



World Scientific News

An International Scientific Journal

WSN 147 (2020) 76-87

EISSN 2392-2192

Re-evaluating the Problems of Gas Flaring in the Nigerian Petroleum Industry

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ABSTRACT

Though Nigeria possesses one of the largest natural gas reserves in the world, it is unfortunate that we are still one of the major gas flaring nations in the world. Besides the grave environmental consequences of gas flaring, it is still an unwise practice considering the impending global energy crisis within the next 50 years. In this paper, the potentials of natural gas as an untapped reserve of wealth and socio-economic power is discussed. The potential of the Nigerian gas sub-sector can be fully harnessed if the mechanisms of commercialisation in line with the gas master plan is put in motion. The completion of a comprehensive gas pipeline network and the promotion of direct foreign investment is a good means of achieving the commercialisation initiative. About \$3.5bn worth of investments is coming into the country to achieve the gas flare commercialisation targets by 2020. The commercialisation programme seeks to provide a framework to eliminate gas flaring which when fully implemented would actualise potential for immense wealth laden in Nation's gas reserves.

Keywords: Natural gas, Gas flaring, Gas Reserves, Pollution, Commercialisation

1. INTRODUCTION

Nigeria is the 10th largest oil producing nation in the world and the third largest in Africa [1]. Oil revenues account for about 90% of the country's foreign exchange earnings and the government has an average of 60% ownership interest in Joint Ventures (JVs) with International oil companies (IOCs) [2]. These JVs account for the majority of our oil and gas production. Natural gas in Nigeria has not been exploited as much as petroleum crude [3]. Though there are some draw backs in exploration (especially issues having to do with its volume) in comparison to other fuels, natural gas still possesses great potentials due to its large reserves [4]. The major component of natural gas is methane. Nigerian natural gas is composed of roughly 90% methane, 1.5 – 2.0% carbon dioxide, 3.9 – 5.3% ethane, 1.2 – 3.4% propane, 1.4 – 2.4% heavier hydrocarbons and trace amount of sulphur [5]. Natural gas burns cleaner than other fossil fuels and it has a greater heat of combustion per CO₂ formed in contrast to other fossil fuels [3]. With an estimated natural gas reserve of about 180 trillion cubic feet (See **Figure 1**), Nigeria is the largest natural gas reserve holder in Africa, and one of the largest in the world [3]. About 52% of the Nigerian total proven gas reserve is associated natural gas [6] trapped along with the crude oil in the reservoir.

