



Gas Flaring: When Will Nigeria Decarbonise Its Oil and Gas Industry

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Abstract: Gas flaring and venting are a safe methods of disposing unwanted gas during emergencies and equipment failures, or where the gas cannot be captured, stored or used economically. In whichever circumstance the flaring and venting occur, they both present an environmental and a resource management challenge. In Nigeria, gas flaring and venting began ever since the start of oil production in 1956. Gas flaring and venting have a number of negative consequences on the environment, human health, and the economy of the Nigerian state. Studies have put the revenue lost to flaring by Nigeria at around US\$2.5billion annually. This study reviews the various measures put in place by the government and the oil companies in form of laws, policies, regulations, programmes, and penalties with a view to discouraging flaring and encouraging gas utilisation. However, these measures have not been able to phase-out flaring in the country. Gas flaring elimination deadlines have repeatedly been shifted with the most recent one being December 2012. It was found that economic and fiscal considerations on the part of the oil companies and lack of strict enforcement of gas flaring reduction regulations on the part of the government, couple with ageing infrastructure to develop and utilise the gas resource, poor access to local and international energy markets, and lack of political will to see to the end of gas flaring are the main reasons for continued flaring in Nigeria. Policy makers in the country need to strategise and come up with effective gas utilisation programs. They need to reform and develop the gas industry to effectively support gas gathering; marketing and distribution, and on the part of the government, strengthen its legal and regulatory frameworks related to gas flaring and venting. Incentives should be granted for gas flaring reduction projects and penalties should realistically reflect the prevailing economic value of flaring. If these are not done analysts would continue to question when Nigeria is actually ready to decarbonise its oil and gas industry by eliminating the flaring and venting of associated gas into the atmosphere.

Keywords: Gas Flaring, Gas Venting, Gas Utilisation, Decarbonisation, Nigeria

1. Introduction

Traditionally, the burning of associated gas (AG) in open flames (gas flaring) and the direct release of unburned AG into the atmosphere (gas venting) [1] are a safe methods of disposing AG during emergencies, equipment failures, and shut down situations [2]. This usually is done in order to avert the risk of fire explosion that may likely occur where AG cannot be stored or used economically [3]. Similarly, where it is not technically or economically feasible to capture, sell or re-inject AG, the resulting option is either to

flare or vent the gas [4].

Through gas flaring and venting, valuable amount of resources which could have been used for other productive activities are wasted [5 – 6]. Over 5 trillion cubic feet (tcf) or 140 billion cubic metres (bcm) of natural gas are flared annually [7]. This figure, according to reference [7], could generate 750 billion kwhr of electricity, more than the entire African electricity demand. The amount of gas flared by oil companies around the globe could substantially meet the combined gas consumption of Central and South America [8] or that of Germany and France combined [9]. Another estimate projected that over 150 bcm of natural gas is flared

or vented annually around the globe [10], enough to supply some 30% of the European Union's annual gas consumption or a quarter of a year gas consumption of the United States [11]. In 2000, it was estimated that flaring in Africa, which stood at 37 bcm, could generate 200 terawatt hours of electricity or half of the then continents' power consumption if gas flaring was to be eliminated [8]. This is happening despite the realisation of the fact that gas is one of the least-cost options for power generation and is a means for providing energy to the rural communities [4].

Gas flaring and venting, which occur mostly in developing countries that produce oil, present both an environmental and a resource management challenge [4]. Environment in the sense that they have become major components of greenhouse gas (GHG) emissions that bring about global warming and environmental degradation [5, 11] and a resource management because valuable resources that could have generated about US\$35 billion in revenues are wasted [4, 7]. The Global Gas Framework Reduction (GGFR) Partnership estimates that around 400 million tonnes of carbon dioxide is emitted annually from gas flaring [12]. Africa is endowed with a huge gas resources which if properly utilised could overcome most of the continent's power challenges. Algeria is said to have a developed gas industry in Africa while Nigeria, along-side Egypt and Libya have rapidly developing gas industries [13]. Together, these countries account for more than 90% and more than 95% of the continent's gas reserves and total production respectively [13].

Efforts are been made around the globe to reduce the flaring of AG. In 2002, the World Bank introduced a public-private partnership initiative called the GGFR Partnership in a bid to galvanising support from the public, the oil companies, the oil owners, governments, and the international community on the need to reduce the flaring and venting of AG globally [14]. However, stakeholders may face serious challenges abating the menace because as the world oil production was expected to increase by 60% between 2000 and 2020, AGs may likely follow the same trend [8]. This is so because AG would naturally be produced once there is oil production, and will therefore increase with increased oil production. The World Bank is proposing a world-wide zero flare out by the year 2030 through a new initiative – the Zero Routine Flaring by 2030 [7, 15].

Nigeria is the ninth country in the world and the number one in Africa with abundant gas reserves [16-17]. However, much of these gas resources have been flared over the last decades. A number of studies have exposed the negative impacts of gas flaring in Nigeria on the environment [18], human health [18-19], the economy [20-21] and the society [22]. This thwarts economic and human development by contaminating the water system [23], crippling social and economic activities [4], increasing food insecurity [23], encouraging increased social vices [22], and presenting a big loss in government revenues [20-21]. This prompted the country to establish laws and regulations and to initiate projects aimed at eliminating the flaring and venting of AG.

This study critically reviews these measures and observed that though they have helped in changing the country from being the number one flaring nation on earth in the 1990s to the number five at the end of 2014, they have not been able to change the country's position in Africa in which it still ranks the number one. Gas flaring and venting have not been completely eliminated in Nigeria due to, among other reasons, inadequate finance to implement gas utilisation projects [13], unrealistic emissions taxations [3], inadequate gas infrastructure to capture and utilise the otherwise flared gas resource [24], and underdeveloped local market for the gas resource [25-26]. Gas flaring elimination deadlines have repeatedly been shifted by the country. Currently, Nigeria is looking forward to 2020 as its new phase-out target year.

2. Gas Flaring in Nigeria

Nigeria, with a proved gas reserves of 180.5 trillion cubic feet (tcf) (5.1 trillion cubic metres (tcm)), is the ninth country in the world and the number one country in Africa with abundant gas reserves (16-17). It was ranked in 2015 the fourth largest exporter of Liquefied Natural Gas (LNG) in the world [24]. On a class-by-class basis, Nigeria is said to be blessed with about 97 tcf and 90 tcf of AG and non-AG reserves respectively, suggesting an even division in the ratio of 1:1 between the AG and the non-AG [27]. With this, Nigeria is said to have been endowed with more gas reserves than oil, which with the current production rate is expected to last for more than 60 years [28-29]. It is believed that Nigeria's gas reserves profile could potentially rise to 600tcf if more efforts are geared towards increased search for the gas resource separately against the traditional way of finding it while searching for oil [28-29].

Table 1. Gas produced and flared in Nigeria in 15 years (NNPC estimates).

