



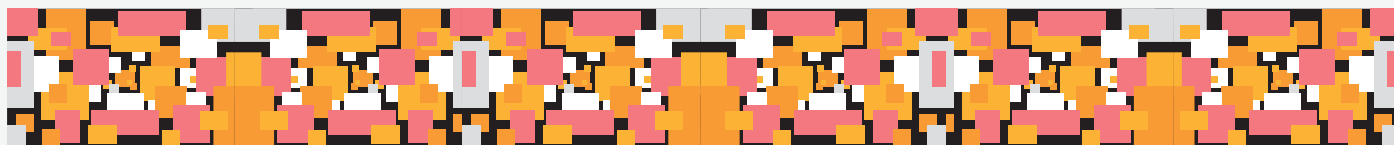
Assessing the Impact of Gas Flaring on the Nigerian Economy





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This publication is the first of a three-part series on the Nigerian Gas sector. The series aims to highlight the industry issues and challenges, as well as assess the opportunities across the value-chain, in addition to providing an outlook for the sector.

In the first part, we assess the impact of gas flaring on the Nigerian economy by estimating in monetary terms the economic and health effects of gas flaring, as well as the revenue potential lost to flaring.

In the second part, we take a more in-depth look at the challenges across the entire value-chain and assess the potentials that exist in each segment of the sector.

In the third part, we explore opportunities for private investment in the sector.

Executive Summary

Nigeria has the largest proven gas reserves in Africa and the 9th largest in the world (as at 2018) with 5,675 billion cubic metres (200.41 trillion cubic feet) of natural gas, while the country's proven oil reserves is 36,972 million barrels (207.6 billion cubic feet) natural gas equivalent. This implies that Nigeria's gas reserves are over 900 times the country's total oil reserves. In addition, Nigeria accounts for 2.7% of the global proven reserves of gas. (OPEC statistical bulletin, 2018)

In terms of production, Nigeria produced 1.7 trillion cubic feet (49.2 billion cubic metres) of natural gas (excludes gas flared or recycled) in 2018. Daily gas production remains low, despite the large proven and unproven reserves the country holds.

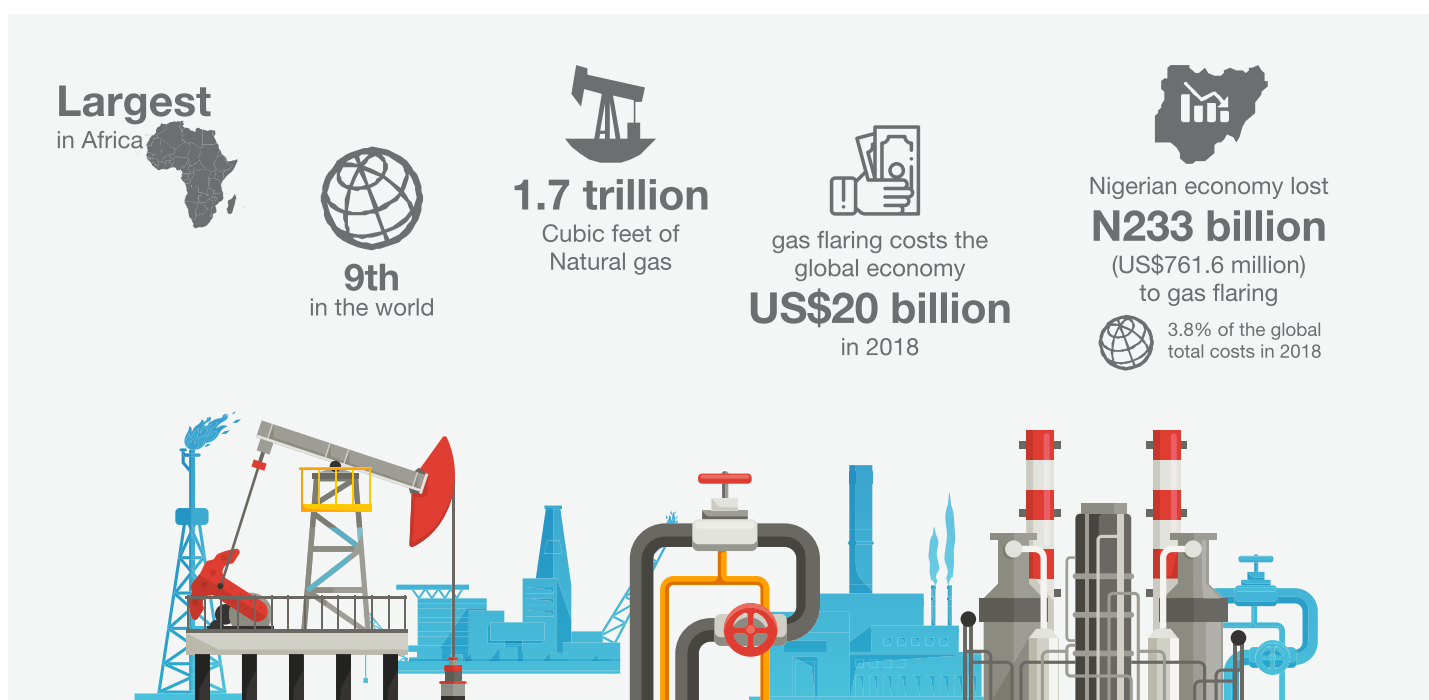
The National Gas Policy and the Nigerian Gas Flare Commercialization Programme (NGFCP) are some of the frameworks through which the government seeks to deepen and accelerate the growth and development of the gas sector, as well as reduce gas flaring, reduce imports and drive domestic consumption of gas through the development of gas-allied projects (such as electricity) in the country.