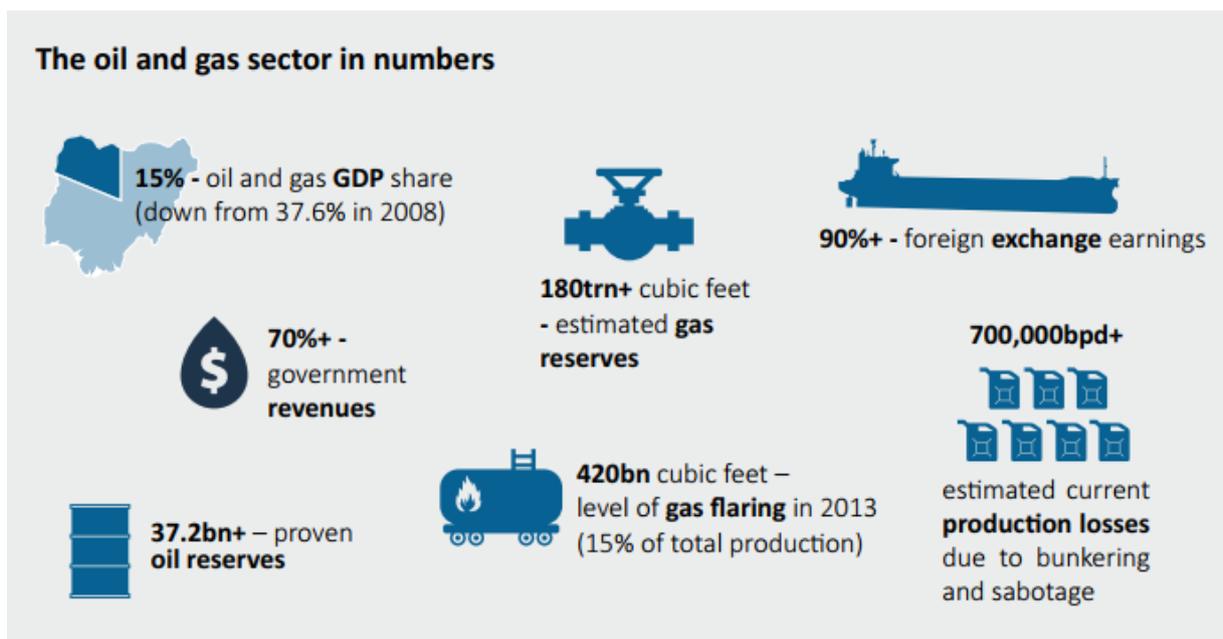


Figure 1. The oil and gas sector in numbers

Gas flaring is the combustion of the natural gas [7]. Globally, about 130 billion cubic meters of gas are flared annually [8]. In the Niger delta region of Nigeria, flaring and venting associated with petroleum exploration and production has continued to generate complex consequences in terms of energy, natural environment, human health, socio-economic environment and sustainable development over the past fifty years [9]. The aim of this paper is to re-evaluate the problems of Nigeria gas flaring and discuss the current government drive to harness the potentials in the vast gas reserves. In this mini-review, the negative effects of flaring

and positive potentials of natural gas is evaluated in light of the Nigerian socio-economic terrain. The gas commercialisation initiative and the Nigerian gas masterplan are discussed with the associated investment and opportunities it could provide.

2. CURRENT SITUATION OF GAS FLARING IN NIGERIA

The flaring of natural gas in Nigeria is due to the lack of infrastructure at many oil fields to harness the associated natural gas produced during the production of petroleum crude. Also, some of the flaring activities takes place in remote offshore petroleum production facilities which does not have any infrastructure for transporting the associated natural gas. Records of the volume of gas flared are currently unreliable as most flaring activities takes place in remote locations [10]. Some studies have attempted quantifying the flared volumes using a sum of light index values obtained from satellite images of the flames from the flaring sites [10]. As shown in **Figure 2**, there has been a 91% increase in the volume of natural gas produced and a 38% decrease in the volume flared between 2001 and 2016. The government has been putting efforts (in the form of regulations and legislations) to ensure the oil companies cut on gas flaring. Progress has been made, but quite slowly.

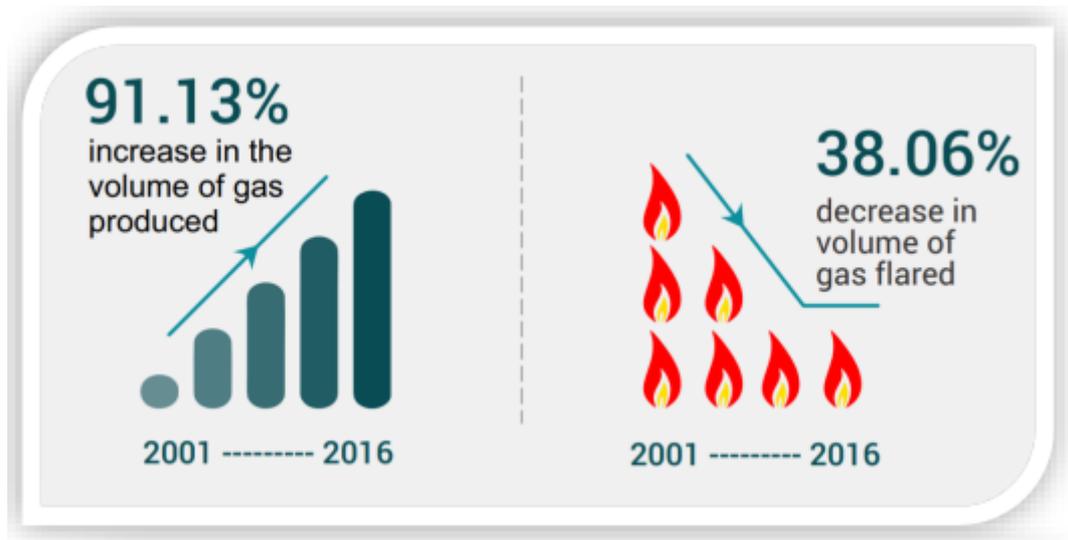


Figure 2. Trends in gas production and flaring in Nigeria

Rufai *et. al* [11] pinpointed two main reasons why gas flaring can occur. The first being an emergency flaring for safety reasons, which is done impromptu to ease pressure on the production plants. The second being process flaring which is due to unwanted gas after production. There are 3 types of flares; air-assisted, steam-assisted and pressure assisted flare [8]. Flares are assisted so as to enhance the turbulence and mixing of the fuel gas and air in the combustion zone thereby suppress smoking of the resulting flame [8]. In fact, in western Europe 99% of associated gas is used or re-injected into the ground. However, Gas flaring in Nigeria is still a common practice. The amount of flared gas in Nigeria can actually meet our energy