Year	Gas produced (in bscf)	Gas utilised (in bscf)	Gas flared (in bscf)	% utilised	% flared
2000	1,598.95	716.19	882.76	44.79	55.21
2001	1,822.92	902.02	920.90	49.48	50.52
2002	1,651.59	897.79	753.80	54.36	45.64
2003	1,828.54	983.56	844.98	53.79	46.21
2004	2,082.28	1,195.74	886.54	57.42	42.58
2005	2,093.63	1,282.31	811.32	61.25	38.75
2006	2,182.43	1,378.78	803.66	63.18	36.82
2007	2,415.65	1,655.96	759.69	68.55	31.45
2008	2,287.55	1,668.15	619.40	72.92	27.08
2009	1,837.28	1,327.93	509.35	72.28	27.72
2010	2,392.84	1,811.27	581.57	75.70	24.30
2011	2,400.40	1,781.37	619.03	74.21	25.79
2012	2,580.17	1,991.50	588.67	77.18	22.82
2013	2,325.14	1,916.53	409.31	82.40	17.60
2014	2,524.27	2,234.67	289.60	88.53	11.47

Sources: References [31, 32, 33, 34, 35]

In Nigeria, Gas flaring and venting began ever since the start of oil production in 1956, but just like the quantity of oil produced was low – 5000 barrel per day (b/d) – AG produced along-side the oil was also insignificant [13; 30]. However,

with successive increases in the amount of oil produced, which currently averages between 2 million and 2.5 million barrels per day (mbpd), AG, produced alongside oil, also increase in the same manner. But because there was no viable market for the gas resource, much of it has been flared and or vented [25].

In 1997, available statistics showed that Nigeria was the most flaring nation on earth, accounting for 21 billion standard cubic metres (bsm³) or 19 per cent of the then global recorded data [4]. The entire African continent accounted for 38 per cent in that year [4]. In 2000, an estimated 17.2 bcm (607.16 bscf) of gas was flared by Nigeria [8; 36]. A 2001 report suggests that the amount of gas flared by Nigeria in 1998 alone was equivalent to 45 per cent of the Norwegian gas exports of that year [4]. In 2010, a satellite data by the GGFR Partnership put Nigeria the second emitter, after Russia, of GHGs through the flaring of AGs during oil production [37]. Thus, Nigeria has successively been one of the highest emitters of GHGs in Africa and the world through gas flaring.

Table 2. Gas produced and flared in Nigeria in 15 years (OPEC estimates).

Year	Gas produced (in bscf)	Marketed production (in bscf)	Gas flared (in bscf)	% utilised ¹	% flared
2000	1230.45	439.82	607.13	50.66	49.34
2001	1387.22	525.94	677.73	51.14	48.86
2002	1750.23	563.61	805.33	53.99	46.01
2003	1861.98	671.48	820.76	55.92	44.08
2004	2109.46	790.26	851.36	59.64	40.36
2005	2059.65	790.68	811.86	60.58	39.42
2006	2181.43	1006.00	787.15	63.92	36.08
2007	2414.40	1147.20	787.15	67.40	32.60
2008	2563.99	1158.67	673.24	73.74	26.26
2009	2002.01	819.13	470.46	76.50	23.50
2010	2532.93	991.85	539.85	78.69	21.31
2011	2965.20	1458.63	503.71	83.02	16.98
2012	2994.92	1502.68	465.30	84.46	15.54
2013	2810.66	1355.84	427.53	84.79	15.21
2014	3047.13	1547.53	378.99	87.56	12.44

Sources: References [36; 38; 39; 40]

Estimates of the gas flared by the country vary among sources. For instance, in 2014, while the Organisation of Petroleum Exporting Countries (OPEC) reported that an estimated 379 bscf was flared by the country, the nation's oil company, the Nigerian National Petroleum Corporation (NNPC) estimated that only about 289.60 bscf was flared (Table 2; Table 3). However, the different sources suggest a decreasing trend of gas flaring over the last decades, from about 50% in 2000 to around 12% at the end of 2014. With this achievement, Nigeria has now shifted from being the

most flaring nation on earth in 1990s [4] to the 5th flaring nation at the end of 2014 [24; 38].

Table 3. World's top 5 gas flaring nations by 2014.

Serial Number	Country	Percentage flares
1	Russia	13
2	Iran	12
3	Venezuela	11
4	Iraq	10
5	Nigeria	8
6	United States	7
7	Rest of the world	39

Sources: References [24; 38]

Being the cleanest of all the fossil fuels [41], natural gas, if properly utilised, provides an effective energy source that is free from environmental degradation. However, with the growing interest in, and the increasing acceptance of, renewable energy resources, global oil and natural gas demand is expected to decline [42]. It is therefore imperative for Nigeria to decarbonise its oil and gas industry so that it can tap into the numerous opportunities provided by the gas resource before it become unattractive.

3. Reasons for Continued Gas Flaring

A number of reasons could be attributed to the continued flaring of AG worldwide. These range from the traditional safety and emergency reasons, to inadequate regulatory and legal framework, lack of adequate economic incentives to encourage the utilisation and the re-injection of the gas, through to inadequate political will especially in developing nations to enforce compliance to phase-out targets and regulations.

Reference [4] have identified three major factors that encourage the continued flaring of AG in Nigeria in particular and other gas flaring nations in general. Firstly, there is always the issue related to the continued use of ageing production facilities that were constructed in the 1960s and 1980s. In those years, adequate environmental and ecological consideration and effective plans to develop gas infrastructures for gathering and distribution of the gas resources were not put in place. Secondly, local demands for the gas resource in these countries are generally low with no ready-made viable market, thus discouraging gas capture and marketing. Over the years, oil companies have considered the gas resource uneconomical to develop due to the huge amount of investments which would not be recovered without a viable market for it [25]. Many oil companies particularly those operating in developing countries believe that gas infrastructural development are a hindrance to increased oil production [43]. Thirdly, AGs produced in oil fields are generally small and low in pressure thereby increasing recovery, treatment and distribution costs.

A study by the GGFR in 2002 identified three main barriers to gas utilisation and by extension the increased flaring of AG. These are (i) lack of an efficient regulatory framework, (ii) poor access to local and international energy

¹ Here, the utilisation rate also include the volume re-injected and the volume shrinkage which are ostensibly omitted in this analysis

markets, and (iii) financing constraints for projects that reduce flaring [26]. Absence of efficient and effective regulatory framework and the inability of the local authorities to enforce gas flaring regulations is a major issue hindering the abatement of gas flaring particularly in developing countries [3]. Difficulty in building pipelines and power generation and distribution lines² from oil fields and offshore platforms due, especially, to the remoteness of most of the fields also compounds the issue and encourages the continued flaring of the gas [3].