According to the World Bank, gas flaring costs the global economy US\$20 billion in 2018. In Nigeria, PwC estimates that Nigerian economy lost N233 billion (US\$761.6 million)¹ to gas flaring, which translates to 3.8% of the global total costs in 2018.

Furthermore, the environmental cost of gas flaring amounts to N28.8 billion (US\$94 million) annually, according to the National Environmental, Economic and Development Study (NEEDS) for Climate Change in Nigeria.

The percentage of gas flared in Nigeria has been reducing since 2002 and stood at 10% in 2018, in terms of volume of gas flared, the country still ranks in the top 10 gas-flaring countries in the world, with 7.4 billion cubic feet in 2018 (see graph 1.2 and 2.0). Total gas flared in Nigeria accounted for 6.9% of the top 10 gas-flaring countries in 2018.

The objective of this paper is to examine the issues and challenges; estimate the costs; as well as provide recommendations to reducing the gas flaring in Nigeria.



1. This conversion was done using an exchange rate of N305.9/\$1 based on a simple average of the official exchange rate in 2018



Introduction

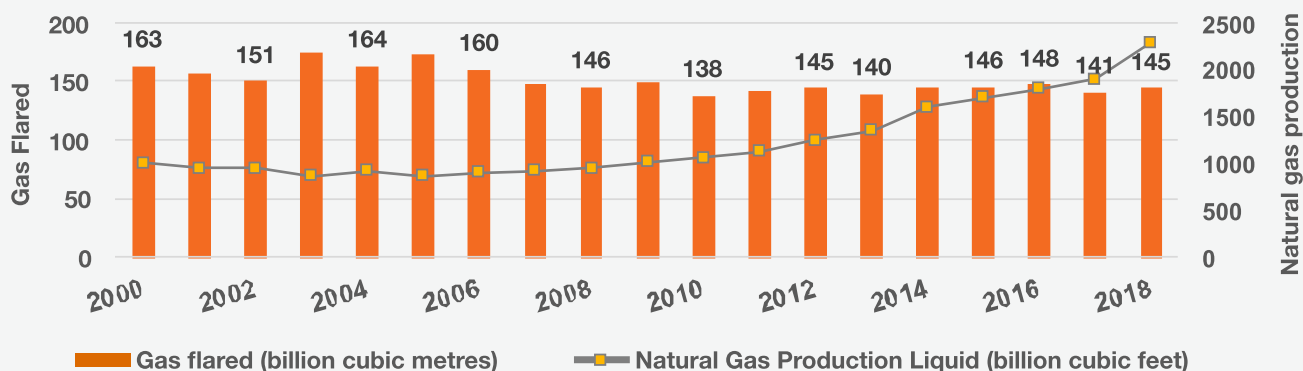
Gas flaring is commonplace during production or industrial activities on oil rigs, refineries, chemical and coal plants. In the process of flaring, excess amounts of carbon dioxide and methane are released into the atmosphere, resulting in depletion of the ozone layer, acid rain and global warming.

