOCATION	*DISTRIBUTOR*	*NO OF CUSTOMERS*
Aba	SPDC	6
Portharcourt	River state ministry of power	11
Warri/Ugheli	SPDC/NGC	3

Escravos-Lagos pipeline system	NGC	9
Others	NGC/NLNG	3

Source: (Obeche 2000)

It is estimated that 80% of the produced natural gas is used to generate electricity while the remaining 20% is consumed by the allied industries. Such as petrochemical, steel and aluminum industries, cement industries, fertilizer company, rubber and manufacturing industries. Nigeria's energy demand has been achieve through an energy mix as shown in the report of Adeniji and Sipasi (2011). This includes firewood, petroleum products, natural gas and hydro electricity. A U.S energy report showed that Nigeria consumed 111,200,00 tons of oil equivalent energy (4.4 quadrillion Btu) in 2010. Out of which 82% is from biomass (firewood), 13% from oil, 4% from natural gas and 1% from hydro electricity. This statistic reveals that about 50% of Nigeria population does not have access to electricity. Though government has a projection of 40,000 MW capacity by 2020, there is need to improve the use of gas in the generation of electric power. The country's source of electricity consists of 64 % thermal (gas) power plants, 13 % thermal (oil) power plants, 22 % hydroelectricity, less than 1% from biomass and less than 1% from wind and solar (Otiotio, 2014 and IEA,2014). Technological barriers could be defeated to transmit gas to residential areas. This could reduce the use of biomass as source of fuel. There is need to improve use of gas to supplement use of firewood and reduce deforestation.

TABLE 2: Local Gas Consumption In Nigeria projected to 2020 (mmfcd)

Utilization	*Year 2000*	*Year 2010*	*Year 2020*
Power	225	1390	3770
Cement	25	82	275
Fertilizer	70	80	172
Aluminum	15	39	102
Iron and Steel	2	15	129

Others	86	200	358
Total	423	1806	4806

Source : DPR Report (2002)

Based on the DPR report Table 2, both present and future projection of gas consumption has shown power sector to consume 78.4% of gas demanded locally while 21.6% will be used for industrial purpose. More industrial demands are expected to boost the infrastructural and economic development in Nigeria.

Regional gas distribution has suffered a lot of set back in the time past. The West African gas pipeline was borne to relief the region. Nigeria will play a vital role in regional development because of her massive oil and gas deposit.

Nigeria is expecting to export about 250mmscfd through the West African gas pipeline to Togo, Ghana and Benin Republic. This project is supposed to increase domestic market demand.

GAS MANAGEMENT BY NATURAL GAS HYDRATE TECHNOLOGY

Natural gas Hydrate is relatively a new technology used in gas management. Natural gas hydrate (NGH) technology was first developed to handle associate gas on FPSO's to solve the stranded and marginal gas problem in the oil industry (Gudmundsson etal 1998). About 184 trillion scf gas is in place in Nigeria and much of it is likely to remain stranded until something like NGH can be used to bring the gas to market on a large scale. Natural gas hydrates technology has the ability to store and transport natural gas from stranded or marginal fields to the market. Gas hydrate equipment can carry natural gas, associated gas and mixture of associated gas and oil in the presence of water. Natural gas hydrates are often likened to frozen water. Natural gas hydrate contains 150 (scm) standard cubic meter of gas per 1cubic meter of hydrates. Natural gas hydrate has the potential to transport large volume of gas. It is cheaper for long distance transportation. Comparative study carried out has shown that in terms of capital cost NGH is lower than any other means of transporting natural gas for distances in excess of 1800km (Gudmundsson etal 1998). This cost includes production, processing and transport. Gudmundsson, and Borrehaug, (1996) show that

pipeline distribution can be used economically for short distance transportation and natural gas hydrate is most suitable for long and very long distances (Table 3).

Table 3: Comparison of Capital Cost and Distance of Various Gas Transport Options

Pipeline		LNG		Sync		NGH	
Cost m$	Dist. km	Cost m$	Dist.	Cost m$	Dist. km	Cost m$	Dist km
0	0	1600	0	2100	0	1100	0
500	600	2200	6000	2200	6000	1500	5000
1000	1200	2250	6500			1700	6500
1500	1800					2000	10000
2000	1900						

Source: Gudmundsson, J.S and Borrehaug, A. (1996)

GOVERNMENT'S ROLE IN GAS MANAGEMENT IN NIGERIA

Over the years, gas flaring has been a nightmare to the Government. In the past decades, government was not deriving any revenue from gas rather this was flared. Government in 1979 introduced a penalty of 2k per one thousand standard cubic feet (mscf) of gas flared which rose to #20/mscf in 1999. Since then government has also been embarking on gas based projects to encourage industrialization such as steel industries, fertilizer companies and others alike including generation of electrical power. In 1991, government introduced incentives which will abate gas flaring. Such incentives as:

- Free duty and VAT
- Free import of machinery and equipment
- Tax holiday for 5years
- 5-7% royalty
- Zero% petroleum profit tax
- Investment tax credit of 5%.