In Nigeria in particular, inadequate finance was cited as one of the reasons for the non-implementation of the 1979 Associated Gas Re-Injection Act [13]. Emissions taxations in Nigeria are too low to discourage oil companies who see flaring as a more economical way of disposing off the AG instead of investing in technologies and activities that reduce and/or eliminate flaring [3]. Lack of infrastructure to develop and utilise AG also encourages the flaring of gas in Nigeria [24]. Thus, economic and fiscal considerations on the part of the oil companies and lack of strict enforcement of gas flaring reduction regulations on the part of the government are the main reasons for continued gas flaring in Nigeria [3].

4. Impacts of Gas Flaring in Nigeria

Gas flaring presents a number of negative consequences on the environment, human health, and is one of the major components of GHG emissions which cause global warming. In addition, flaring and venting wastes valuable energy resources which could have been used for other productive and economic purposes [11]. It has been estimated that sizeable number of the electricity demand of the African continent could have been generated easily if the AG flared and vented were otherwise channelled to power generation in the continent [8]. This, off-course, is a denial of the right of Africans to one of the most important global public goods for their economic and social development. In Nigeria, the continued flaring of AGs has over the years denied Nigerians access to cleaner and often cheaper source of energy for their industrial and domestic uses.

The AG flared (which brings about carbon dioxide emissions) and vented (which brings about methane emissions) is a significant element of the anthropogenic GHGs which cause global warming thereby harming human health and the environment [5; 11]. On a scale of magnitude of the global warming potential, methane tends to have about 21 times [1] or even 23 times [5] greater impact on global warming than carbon dioxide. Thus, though flaring is more pronounced than venting when it comes to GHG emissions, it is generally preferred to, and less harmful to, venting [4; 11].

As Nigeria celebrates and enjoys the bountiful benefits arising from the discovery of oil over the past seven decades, it on the other hand battles with the numerous challenges occasioned by the exploitation of oil. The Nigerian situation

with respect to environmental degradation, human health and economic difficulties arising from gas flaring and other oil contaminations is summarised by Abbott in the following words [18]:

“Nigeria’s greatest blessing has been oil; but it has also been its greatest curse...the discovery of oil has been an ecological disaster for the Niger Delta where the oil is extracted. Shell and other western oil companies have, in collusion with successive military dictatorships, raped the region. Petrol contamination of the water table has made local water undrinkable. Farming and fishing grounds have been ruined and gas flaring in the Delta is cited as Africa’s single biggest contribution to greenhouse gas emissions. it is symbolical of the brutally exploitative nature of the oil industry in Nigeria that natural gas by-product (which other oil producers like Trinidad liquefies and markets) is simply burnt in giant flares which cause incalculable environmental damage.”

Gas flaring and venting affects the environment through the emissions of GHGs and pollution which contaminates water systems; streams; and lakes; increase food insecurity by contaminating the soil, affects human health, and presents a big loss of revenue to the government [23]. Soil and land degradation makes farming difficult thereby forcing local farmers particularly those of the youthful ages abandon their farms and move to cities, further exacerbating the food security challenge and increasing social vices in the cities [22]. A 2005 report by the Environmental Rights Action (ERA) and the Climate Justice Programme (CJP) on the impacts of toxic air emissions from gas flaring at 17 onshore flow stations in Nigeria’s Bayelsa State on the people living within the vicinity of the areas of the oil production facilities indicates that these emissions were the likely causes of 49 premature deaths, respiratory illness in 4,960 children, 120,000 asthma attacks, and 8 additional cases of cancer each year [19]. In economic terms, a number of studies have come up with almost similar figures for the amount of revenue lost suffered by the country due to gas flaring. The Nigerian Gas Association estimates that Nigeria has lost about US\$72 billion from 1970 to 2006 – translating to about US\$2.5 billion a year in revenue losses – due to gas flaring [20]. Another study puts the estimated revenue losses to gas flaring in the range of \$500 million to \$2.5 billion annually [21].

5. Gas Flaring Elimination Efforts in Nigeria

Government and oil companies have over the years set several deadlines for the phasing out of the flaring of gas in Nigeria. However, lack of effective legal and regulatory framework and inadequate political will on the part of the government, and ineffective economic incentives and inadequate gas infrastructures to support the utilisation and re-injection of the gas resource have been hampering the flare out efforts. As far back in the 1990’s, Mobil had

² In Nigeria, most programmes aimed at reducing flaring are geared towards the channeling of the wasted gas to electricity generation and production platforms

announced its commitment to zero flares by 1998 [44]. This pledge was not however achieved. More recently, Mobil, Agip, Chevron, Shell, Texaco, and Elf had sometimes announced their intentions to end gas flaring in 2004, 2005, 2008, 2008, 2005/6, and 2008 respectively [4]. These pledges were not met by these companies. The government had repeatedly set deadlines for zero flare out which have been repeatedly postponed, with the most recent deadline being December 2012 [24].

The Nigerian government has since the beginning of oil production in 1956 introduced some series of laws, provisions and policies, and has been involved in the execution of projects that are directly or indirectly targeted at eliminating and/or reducing the amount of gas flared during oil production. Regulations on gas flaring and venting can either be imbedded in primary or secondary legislation [45]. Primary legislations are legislations in relevant petroleum and hydrocarbon and environmental laws and empower the relevant regulatory agencies to carry out natural resource management functions and environmental policies without explicitly referring to gas flaring and venting [45]. On the other hand, regulations, policies, codes, guidelines, and licenses, formed to explicitly reduce and/or regulate gas flaring and venting are secondary legislations [45].

Three major alternative measures for the management of AG are available where flaring is eliminated. It could be re-injected into the reservoir to maintain pressure and enhance oil recovery; it can be used as an energy means on the production facility; and it can be processed and marketed in the local or international markets [4, 8]. Table 1 provides more detailed approaches to reducing and eliminating gas flaring.

Table 4. Methods for flare reduction and gas management.

Export by pipeline	Either: a) Re-compressing and treating the gas to sales pressure and quality or b) Exporting for use to generate power on a neighbouring facility as a fuel
Power generation	This involves reusing the gas to power equipment on the installation (such as gas turbines-driving-compressors, boilers and engines, etc.), or by providing energy to local communities.
Re-injection	This involves re-injecting the gas back into the formation to promote enhanced oil recovery or into the annulus of the well bore to facilitate gas lift.
LNG and Gas to Liquids (GTLs)	In the absence of a gas pipeline, consideration can be given to producing Liquefied Natural Gas (LNG) or Gas to Liquids (GTLs), such as Methanol or Dimethyl Ether, and exporting via ship or road.