demand and that of other neighbouring countries [6]. Ahmed *et. al* [3] proposed several other historical, geographic and economic factors that have led to the issue of gas flaring in Nigeria.

They include the following

- i. Only a few of the reservoirs are suitable for gas re-injection and storage.
- ii. The large costs involved in developing and installing a pipeline network for natural gas.
- iii. A limited local, regional and international natural gas market.
- iv. The difficult terrain of the Niger delta which is a hindrance to the gas gathering process.

3. PROBLEMS ASSOCIATED WITH GAS FLARING

Gas flaring has been ongoing in the Niger delta since oil production started in the 1960s [7]. Nigeria is one of the top countries in the world in terms of flaring of natural gas as part of its petroleum production (second to only Russia). Gas flaring is discouraged by the international community because it has a significantly negative impact on the environment. However, due to inadequate pipeline infrastructure and gas processing facilities, this is still a popular practice in Nigeria. In this sub-section, we examine the problems associated with gas flaring with emphasis on the Nigerian situation.

3. 1. Air pollution

The flaring of natural gas leads to the release of toxic green-house gases (as combustion products) into the environment [12]. These gases include CO₂, CO, SO₂, NO_x, Polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and particulate matter (PM) in the form of black carbon [8]. The extent and nature of toxic pollutants released depends on the design of the flare system, velocity of the gas stream and the composition of the gas [5]. Anomohanran [13] conducted an investigative study on the extent of green-house emissions from gas-flaring activities in Nigeria.

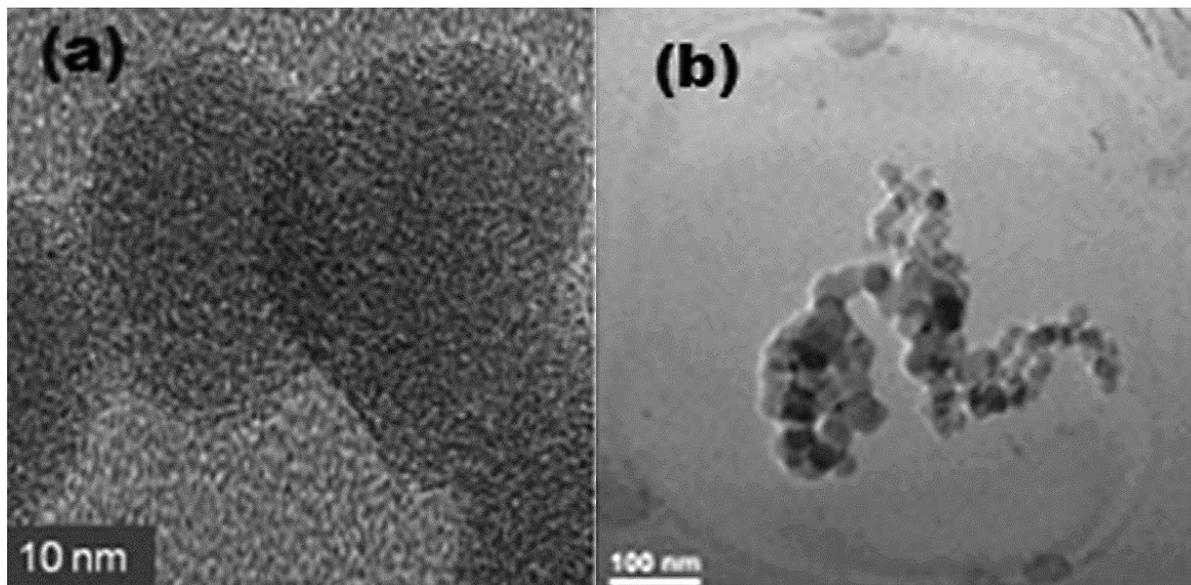


Figure 3. TEM micrograph of soot (a) microstructure (b) agglomerates [8, 15]