In the petroleum industry, gas flaring represents the loss of raw natural gas when associated gas is extracted. This loss may result from inadequate gas extraction, processing and transportation infrastructure. Some oil and gas companies prefer to flare gas as it prevents over-pressuring of industrial plant equipment. Gas is flared through a flare stack, a gas combustion device used in refineries, chemical plants and gas processing plants.

The World Bank's Global Gas Flaring Reduction Partnership (GGFRP) estimated that the volume of gas flared rose by about 3% between 2017 and 2018 to 145 billion cubic meters (bcm). The rise in global gas flared was driven by the increased production of shale oil in the United States. In the United States, liquid natural gas production increased by 20% from 1.9 trillion cubic feet (tcf) to 2.3 trillion cubic feet, while gas flared rose by only 2.8% from 141 tcf to 145 tcf.

Furthermore, from the chart below, there are periods when rising natural gas production did not lead to an increase in volume of gas flared. Examining the historical trends in the chart below, it appears that gas production is not the sole determinant of gas flaring globally. Country-specific regulations have impacted gas flaring more than the volume of gas production.

Graph 1.0 - Gas Flared and Natural Gas Production



Source: International Energy Agency

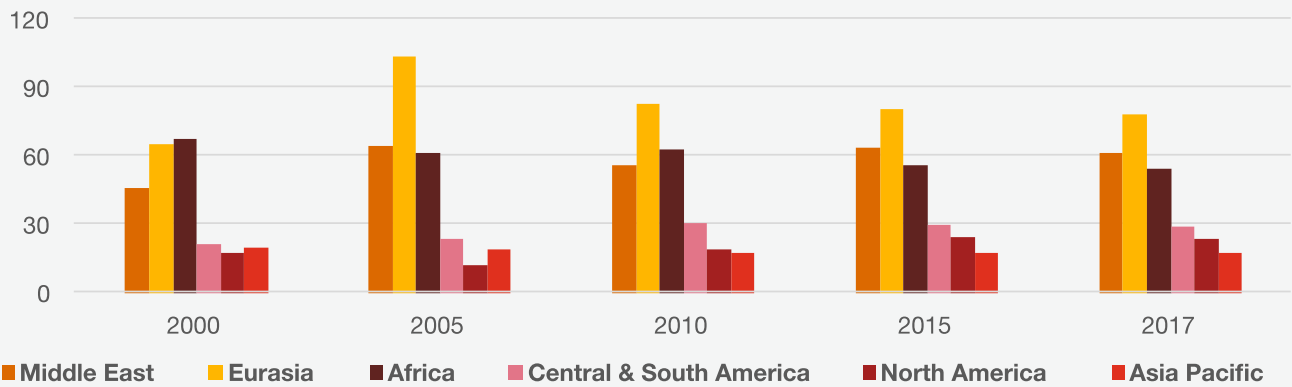
Gas flaring patterns by global regions

Identified patterns on gas flaring across global regions include the following:

Eurasia (Europe and Asia) and the Middle East flared the highest volume of gas since 2000. The three regions cumulatively accounted for over 50% of total gas flared globally in 2017.

Gas flaring in Africa reduced marginally up to 2017. This follows from reduction in the volume of gas flared in countries like Angola, Egypt and Gabon.