Adapted from Reference [11]

5.1. Gas Flaring Phase-Out Legislations and Regulations

The first series of laws, the Petroleum Act of 1969 (PA) and the Petroleum (Drilling and Production) Regulation of 1969 (PDPR), regulating oil production in Nigeria did not explicitly make any provision on gas flaring or provided any penalty for the flaring of gas in the country. It was not until the 1970s that the government started making steps to enact

laws that were specifically targeted at discouraging the flaring of AGs. Even with these laws in place, the country has continued to be the number one contributor of GHGs in Africa and among the top contributor to global warming as a result of gas flaring. Analysts blame the weakness of the laws in providing commercial incentives to oil companies vis-a-vis their effective utilisation, and the lack of political commitment on the part of the government to fully enforce and effectively implement these laws as some of the reasons for the persistent shifts of the deadlines set for the companies and especially the government to phase out the flaring. These laws are highlighted below:

5.1.1. The Petroleum Act 1969

The Petroleum Act of 1969 merely contains rules and regulations regarding exploration and prospecting activities of petroleum resources in Nigeria as well as the duties and obligations of the Minister of Petroleum Resources in this regard [46]. No section of the Act talks about gas utilisation or penalties for gas flaring. This may not be unconnected with the fact that at the time the Act was promulgated, issues of climate change and global warming were not very much discussed at the global level. In 1973, the Petroleum (Amendment) Act exempted the production of AG from royalty payments and gave government the right to take gas at the flare free of cost [47].

5.1.2. The Petroleum (Drilling and Production) Regulations 1969

The Petroleum (Drilling and Production) Regulations 1969 under regulation 43 only requires operator to "... not later than five years after the commencement of production from the relevant area....submit to the Minister any feasibility study, programme or proposals that he may have for the utilisation of any natural gas, whether associated with oil or not, which has been discovered in the relevant area" [48]. The regulation did not provide for compulsory phasing out of gas flaring or any penalty thereof. It only urged, and not compelled, oil companies to submit a proposal on how they might use any natural gas discovered during their operations. It did not also specifically describe how the gas should be utilised or provide any penalty for non-compliance. Because of the lack of adequate penalty, operators' compliance was largely low.

5.1.3. The Associated Gas Re-injection Act 1979

A subsequent legislation, the Associated Gas Re-Injection Act of 1979 mandated companies operating in the Nigerian oil and gas industry to submit to the Minister of Petroleum Resources a preliminary programme for the utilisation and the re-injection of all AG produced during oil production on or before 1 April 1980, and to, not later than 1 October, 1980, submit to the Minister, a detailed plan for the reinjection and the utilisation of all AG produced during oil production [49]. Gas utilisation refers to "the marketing and distribution of natural gas for commercial purposes and includes power plant, liquefied natural gas, gas to liquid plant, fertiliser plant, gas transmission and distribution pipelines" [50]. The

Act also sets a January 1 1984 deadline for the phasing out of gas flaring in the country unless there was a written permission of the Minister to do so. The Act rests with the Minister the responsibility for the specification of the terms and conditions relating to the continuation of gas flaring. Apart from the fine for violating the provision of the Act, which the Minister was empowered to specify, the Act also provided for the forfeiture of the field given to an operator in case of violation.

In 1984, the Associated Gas Re-Injection (Continued Flaring of Gas) Regulations provided some exemptions for the continued flaring of AG in the country [51]. The 1985 Associated Gas Re-Injection (Amendment) Decree 7 strengthened the previous legislations with the introduction of a fine of 2 Kobo (equivalent to US\$0.0009) on any operator for every 1000 scf of gas flared [52]. This fine was raised by the government in 1990 under the Associated Gas Re-injection (Amendment) Regulation to 50 kobo (about US\$0.50) for every 1000 scf of gas flared [47]. The gas flaring penalty was raised in 1998 to ₦10 (about US\$0.12) for every 1000 scf of gas flared following the introduction of the Petroleum (Drilling and Production) Regulations (Amendment) Decree 1998 [47]. In 2004, the Associated Gas Re-Injection (Amendment) Act 2004 also directed operators in the oil and gas industry in the country to submit detailed plans for gas utilization [20]. The flaring of gas was also prohibited except where there was a written permission of the Minister [52].

5.1.4. The Associated Gas Framework Agreement (AGFA) of 1992

The AGFA was introduced in 1992 as part of fiscal policies that provided incentives for the utilisation of natural gas [20]. These incentives provided tax holidays for three years, and counting as part of oil field development programme of any investment that separate oil from gas from reserves into suitable production. In 1998, the Government provided additional incentives for investment in the economic utilisation of flared gas. These fiscal incentives included:

- Gas projects taxes at 30% versus 85% for oil projects;
- Capital expenditures for gas projects chargeable under Petroleum Profits Tax;
- Tax holiday of 5 to 7 years;
- Exemption on custom duties and VAT on gas related development equipment;
- A 15% investment capital allowance that shall not reduce the value of the asset;
- An accelerated capital allowance after the tax-free period in the form of 90%, with 10% retention on the books for investment in plant and machinery;
- Tax-deductible interest on loans for AG utilisation projects;
- Dividends during tax holiday are tax free.

5.1.5. The Petroleum Industry Bill (PIB) 2012

The controversial PIB³ came to consolidate all the

previous legislations relating to oil and gas operations in the country, providing comprehensive legal, fiscal and regulatory framework for the exploitation of oil and gas resources. The PIB aims to enhance exploration and exploitation of petroleum resources in Nigeria for the benefit of Nigerians, increase domestic gas supplies especially for power generation and industrial uses, fully deregulate and liberalise the downstream petroleum sector, and create efficient and effective regulatory agencies [53]. Some important features of this bill with respect to gas flaring are the provision that tied the granting of oil production licence with the production of an acceptable comprehensive programme for the utilisation or reinjection of the otherwise flared gas resource, and the requirement that provides for a penalty of flares equivalent to or more than the value of the gas flared, thus overcoming the weaknesses of the previous legislations in terms of gas flaring penalties. Furthermore, the bill contains comprehensive regulations for gas utilisation plans, gas flaring measurement, gas flaring reporting system, gas flaring prohibition, gas flaring offences and penalties, and circumstances upon which flaring can be permitted by the Minister.

The bill in section 277(1 and 2) prohibits the flaring of AG after a flare out date to be prescribed by the Minister unless where there was permission from the Minister in such instances as start-up, equipment failures, shut down, safety flaring or due to inability of gas customer to off-take-gas. Section 277(3) provides for a fine of an amount which shall not be less than the value of flared gas in the event of flares without the Minister's permission in such other circumstances mentioned above.

The bill mandated oil and gas operators to, within six months of the commencement of the Act, categorise all their flared gas resources and submit same together with the utilisation plan before the flare out date to the Upstream Petroleum Inspectorate, and the Inspectorate shall make these data available on its website for public domain. Section 278(a) of the bill further provides that no new licence for the production of oil and gas resources in the country shall be granted unless such an application for a licence is "accompanied by a comprehensive programme acceptable to the Minister for the utilization or reinjection of natural gas." Furthermore, section 279 (1 and 2) mandated all operators in the oil and gas industry to, within three months of the commencement of the bill, install metering equipment that would be specified by the Inspectorate on each of their facilities from which gas is flared or vented with a view to measuring the volumes of flared or vented gasses from the facilities.