The study revealed that the amount of gas flared in Nigeria declined at a yearly rate of 10.5%. However, the emissions from flaring far exceeds those from the use of the other petroleum products combined. The emissions of black carbon particulates into the air have been identified as a major challenge due to the excessively large amount of black soot produced from the combustion process [14]. Even seeming non-soothing flames still produce as significant amount of soot as the particle size lies between 10 to 200 nm [8]. **Figure 3** shows a transmission electron microscope (TEM) image of soot revealing the microstructure and agglomerates. Besides the CO₂ released from the combustion reaction, the methane itself might escape the combustion zone and be released into the atmosphere. Methane has a far greater global warming potential than CO₂.

3. 2. Waste of valuable energy resource

There are over 100 flaring sites of associated natural gas in Nigeria [5] leading to a significant amount of wastage of valuable resource. Nigeria lose an estimated revenue of 2.5 billion dollars to gas flaring annually (see **Figure 4**). This is simply wastage. In the long run the decision to flare gas is a bad one as global fossil fuel reserves are in continual decline. As shown from **Figure 4**, Nigeria could lose up to 9 Trillion Naira cumulatively within the next 10 years at the current rate. This is a key reason why the government is putting into motion the gas master plan and the commercialisation initiative to see how these resources can be harnessed.

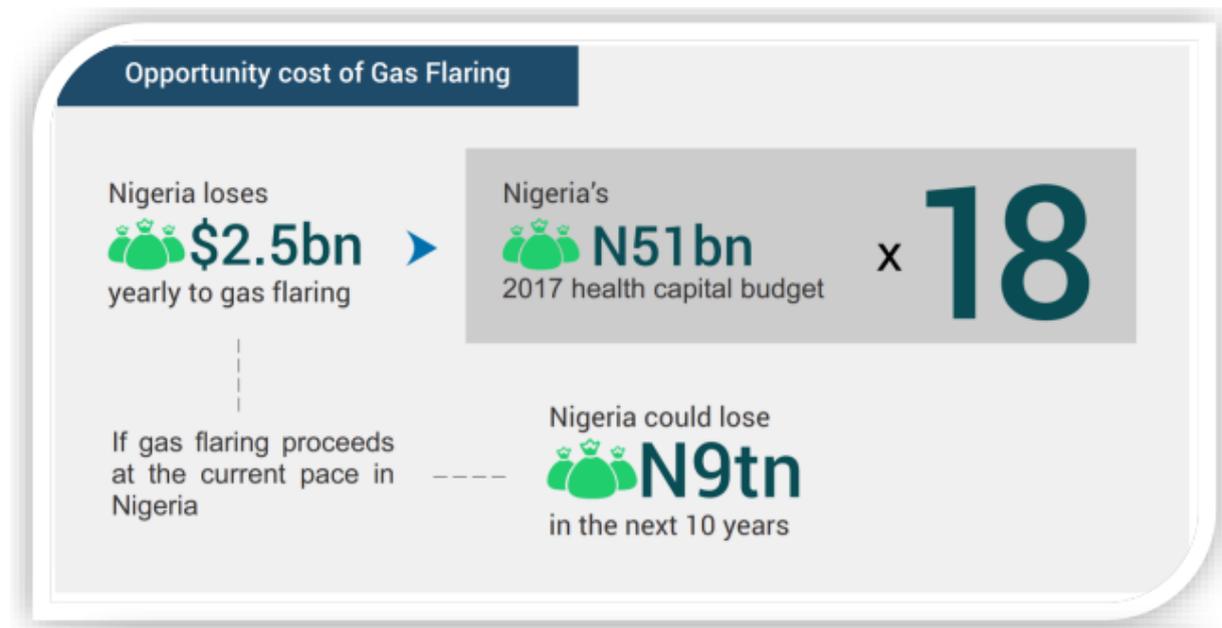


Figure 4. Opportunity cost of gas flaring

3. 3. Soil and Groundwater pollution

The flare systems release a lot of pollutants which include toluene, ethyl benzene, benzene, xylenes, aliphatic and polycyclic aromatic hydrocarbons (PAHs) [5]. Some of these