Graph 1.1 - Global Gas Flaring



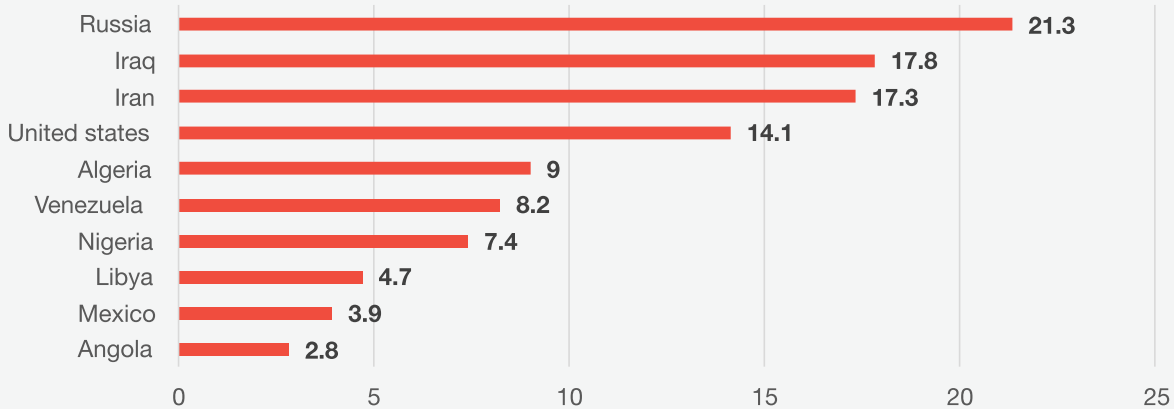
Source: International Energy Agency (IEA)

Top gas-flaring countries in the world

The top five gas-flaring countries are Russia, Iraq, Iran, United States and Algeria, with combined emissions of 79.5 billion cubic feet (bcf) in 2018. In Russia and Iraq, oil fields are mostly remote, and low, subsidized gas prices reduce the incentive to bring associated gas to market (IEA, 2014). While rising shale

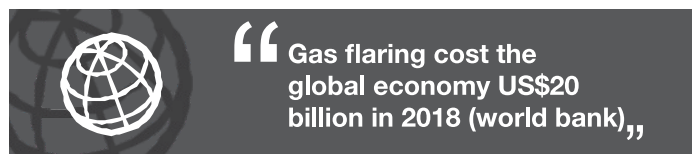
oil is the cause for the high record of gas flared in the United States. In Algeria, gas markets and infrastructure are underdeveloped, and there are limited financial incentives to exploit associated gas (IEA, 2014).

Graph 1.2 - Top Ten Countries Flaring Gas in 2018 (billion cubic feet)



Source: International Energy Agency (IEA)

The World Bank defines the cost of gas flaring as the lower of the cost of reducing or eliminating CO₂ emissions and/or the economic cost of the damage to the physical and biological environment caused by the CO₂ emission.



While gas flaring remains a serious environmental and health threat, the International Energy Agency (IEA) believes that this phenomenon will steadily drop to zero-level by 2030 due to individual and joint government commitments via regulatory pledges to the cause.

The leading concerted effort in eliminating gas flaring globally is the Global Gas Flaring Reduction (GGFR) Partnership. This is a public-private partnership comprising oil companies, national governments and international organizations aimed at removing technical and regulatory barriers to reducing gas flaring, conducting research and developing country-specific initiatives to reduce gas flaring. The GGFR hopes to achieve zero gas flaring by 2030.

Since the GGFR was introduced in 2002, there has been minor achievement in reducing gas flaring. From 5,332bcf in 2002, the volume has only declined slightly by 4.1% to 5,121bcf in 2018. This marginal achievement was as against is due to increase in flaring in countries like Iran (180.1bcf), Iraq (134.2bcf), Russia (105.4bcf), USA (95.35bcf) and Algeria (10.59bcf)



Background to Gas flaring in Nigeria

Nigeria has proven gas reserves of 201 trillion cubic feet and unproven gas reserves of 600 tcf; yet, production of gas remains very low and unstable. Noticeably, the ratio of gas flared to gas produced has been steadily reducing. This is because gas production has been growing while gas flared has been reducing.

There has been a steady drop in the percentage of gas flared in Nigeria. While the volume of gas flared in 2002 was equivalent to 53% of gas produced, the volume of gas flared in 2018 was equivalent to 10% of the volume of gas produced.