Another important feature of the bill is the opportunity

the petroleum industry in Nigeria. Controversial areas of the bill include the proposed changes in the contracts with oil companies and changes in tax and royalty structures, the planned restructuring of the NNPC, the downstream sector deregulation, the perceived high level concentration of power in the hand of the Minister of Petroleum Resources, and the proposed mandatory contribution by oil companies of 10% of monthly net profits to the Petroleum Host Communities Fund.

³ The PIB has been an issue of controversy from different quarters in and outside

given to individual, group of individuals or community to lodge a documented report of gas flaring to the Inspectorate who shall then inspect, verify, and determine the cause(s), the date, and the volumes of the gas flared within forty-eight hours of the receipt of the report. The officer who verifies the report shall submit to the Inspectorate who shall then determine the authenticity of the report of flaring and either impose the appropriate penalties where necessary, issue a shut-down order, or combine the two. Section 280(6) of the bill provides that where a shut-down order is served on an operator for reckless flaring of gas, such an operator must comply with the order within forty-eight hours of the receipt of the order. The bill also considers it an offence for an oil company to fail to forward or falsify any report of flared gas with a penalty of three months imprisonment or an option of fine of not less than the value of fifty per cent of the volume of gas flared or vented.

The PIB is the kind of legislation that is needed if the legal framework is anything to go about in the crusade against gas flaring in Nigeria. At least, for the first time, penalties for gas flaring are directly related to the market value of the volume of the flared gas in question, with a combination of shut-down orders or imprisonments, where necessary. This will deter the oil companies from flaring and invest in utilisation and re-injection projects. However, these stiff provisions in the different sections of the bill make it to be so controversial as some of the stakeholders in the country's oil and gas industry consider it detrimental to their operations in the industry, thus explaining some of the reasons behind the lingering slow pace of the passage of the bill into a full fledged Act of the Nigerian state since 2012.

5.2. Gas Utilisation Projects

Apart from the laws and regulations, Nigeria, in collaboration with the oil companies, has embarked on a number of gas utilisation projects to develop and harness the AG that is being produced. Some of these projects are listed below.

5.2.1. The Nigerian Gas Company (NGC)

The Nigerian Gas Company (NGC), a subsidiary of the NNPC, supplies gas for power generation, either as a source of fuel or as feedstock to fertiliser, cement, glass, food and beverages and other industries operating in the country [54]. Established in 1988, the NGC also supplies gas to the West African region through integrated pipeline networks [55]. In addition to servicing the domestic and the West African gas demands, the NGC is responsible for ensuring the existence of an efficient gas industry in the country.

5.2.2. The West African Gas Pipeline (WAGP)

In 1982, the Economic Community of West African States (ECOWAS) together with the governments of Nigeria, Ghana, Benin, and Togo as well as some multi-national oil companies led by ChevronTexaco initiated the West African Gas Pipeline (WAGP) project as a regional program for the supply of natural gas across the West African sub region and

as a tool for regional integration [56]. WAGP is a pipeline project owned and managed by the West African Gas Pipeline Company (WAPCO), a private limited company headquartered in Accra, Ghana, with offices in Nigeria, Benin and Togo [57]. Chevron owns the largest share of the company with 36.9 per cent; followed by the NNPC, 24.9 per cent; Shell Overseas Holding Limited, 17.9 per cent; Takoradi Power Company Limited, 16.3 per cent; Societe Togolaise de Gaz, 2 per cent, and Societe BenGaz S.A., 2 per cent [58].

The WAGP stretches a distance of 678 km (421 mile), with a capacity to transport about 170mcf of natural gas per day for power generation and industrial uses, and covering Cotonou in Benin, Lome in Togo, and Tema and Takoradi (the final terminal of the pipeline) in Ghana, from onshore and offshore oil fields in Nigeria [59]. Eighty five per cent of the transported gas is used for power generation while the remaining fifteen per cent is used for industrial applications [60].

One of the projects the WAGP provides feedstock to is the West Africa Power Pool (WAPP) project, a project aimed at benefiting the entire Gulf of Guinea by providing reliable electricity at affordable prices, thereby reducing the vulnerability of the region to power shortages from drought-induced hydropower stations [61]. Apart from providing sustainable natural gas supply to these countries for industrial and domestic uses, the project was expected to reduce gas flaring by an approximate 78 million tons of carbon dioxide equivalent (CO₂e) [3] or a reduction of 25% of GHG emissions in Nigeria alone [61].

With the kind of cooperation seen in the implementation of the WAGP, sizeable amount of AG, which would otherwise be flared, is utilised and used by the people of the West African region for economic and social reasons thereby providing one of the most important global public goods⁴ of the 21st century affordably across the region.

5.2.3. The Nigerian Liquefied Natural Gas Project

The idea for the initiation of the Nigerian Liquefied Natural Gas (NLNG) project was unveiled in November 1985 with the signing of joint venture (JV) agreements between the NNPC on one hand and Shell Petroleum Development Company of Nigeria Limited (SPDC), Total Exploration Production Nigeria (TETPNG) and the Nigerian Agip Oil Company Limited (NAOC) on the other hand [28]. However, it took about a decade before the construction contract for the NLNG to be signed and awarded in November and December, 1995 respectively, and few months later (in February 1996), construction work for the proposed plant (made up of two LNG processing units (Trains 1 and 2), called the Base Project, the Gas Transmission System (GTS) and the Residential Area (RA)) started [62]. The

4 Christiansen and Haugland (2001 p. 34) define global public goods as "commodities, resources, services – and also systems of rules or policy regimes – with substantial cross-border externalities that are important for development and poverty reduction, and that can be produced in sufficient supply only through co-operation and collective action by developed and developing countries"

NLNG project, whose initial cost was estimated at USD3.8 billion, consists of a two-train liquefaction plant, a 218-km gas pipeline system, AG utilities, storage and loading facilities, and other infrastructure investments [4].

The NLNG project has the main objective of conveying associated and non-associated gas by pipelines to a liquefied plants on Bonny Island where they will be processed to remove water and carbon dioxide into liquefied natural gas (LNG) and natural gas liquids (NGLs) for eventual shipment to Europe and the US [28]. Train 2 of the plant was completed in August 1999 and began production of LNG in September 1999 [29]. The first overseas shipment of LNG commenced in October 1999 [28]. On February 27, 2000, train 1 subsequently came into being [62].

Following the success of the Base Project, construction for the second phase of the project, the Expansion Project, started in February 1999, few months before the completion of the Base Project [62]. The Expansion Project, a project aimed to develop Train 3, was completed in 2002 and put into operations in that same year [28]. The third developmental phase, called the NLNGPlus, for the construction of Trains 4 and 5, commenced in March 2002 [29]. Trains 4 and 5 began operations in November 2005 and February 2006 respectively [62]. The fourth developmental phase, the NLNG Six Project, made up of Train 6 and another condensate (Natural Gasoline) processing and Liquefied Petroleum Gas (LPG) storage and jelly facilities, commenced in 2004 and became operational in December 2007 [28].