compounds are mutagens and carcinogens that can bio-accumulate in organic tissues due to their electrochemical stability and lipophilic character. Soil temperature, pH and moisture content has been shown to be negatively affected by gas flaring too [16]. Studies have revealed that there are poor water qualities in several parts of the Niger delta, and these are due to not only oil spills, but gas flaring too [17]. The physicochemical characterisation of such ground waters shows that it contains higher concentrations of harmful metals such as selenium, cadmium, barium, cyanide, chromium, iron, manganese and copper [17]. There is also an increased conductivity, colour change as well as presence of taste in the water from gas flaring environment, when compared to areas having minimal gas flaring activities. The presence of pollutants such as oil, grease, hydrocarbons and heavy metals have been established in surface and groundwater in some cities in Nigeria such as Ibadan [18], Warri [19, 20], Port Harcourt [21, 22], Oghara [23], Ibeno [24], Benin [25], Bight of Bonny [26], Ogoni [27] and a host of other southern cities.

3. 4. Effects on Humans

The flaring of gas also has negative effects on humans [7] as it is closely associated to some respiratory diseases. Proximity is a key factor as an estimated 2 million people in the Niger delta live within 4 kilometres of a gas flare site (see **Figure 5**).

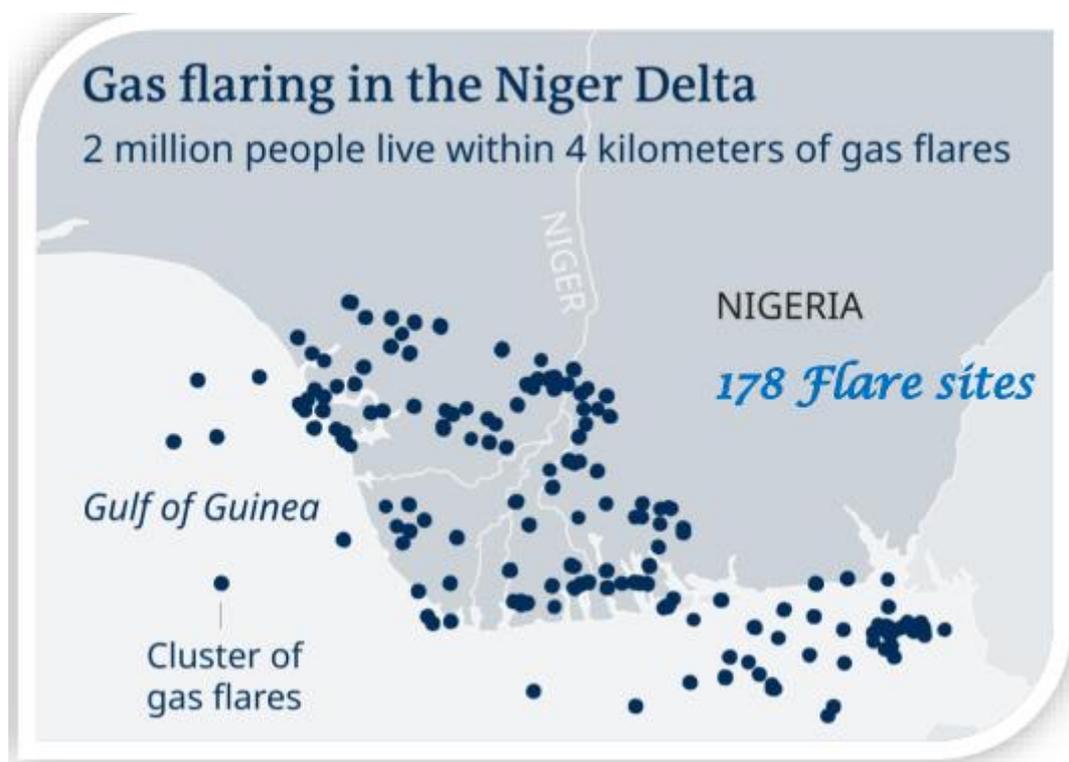


Figure 5. Closeness of human to gas flares in the Niger Delta

The flaring of gas can lead to the formation of a micro-climate within several kilometres of the flaring point [5]. In areas around flare systems, there is a greater frequency of diseases

such as asthma, bronchitis, breathing difficulty, cough, eye irritation and skin irritation [5]. The solubilisation of oxides in the air into incoming precipitation to form poisonous acid rain (which is more intense around gas flaring sites) can lead to pollution of water sources which in turn affects the health of the natives in these flaring areas. In general, the air, soil and water (key parts of the ecosystems) are polluted which inadvertently bio-magnifies into the system of the locals.