Accounting for this drop is a few combined factors including: The increased reinjection of gas to lift more crude oil out of the wells, when production declines; Significant growth in industrialization around oil-producing areas, which has been responsible for mopping up gas flares for industrial use;

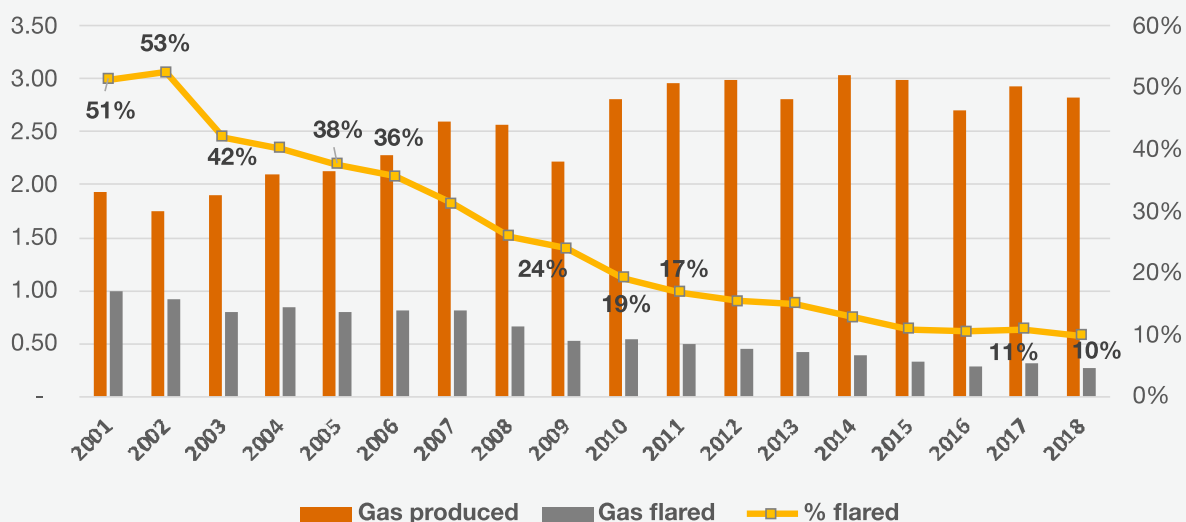
Growing environmental awareness and regulations has compelled International Oil Companies in Nigeria to cut down their emissions level due to global outcry.

With global oil markets somewhat depressed, more countries and oil producers are investing in the commercialization of gas as the current growth market. For instance, Qatar is aggressively investing in gas production. The United States is significantly pursuing shale gas production.

In Nigeria, the indigenous and international oil producing companies are investing in gas commercialization projects under the Nigeria Gas Flare Commercialisation Programme (NGFCP).

For instance, the Assa-North Ohaji-South project in Imo State, Nigeria, is one of the largest greenfield gas condensate development projects being undertaken in the country.

Graph 2.0 - Gas Produced and Flared in Nigeria in 2018 (trillion cubic feet)



Source: DPR Annual Oil and Gas Report

It is important to clarify the distinctions in gas production to shed more light on the impact of gas flaring on the industry.

Associated vs. non-associated gas: which contributes more to flaring?

Associated gas represents natural gas obtained in the process of mining crude oil through a process called fractionation.

Non-associated gas does not require processing, as the natural gas is not mixed with crude oil.





In some instances, gas flared from associated fields are sometimes due to the following:

1. Oil fields are too distant from the nearest utilizers and gas transport infrastructures are insufficient.
2. Oil fields have significant amount of associated gas in locations where re-injection is not possible.
3. The local market for gas is not yet fully developed, and consumers are not willing to pay appropriate price for it.
4. In some instance, the cost of processing the associated gas and transporting it to the market for sale, is higher than the market sale price itself.

Due to these operational and cost inefficiency, most associated gas is flared.

Onshore vs. Offshore: where is gas flared the most?

Onshore flaring relates to gas flared on land, while offshore flaring pertains to gas flared on water. Statistics show that gas is equally flared on both surfaces.