With all the six trains in operation, NLNG Limited boasts of producing 22 million tons per annum (mtpa) of LNG and 5 mtpa of NGLs (LPG and Condensate (Natural Gasoline)) from 3.5 bscfd of natural gas intake [62]. With these milestones, the NLNG has over the years become one of the major suppliers (delivering about 7 per cent of global LNG supplies) of LNG to the European, the North American, and the Far East Markets, and has become a supplier of about 80 per cent of annual Liquefied Petroleum Gas (LPG) (otherwise called cooking gas) demands to the local markets since 2007 [28]. In the struggle to end gas flaring, NLNG has been able to convert about 133 bscm or 4.68 trillion cubic feet (tcf) of AG to export as LNG and NGLs from the period 1999 to 2013, thus reducing Nigeria's flaring profile [28].

Plans are underway to increase the NLNG's production capacity to 30 mtpa with the building of Train 7 [62]. If this is achieved, the NLNG will be able to mobilise and process additional AG that would otherwise be flared and will provide it the opportunity to expand its market penetration globally.

5.2.4. The Escravos Gas Project

The contracts for the construction of the Nigeria's first plant dedicated to the utilisation of AG, the Escravos Gas Project Phase 1 (EGP 1), expected to gather and process otherwise flared gas from Chevron/NNPC operated oil fields, were awarded on March 23, 1995 at a cumulative contract cost of US\$320 million [63]. EGP 1 was completed in 1997

with a capacity to produce over 8000 barrels of LPG, 145 mscf of dry gas, and 2000 barrels of condensate per day [64]. In that same year, the EGP 1 started operations with the lifting of 30,000 metric tons of LPG billed for Houston, United States [64]. Phase 2 of the project began operations in 2000 with a capacity to process about 200 mcf of natural gas that would otherwise be flared [65].

Furthermore, in furtherance of their efforts to eliminate gas flaring during oil production, the NNPC and Chevron in 2000 launched yet another initiative to build the Escravos Gas Project 3 (EGP3) and Escravos Gas-to-Liquid (EGTL⁵) project [66]. The GTL plant, which began operations in mid-2014, was designed to convert 325 mcf of natural gas into 33,000 barrels of liquids per day [67]. The GTL technology converts natural gas into a clean-burning diesel fuel, liquid petroleum gas and naphtha [67]. These fuels have no sulphur and no aromatics, suggesting that they have lower hydrocarbon, lower carbon monoxide, lower nitrogen oxide and lower particulate emissions than conventional fuels [68].

5.2.5. The OSO NGL Recovery Project

The OSO natural gas liquid (NGL) project is the second phase of the Oso Condensate project⁶ designed to handle the production of 100,000 barrels of condensate a day [69]. It is a JV project between ExxonMobil (51 per cent) and the NNPC (49 per cent) for the recovery of a total of 350 million barrels of NGL over its 25 years lifetime through a feed gas of some 17 mscmd (600 mscfd) from the OSO condensate field and other fields operated by Mobil [20]. The project involved the construction of offshore platform for the extraction of NGL and the injection of the processed gas into the Oso reservoir for improved NGL recovery system, thereby minimising flaring [70]. The project is located offshore at the Oso field and onshore at the Bonny River Terminal, and had its first cargo of NGLs lifted and exported out of the country in September 1998 [71]. Apart from reducing the flaring of AG, over the 25 years production period of the project, the government was expected to earn a net revenue of over US\$3.2 billion [44].

5.2.6. The Proposed Trans-Saharan Gas Pipeline

In 2009, the Nigerian NNPC and Algerian Sonatrach signed a memorandum of understanding for the construction of 2,500-mile (4401km) pipeline, the Trans-Saharan Gas Pipeline (TSGP), that would transport gas from the Nigeria's Niger Delta to Algeria's BeniSaf export terminal on the Mediterranean Sea through Niger Republic, for eventual supply to Europe from Spain [24]. When completed in 2018, the project will have an estimated annual capacity of 30billion cubic litres of natural gas [72]. Apart from mobilising Nigeria's gas resource that would otherwise be flared, the project is expected to strengthen the economic ties

5 Sasol and Chevron announced their intentions to create a global GTL company that will collect and process natural gas to liquids

6 The Oso project is the first project the World Bank has ever sponsored in the Nigerian upstream petroleum industry (Izeze 2013; Toledano and Archibong 2014).

between Africa and Europe as the latter struggles to diversify its source of energy (particularly gas) from the Russian Federation. However, security concerns along the entire route of the pipeline, and increasing cost have continued to delay the project.

In addition to the above, the following projects were also aimed at increasing the utilisation of gas and by extension reducing flaring in Nigeria [54]. The Oso 2Y2 Project is an NNPC/Mobil JV project aimed at making up additional gas available for the Oso NGL project. The Ekpe Gas Compression Project is another NNPC/Mobil JV project that gathers gas that was previously flared in the Ekpe oil field by lifting and re-injecting the gas during oil production for enhanced oil recovery. The Belema Gas Injection Project, on the other hand, is an NNPC/Shell JV project that has the objective of reducing the flaring of AG in five flow stations

by re-injecting some of the gas for gas lifting and some for use as fuel by local industries. Similarly, the Odigbo Node Gas Project is yet another NNPC/Shell JV project that gathers around 113mmscf/d of AG from six flow stations in the NNPC/Shell Eastern Nigeria Fields, and subsequently supplies around 92 mmscf/d to Aluminium Smelting Company of Nigeria (ALSCON) as feed gas and for gas lifting. The Odidi AGG Project, another NNPC/Shell JV project, gathers gas and injects same into the Escravos-to-Lagos Pipeline as part of the WAGP project that supplies gas to some West African nations. The Cawthorne Channel Gas Injection Project gathers the gas that would otherwise be flared in the field for re-injection and for supply to third party for LPG extraction. Table 5 contains some gas projects that are expected to be on stream in the years ahead.

Table 5. Planned natural gas projects in Nigeria.

Serial Number	Project name	Operator	Gas production (MMcf/d)*	Final investment decision?	Estimate start date
1	Sonam Field Development	Chevron	215	Yes	2017
2	Forcados/Yokri Integrated Project	Shell	65	Yes	2017
3	Southern Swamp Associated Gas	Shell	45	Yes	2017
4	Gbaran-Uble Phase two Project	Shell	800	Yes	2017
5	Bonga Southwest and Aparo	Shell	15	No	2020+
6	Bonga North	Shell	60	No	2020+
7	Bosi	ExxonMobil	260	No	2020+
8	Uge	ExxonMobil	20	No	2020+

*MMcf/d is million cubic feet per day

Source: Reference [24]

6. Other Policy Thrusts Directed at Conserving the Environment and Eliminating Flaring

6.1. The Nigeria's Agenda 21

The Nigeria's Agenda 21 is the country's statement that incorporates most of the requirements of the United Nations' Agenda 21 which contains the UN's sustainable development indicators that were launched at the UN Conference on Environment and Development held at Rio de Janeiro, Brazil, in 1992. It contains some set of policies and strategies for addressing the numerous environmental challenges facing Nigeria. The Agenda provided for the sustainable exploitation of petroleum resources as a means to eliminate gas flaring and preserve the environment. Specifically, the Agenda has the following (but not exhaustive) goals with respect to oil and gas exploitation in Nigeria [73].