3. 5. Other effects

The flaring of natural gas has been shown to have adverse effect on the crops cultivated in areas around the site of flaring. These manifest in the form of deformations, decreased dimensions of leaf length and width [28]. The micro-climate formed around flaring systems can lead to a negative impact on the plants and even on aquatic animals too [5]. The toxic gases released into the environment also have numerous other secondary negative impacts that do not appear under any of the above mentioned categories. A good example is acid rain which is formed from the sulphur and nitrogen oxides present in the air [12]. Studies have shown that noise pollution is also of concern in areas of gas flaring [16].

4. EXPLOITING THE NATURAL GAS RESERVE

The utilisation of natural gas (instead of flaring) has been acknowledged by the Nigerian government as an important means of diversifying the nation's revenue base. In order to reduce the huge wastage of valuable resources, the government is currently vigorously pursuing a number of ventures and avenues associated with the harnessing of natural gas. Elvidge *et. al* [10] proposed some mechanisms for the reduction of natural gas flaring (though not all can be implemented in Nigeria) due to infrastructural and economic constraints.

- i. Increased utilisation
- ii. Decreased oil production
- iii. Increased reinjection of gas
- iv. Commercialisation of gas for industrial and domestic purposes.

4. 1. The Nigerian gas master plan

The Nigerian gas master plan was put in place over 10 years ago to stimulate the country's economic growth through the development of the natural gas sub-sector (a sub-sector of the petroleum industry). The key components of the gas master plan are: the domestic gas supply obligation, the gas pricing framework and the all-important gas infrastructure blueprint. The plan was put forward with some key objectives [29]:

- i. To maximise and increase the positive effect of natural gas on economic growth and development via its use for electric power generation.
- ii. The scaling up of domestic LPG usage and setting-up of public transportation based on compressed natural gas. It also involves the stimulation of wide-ranging industrial development using natural gas products.
- iii. To optimise the nation's share and competitiveness in high value export markets
- iv. To apply ecological principles of gas resource management to ensure a sustainable development approach.

The major challenge of the gas master plan is supply. The unstable and insufficient supply of natural gas to the power plants in the country have discouraged the major players in the power sector from putting into motion the plans for expansion of power production capacity [29]. However, this is currently being solved by the government via the construction of several major gas pipelines in the country.

Once the gas pipelines are in place, then there will be adequate supply of gas to local power stations. Utilisation of natural gas to generate electricity will go a long way to ameliorate the current power issue bedevilling the country at the current time.

4. 2. The gas commercialisation initiative

Different commercialisation avenues are being explored by the government to harness the potentials of Nigeria’s large gas reserves. The Nigerian gas company (NGC) a subsidiary of the Nigerian National Petroleum Co-operation (NNPC) currently supplies gas for power generation to cement and fertilizer plants, glass, food and beverages, and manufacturing industries [3]. **Figure 6** shows the amount of gas utilisation by the domestic industries. The NNPC alongside its joint venture partners are also undertaking several export oriented gas utilisation projects to foster the commercialisation initiative. Just over half the gas export is to Asia (see **Figure 7**) and efforts are being made to diversify the export destinations. The current utilisation of Nigerian natural gas is fully in the domain of power generation and gas exports. However, there are several other ways in which natural gas is being utilised and these includes: gas-to-Liquid technologies [30], gas-to-methanol, gas-to-hydrates [31], steam reforming [32] among others.

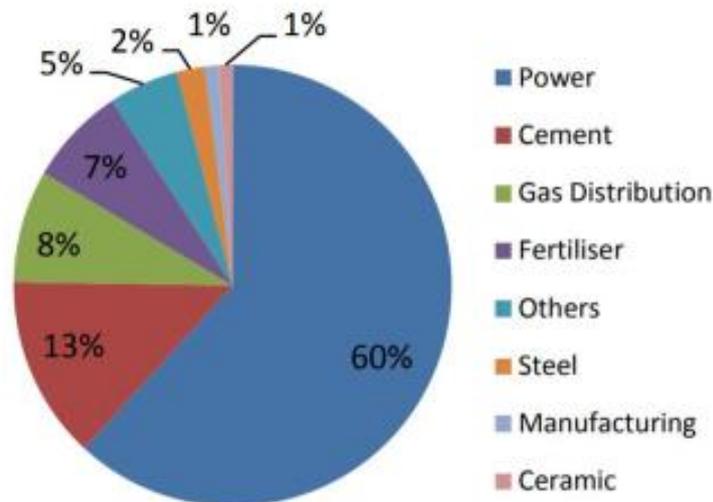


Figure 6. Domestic gas utilisation (2015).