Onshore flaring	Offshore flaring
 240 million Mscf flared Valued at US\$839.9million	 232.4 million Mscf flared Valued at US\$813.6million
 Payable penalty of US\$479.9million 24,000Gwh power generation potential	 Payable penalty of US\$464.9million 23,200Gwh power generation potential

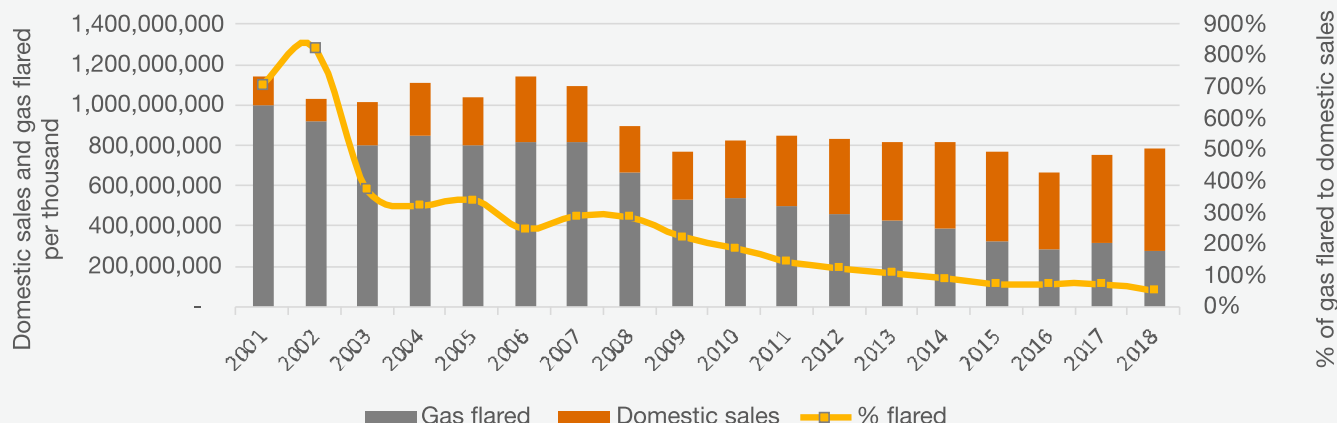
Source: Gas Flare Tracker, PwC analysis

Domestic sale of gas vs. gas flared: How much revenue potential is lost from flaring?

There is an anomaly whenever gas flared surpasses domestic sales. From the chart below, gas flared exceeded domestic sales from 2001 to 2014. From the chart below, the volume of gas flared exceeded domestic sales from 2001 and 2014, thus, significant potential revenue was lost to gas flaring. In 2014, 393 million scf gas was flared while 425 million scf was sold, this implied that the volume of gas flared was almost equal

(94%) to the volume of gas sold. This implied that the volume of gas flared was almost equivalent (94%) to the volume of gas sold. By 2018, 282 million scf was flared relative to the domestic sales of 510 million scf. This shows that the proportion of gas sold is increasing, while the proportion that is being flared is reducing.

Graph 2.1 - Domestic sales and gas flared in Nigeria (2001 - 2018)



Source: DPR Annual Oil and Gas Report



Nigeria Gas Policy Environment

The National Gas Plan (NGP)

In July 2017, the Federal Government of Nigeria launched the National Gas Plan (NGP) to drive investments in the gas sector. This is to boost the growth of the gas segment of the petroleum industry with the production of the various form of gas products like Liquefied Petroleum Gas (LPG) and Liquefied Natural Gas (LNG). The NGP is aimed at reducing the demand-supply gap in the domestic and international gas markets and to prevent another energy crisis in Nigeria (akin to 2015/2016 with the crude oil price crash), by exploiting the significant gas reserves in the country.

The NGP comprises institutional reforms and regulatory changes that would drive revenues and profitability in the gas sector. Prior to this policy, the Nigerian gas sector was encumbered with the underlisted challenges:

- Slow progress with Nigerian gas export projects;
- Slow pace of domestic gas projects;
- Inadequate gas supply for the domestic market;
- Financing challenges from local financial institutions;
- Re-direction of FDI focus from Nigeria to other regions;
- Slow implementation of key infrastructure projects envisaged in the Gas Master Plan.