Though, some other problems have made investments in the gas industry difficult.

PROBLEMS OF GAS MARKET DEVELOPMENT IN NIGERIA

So far gas flaring has defiled all the strategies adopted by government and oil industries to produce and harness oil and gas in Nigeria. This is consequent upon the impediments to gas market development. Gas business is solely market dependent. Since gas market in our region is poor, technology is needed to process, store and transport this gas resource to international gas markets in Europe. The problems to gas market development in Nigeria could be summarized as:

Politics and economic policies: strong economic policy on utilization of gas has not been in place and similar policies has not been followed rigidly due to politics.

Limited Gas pipeline and distribution infrastructure

Lack of gas pipeline and distribution is one of the hindrances to gas market development in Nigeria. Gas distribution is low. At present NGC has 1100km gas pipeline. It has not been possible to actualize the proposal to distribute domestic gas in homes. The great hindrance has been lack of infrastructure. A lot of industries requiring process heat from furnace and boilers can patronize gas as source of energy if there is adequate gas network available to them.

Gas accounts for about 57% of Nigeria's internal commercial energy consumption over petroleum products at 33% and hydroelectric energy at 10% (IEA, 2014). For an average sale of 350mmscfd gas, 245mmscfd gas is supplied to PHCN and the rest is sold to industries. Very small quantity is used as compressed natural gas. Since the gas market is low in Nigeria, there is urgent need to transport this resource to international market where there is much demand for gas. Natural gas is also marketed as LNG and GTL from plant capacities of respectively. With the present use of gas local and export statistics has

FUTURE OF NATURAL GAS HYDRATE TECHNOLOGY IN NIGERIA

From a comparative study of gas utilization in Nigeria and the extent of gas management, there is no doubt about the prospect of natural Gas Hydrate in Nigeria. Nigeria has vast undeveloped gas resource with incremental gas flaring. Gas flaring has numerous environment impacts to the host community and adverse economic and social implication to the country at large. Nigeria produces about 5bscfd gas of which 33% (1.65bcf/d) is re-injected and 50%(2.5bcf/d) is flared.(Ratcliffe etal 2001).Also according to the National

conference on gas development and utilization in Nigeria organized by Nigeria Energy Digest, gas used was 48.91% and 51.09% was flared (Uzukwu 2002).

Oil industries have been trying to curb the menace of gas flaring. The NLNG plus, Chevron's GLT and other gas based projects are expected to bring gas utilization to 90% by 2010. Unfortunately, this target constitutes a major challenge. Ratcliffe etal (2001) reported that a higher target of gas utilization can be achieved by reducing oil production. This target has not been met. In other to make 90% utilization and more a realistic target Natural gas Hydrate Technology can be used to bring this excess gas to the market. The development of this technology in Nigeria will enhance gas utilization and could become preferred method to commercialize this natural gas resource.

CONCLUSION

Nigeria is a gas province. High percentage of Nigeria's discovered, proven and undeveloped gas deposit is wasted because gas market and current technology in our region offers little or no impact to prevent gas flaring and monetize this resource. The development of Nigeria's gas has a lot of challenges ranging from insufficient gas market or outlet in our gas region, limited pipeline and gas distribution infrastructure to poor technological advancement.

Based on the 2 trillion scf annual production 40% (800billionscf) is flared annually (NNPCgroup 2017) although, domestic gas demand is on the increase. Despite all these hindrances, gas industries have engaged some strategies in gas utilization to reduce the economic waste. Fortunately, there are sufficient gas markets in Europe. If this wasted resource could be store and transported as frozen hydrate NGH), the existing impediment of lack of infrastructure and market would be reduced. The local consumption in the form of gas-to-wire (using gas for electric power) technology, increased industrial usage of natural gas and compressed gas as vehicle fuel are some areas to diversify gas utility locally. Government can make electricity affordable to all in Nigeria. This will empower small and large scale industries and create enablement for research and development. There should be a long plan to make gas source of domestic heating in households and industrial heating.

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