- The development of all-round measures that prevent and mitigate the negative impacts of oil and gas exploitation;
- Ensure that environmental laws, regulations, and standards are strictly complied with by oil companies in their oil and gas development and production operations;
- Develop long term plans and long term investment strategies for the sustainable exploitation and sustainable development of the oil and gas sector;
- Provide local and international markets for the country's

gas resource;

- Stop the flaring of associated gas.

6.2. The National Policy on the Environment

The National Policy on the Environment (NPE) is the Nigeria's country-wide policy statement that ensures the sustainable development of the country through the proper management and utilisation of the environment. The NPE generally aims to, among other things, secure and conserve the environment (including land, air, and water) for the benefit of the present and future generations. According to the policy, the government was committed to inter alia ensure the sustainable exploitation of the oil and gas resources through [74]:

- Complete monitoring of air emissions and gaseous wastes (CO₂, NO_x, H₂S, CH₄, SO₂ etc) discharged at production platforms, refineries, petrochemical and gas processing facilities through continual air quality sampling as well as through daily visual checks for leakages around tanks, pumps, pipelines and transfer points;
- Promote conservation and restoration of natural formation pressure through elimination of gas flaring and the re-injection of produced associated gas and formation waters;
- Promote the complete utilisation of produced associated gas, reduce gas flaring and the production of greenhouse gasses;

- Prescribe minimum standards of environmental safety in all upstream and downstream oil sector facilities and maintain regular environmental audits of all existing oil and gas production facilities to ensure the adoption of environmentally safe practices as well as compliance with set standards.

6.3. The Nigerian Gas Master-Plan (NGMP)

The Nigerian government in 2007 launched the National Gas Master Plan (NGMP), a policy framework that seeks to encourage the domestic utilisation of, and the commercial exploitation and management of, Nigerian gas resources [75]. This policy framework is contained in the three point strategic focus of the NGMP namely: (i) gas-to-power project, (ii) gas based industrialisation, and (iii) gas export market [76]. It was envisaged under the NGMP that gas-to-power deliveries will trigger at least three times increase in electricity generation by 2015 and spurs the development of gas-based industries such as petrochemicals, fertilisers and methanol in the country, while positioning Nigeria as a high value exporter of gas resources to the world [27]. Part of the rationale behind the NGMP, which came into being on February 13 2008, was to stop the flaring of gas and strengthen the Nigerian economy [3].

7. Other Factors That May Aid the Abatement Effort

Apart from the legal and the regulatory frameworks, three other factors – standards, financial incentives and contractual rights and the structure of the downstream energy markets – could influence the economics of flared and vented gas [45]. National and international standards on gas flaring may be formed as a means to strengthen conventional legislations or regulations. Standards, which are usually developed by operators, governments, and non-governmental organisations, may be useful in setting improved flaring and venting targets, and standardising monitoring and reporting procedures [45]. At the national level in Nigeria, there is currently no single standard or guideline that deals specifically with issues related to gas flaring and venting measurement and reporting. The PIB, which is yet to be passed into law, provides that oil and gas companies must measure and report their flaring information using a measurement and reporting procedure to be prescribed by the regulators. At the international level, in May 2004, the World Bank-GGFR issued a standard on gas flaring reduction [77]. Also, in 2008, the GGFR and the World Bank jointly issued a guideline on gas flare and vent measurement [78] and in 2009, the GGFR issued yet another guidance on upstream flaring and venting policy and regulation [10].

The economic value of gas flaring and venting determines, to a large extent, the decision by the oil companies to either stop or continue flaring [45]. Theoretically, “the economics of associated gas dictate that operators will reduce flaring and venting until the marginal costs of gas utilization in a

field exceed the marginal benefits” [43]. Thus, oil companies may likely stop flaring and venting if the financial benefits of using the gas outweigh the cost of abatement. In practice, this is not usually the case as most oil producing countries as well as the oil companies consider gas abatement project a hindrance to increased oil production [45]. This may not be unconnected with how oil companies have traditionally considered the viability of AG in isolation while analysing the economic value of their oil production. However, recently, oil companies have begun to appreciate the importance of an integrated approach to oil fields development when assessing the viability of an oil field. The Nigerian government has successively imposed different tax regimes specifically targeted at gas flaring. However, as seen above, these taxes have not been effective enough to stop gas flaring because they tend to be extremely low in relation to the cost of abatement.

The rights and obligations of the companies and the host governments governing the usage and the marketing of AG influence the decision to either use or flare and vent AG [45]. In Nigeria, the Associated Gas Re-Injection Act 1979 as amended empowered oil companies operating in the country to re-inject AG produced during oil production and to utilise the gas in order to optimise oil production. However, although the structure of the downstream energy market and in particular the distribution networks of natural gas in the country have not been fully developed, the government has almost liberalised the downstream gas market, a move seen to entice the companies reduce flaring and explore the opportunities of selling the produced gas in the domestic market.

8. Measurement and Reporting of Flared and Vented Gas

An important aspect of the regulatory framework is the existence of accurate measurement and reporting system for gas flared and vented [45]. Effective measurement and reporting system provides regulators with accurate information and data about gas flaring and venting volumes which could be used to verify the level of compliance of the operators with flaring and venting targets [45]. Effective measurement and reporting system will also provide the operators with adequate data on flare/vent volumes which will aid in designing and evaluating strategies for gas utilisation [79]. However, it is important to note that accurate flare measurement is extremely difficult owing to the complexities of flaring and the unfriendly environment upon which flaring and venting occur [6; 11]. Each oil field contains AG and the proportion of gas-to-oil (Gas Oil Ratio or GOR) varies significantly between oil fields, with some increasing with increased oil production and some decreasing with time or with increased oil production [80]. This difficulty in measuring accurately the quantity of gas flared posed a serious challenge in addressing the environmental aspects of flaring and venting [80].

While developed nations have well-defined and sophisticated measurement and reporting systems, developing nations lack the necessary expertise and the financial muscle to accurately monitor the volumes of gas flared and vented, thus making them rely on the information provided by the operators, often with the possibility of manipulation of the figures submitted [45]. This makes it difficult for the regulators to verify the level of compliance of the operators with established targets for flaring abatement, which the gas flaring measurement and reporting system aims to provide. In Nigeria for example, only recently in the controversial PIB, a provision is made for oil and gas companies to mandatorily install metering devices on their production platforms with a view to measuring and reporting of the amount of gas flared from the facilities.