About \$3.5bn worth of investments is coming into the country to achieve the gas flare commercialisation targets by 2020. The gas commercialisation initiative is quite favourable because when in full swing, the profitability would be immense. The potential of a very large domestic market is there for the taking as Nigeria is one of the most populated nations in the world and one of the largest economies in Africa.

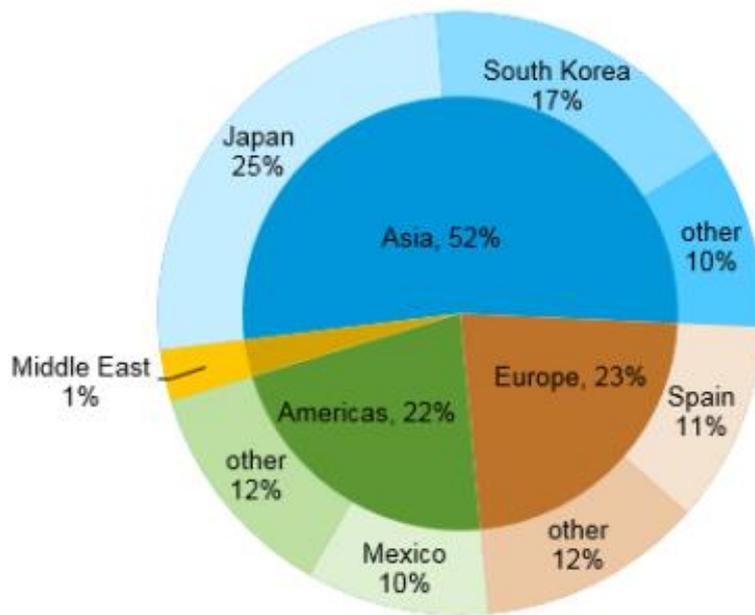


Figure 7. Nigeria's Export of LNG (2014)

Another potential is the access to the Economic Community of West African States (ECOWAS) market. Also, once more entrepreneurs venture into the gas terrain, the commercialisation initiative will be in full pace. Most government policies in the oil and gas sector has interestingly being in this regard as more and more incentives are being put in place for investors to venture into the sub-sector. Several policies are also being put in place to reduce and possibly terminate the undue wastage of a valuable natural resource. This will result in much more positive energy and environmental implications for the country.

5. CONCLUSIONS

In this mini-review, the negative effects of flaring and positive potentials of natural gas is evaluated in light of the Nigerian socio-economic terrain. Upon a cursory evaluation of the current situation of gas flaring in Nigeria, the associated problems were discussed and these includes air pollution, waste of valuable natural resource, soil and groundwater pollution and an overall negative effect on humans. The potential of the Nigerian gas sub-sector can be fully harnessed if the mechanisms of commercialisation in line with the gas master plan is put in motion. There is a great potential for wealth and profitability if the natural gas reserves in Nigeria is properly harnessed. The completion of a comprehensive gas pipeline network and the promotion of direct foreign investment is a good means of achieving the commercialisation initiative. Rufai *et. al* [11] put forward some very excellent recommendations on how the natural gas reserves in Nigeria can be harnessed.

Amongst them includes:

- i. For the government to promote direct foreign investment in the gas subsector.

- ii. The government can explore the possibility of exporting the natural gas to other more industrialised nations to increase foreign exchange earnings.
- iii. The encouragement of domestic consumption for utility and industrial purposes is another way out.

The potential of a natural gas is quite great as there is a very large domestic market. The population of the country couples with its relatively large economy is the reason for this. Another potential is the access to the Economic Community of West African States (ECOWAS) market. Most government policies in the sub-sector has been focused toward making it juicier to potential investors. In summary the gas commercialisation programme seeks to provide a framework to eliminate gas flaring through technically and commercially sustainable gas utilisation projects developed by competent third-party investors. If fully implemented the potential for immense wealth and power would be achieved.

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