Two methods for measuring the volumes of flared and vented gas are (i) the gas flaring and venting metering, and (ii) the gas flaring and venting volumes estimation, otherwise called the indirect measurement system [11, 45]. There are different types of meters available for flare measurement; some of these are flare gas ultrasonic meters (USMs), thermal mass probes and optical correlation flowcharts, insertion turbines meters, averaging pilot tubes, etcetera [3; 11]. Two problems observed with the gas flaring and venting metering are the cost and the practicability of the installation of the meters at production sites due to the fact that each meter needs to be installed at every production well [45]. On the other hand, providing estimates of the volumes of flared and vented gas are usually based on engineering calculations, and for these estimates to be sufficiently relevant, they must pass through some estimate procedures and software packages that have been widely tested and approved [45]. Two major methods used under the indirect measurement techniques are the by-difference calculation method and the inventory calculation method – gas flowrate [11].

9. Recommendations

- (i) Government needs to reform and develop the gas market including a complete overhaul and development of gas infrastructure that would enable the exportation and the supply of gas to international and more importantly domestic markets. As studies suggest, abating gas flaring may remain elusive without a viable domestic gas market [25].
- (ii) In this era where it is extremely impossible for the government to provide all that is needed by the public, it is imperative for the government to provide the enabling environment for the involvement of the private sector in the areas of gas infrastructural development. This will provide the much needed resources and technology to fully develop the gas industry.
- (iii) The various legal and regulatory frameworks related to oil and gas operations in the country need to be strengthened and enforced. The controversies surrounding the passage of the PIB need to be addressed. The various provisions of the laws that

specifically or impliedly deal with gas flare-out should be implemented and the various agencies that oversee the activities of the oil companies should be strengthened to perform their functions effectively.

- (iv) There should be accurate system for measuring and reporting of volumes of gas flared and vented in the country so that accurate information and data about gas flared and vented by the operators are documented. This will provide the regulators with the necessary impetus to carry out their oversight functions. As pointed by reference [45], regulatory provisions could only be effective if there was accurate method for the measurement and reporting of the volumes of gas flared and vented.
- (v) It is estimated that around 93 million people in Nigeria (i.e., around 45% of the population) have no access to electricity [81], and only around 12% of the population's energy consumption is on natural gas [24]. With these estimates, government and private institutions in the energy sector should intensify their efforts at increasing the number of gas fired plants across the country in the gas-to-power programmes that have the main objective of utilising AG to generate and transmit electricity in the country and across the West African sub region. This will not only reduce flaring, it will also improve the standard of living of millions of Nigerians and West Africans who would find it easier to establish businesses and other productive ventures as a result of increased access to electricity. It will also position the country among the league-of-nations that successfully implemented policies that reduce global warming through gas flaring reduction.
- (vi) Adequate time and adequate gas infrastructure should be provided for the implementation of the various gas projects, policies and regulations. The 1979 Associated Gas Re-injection Act could not be enforced due to unrealistic time frame for its implementation and inadequate gas infrastructures to gather and treat the gas.
- (vii) Security in the Niger Delta should be improved. Many analysts blame the persistent insecurity in the Delta and lack of partner funding from the government as two of the biggest impediments to the implementation of gas utilisation projects.
- (viii) Operators in the oil and gas industry should always adopt and be encouraged to adopt best practices in oil production. They should put in place measures that will ensure that AG is utilised or re-injected into oil fields. More importantly, the operators should be encouraged to live up to their corporate social and environmental responsibilities. Government should provide the necessary environment that encourages operators in the oil and gas industry to utilise gas resources.
- (ix) At the international scale, there should be established generally acceptable principle or international best practice for regulating gas flaring and venting.

10. Conclusion and Policy Implications

Gas flaring and venting have become serious global challenges facing mankind and the environment. As Nigeria celebrates and enjoys the bountiful benefits arising from the discovery of oil over the past seven decades, it on the other hand battles with the numerous challenges occasioned by the exploitation of oil. Natural formation in the country's Niger Delta have been degraded, human health have been subjected to various health related issues, government has been losing sizeable amount of revenue, people have been denied access to one of the most important global public good – electricity, GHGs have been emitted through the release of the flared and vented gas into the atmosphere thereby increasing the global warming and climate change phenomenon. Farming and fishing which have been the sources of livelihood to the local populace in the Niger Delta have been put at stake due to flaring and other oil contaminations.

The Nigerian government has over the years promulgated and proposed various laws and regulations to tackle the practice of flaring. It has also, in collaboration with the oil companies, implemented, and proposed for implementation of, various gas utilisation projects. Although these projects have helped in reducing the country's flaring profile to around 12% at the end of 2014 from about 50% in the year 2000, the country still ranks the 5th flaring nation in the world and the number one in Africa.

It is believed that economic and fiscal considerations on the part of the oil companies and lack of strict regulatory enforcement of gas flaring reduction regulations on the part of the government, couple with ageing/absence of infrastructure to develop and utilise the gas resource, poor access to local and international energy markets, insecurity in the Niger Delta, and lack of political will to see to the end of gas flaring are the main reasons for continued flaring in Nigeria. The government therefore needs to strengthen its legal and regulatory frameworks related to gas flaring and venting. Gas flaring penalties should be realistic and incentives should be granted for flaring reduction projects. In addition, the various gas utilisation projects particularly gas-to-power and gas-to-liquid projects (both proposed and on-going) should be speedily implemented. With these, it is believed that Nigeria will eliminate the emissions of carbon dioxide into the atmosphere in the near future.

In terms of policy implications, this study has highlighted the various issues related to gas flaring in Nigeria and the efforts of the government, the private sector and the oil companies in abating the practice. This will help policy makers in the country and beyond to strategise and come up with various programs for gas utilisation, in addition to the existing ones. These programs will help in addressing the various challenges facing the country's gas flaring abatement efforts in particular and the country's oil and gas industry in general. Through this study, policy makers are informed of the need to reform and develop the gas industry including the development of adequate gas infrastructure that would support effective gas gathering, marketing and distribution.

In terms of legislation, the study has highlighted some of the strengths and weaknesses of the various laws, regulations and provisions related to oil and gas operations and gas flaring abatements. The implications of this is that policy makers are informed of the needed actions to be in place for these laws to continue to be relevant in the fight against gas flaring. In this era when the global oil prices are nose-diving, coupled with the abundant gas reserves the country is blessed with, it is important that policy makers in the country are informed of the need to develop the gas industry by eliminating flaring and channelling the otherwise flared gas to marketing and productive operations so that the economic (in terms of public revenues) and social (in terms of public health and well-being) losses are stopped.

Being the cleanest of all the fossil fuels, natural gas, if properly utilised, provides an efficient energy source that is free from environmental degradation. It is therefore imperative for Nigeria to decarbonise its oil and gas industry so that it can tap into the numerous opportunities provided by the gas resource before it become unattractive. This is necessary considering the fact that global oil and natural gas demands are expected to decline with more interest shifted towards the application of renewable sources of energy.

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