The policy seeks to promote more efficient utilisation of capital by encouraging producers to focus their investments and activities more on exploration, development and production of gas, whilst specialised midstream investors can process and transport gas (Nigeria Gas Policy, 2014).

Specific policies aimed at reducing gas flaring

The latest policy regulating gas flaring in Nigeria is the Nigeria Gas Flare Commercialization Programme (NGFCP):

Year	Policies	Objectives	Regulatory thrust
2017	Nigeria Gas Flare Commercialization Programme (NGFCP)	<ol style="list-style-type: none"> 1. Reduction of the environmental and social impact caused by flaring. 2. Protection of the environment 3. Prevention of waste of natural resources 4. Creation of social and economic benefits from gas flare capture 	<ol style="list-style-type: none"> 1. Government takes up all gas that should be flared at zero cost 2. Government will sell the gas at competitive auction bids 3. Creation of permit to access flare gas with right to enter flare site and take flare gas 4. Penalty of US\$2 per thousand standard cubic feet for production of 10,000 barrels of oil or more; penalty of US\$0.5 per thousand standard cubic feet for production less than 10,000 barrels of oil 5. A mandatory additional payment of US\$2.50 per cubic feet for failure to produce accurate flare data, sign connection agreement and provide access to flare site

Year	Policies	Objectives	Regulatory thrust
2008	Nigeria Gas Masterplan	<ol style="list-style-type: none"> 1. Stimulate the multiplier effect of gas in the domestic economy 2. Position Nigeria competitively in high value export markets 3. Guarantee the long-term energy security of Nigeria 4. End gas flaring in 2008 	
1979	Associated Gas Re-injection Act		<ol style="list-style-type: none"> 1. Re-inject all gas produced in association with oil but not utilized in an industrial project 2. Gas flaring defaulters will forfeit concession granted in the field or fields where gas is flared 3. Repair or restoration of reservoir in the field where gas is flared





Challenges to gas flaring in Nigeria

Through the NNPC, the Nigerian government intends to end gas flaring by 2020. This is a decade earlier, when compared to the 2030 target of the Paris Accord. Although this is good, there are challenges to attaining the 2020 target. These are:

Delay in passing other components of the PIB into Law

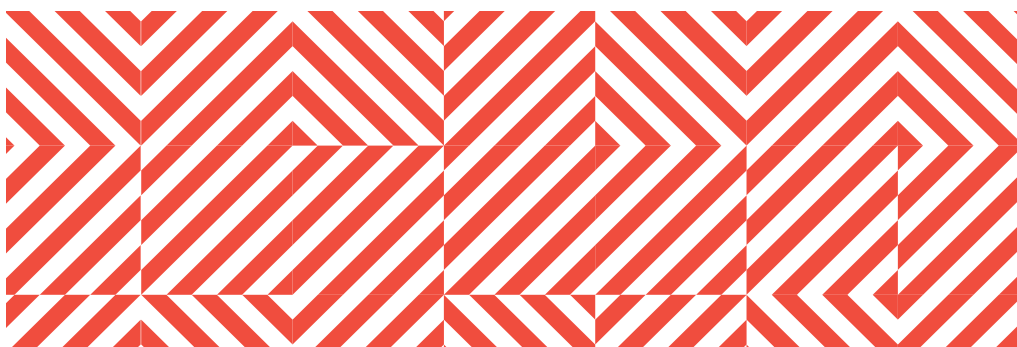
The Petroleum Industry Administration Bill, Petroleum Industry Host Community Bill and Petroleum Industry Fiscal Bill are components of the PIB that are yet to be passed by the legislature and executive arms

Absence of infrastructural support

Excess gas is flared due to lack of processing and storage facilities. An infrastructure-enabled system will ensure it is more expensive to flare gas.

Below optimal punitive measures

In 2017, gas flare penalty stood at N10/mscf (about \$0.03). The NGFCP intends to raise this cost to N720/mscf (for gas production $\geq 10,000$ mscf), but this is yet to be fully implemented. Thus, the 2017 penalties still obtain and is not enough deterrent for gas flaring defaulters





Monetizing the effect of gas flaring on the economy

Economic effect of gas flaring

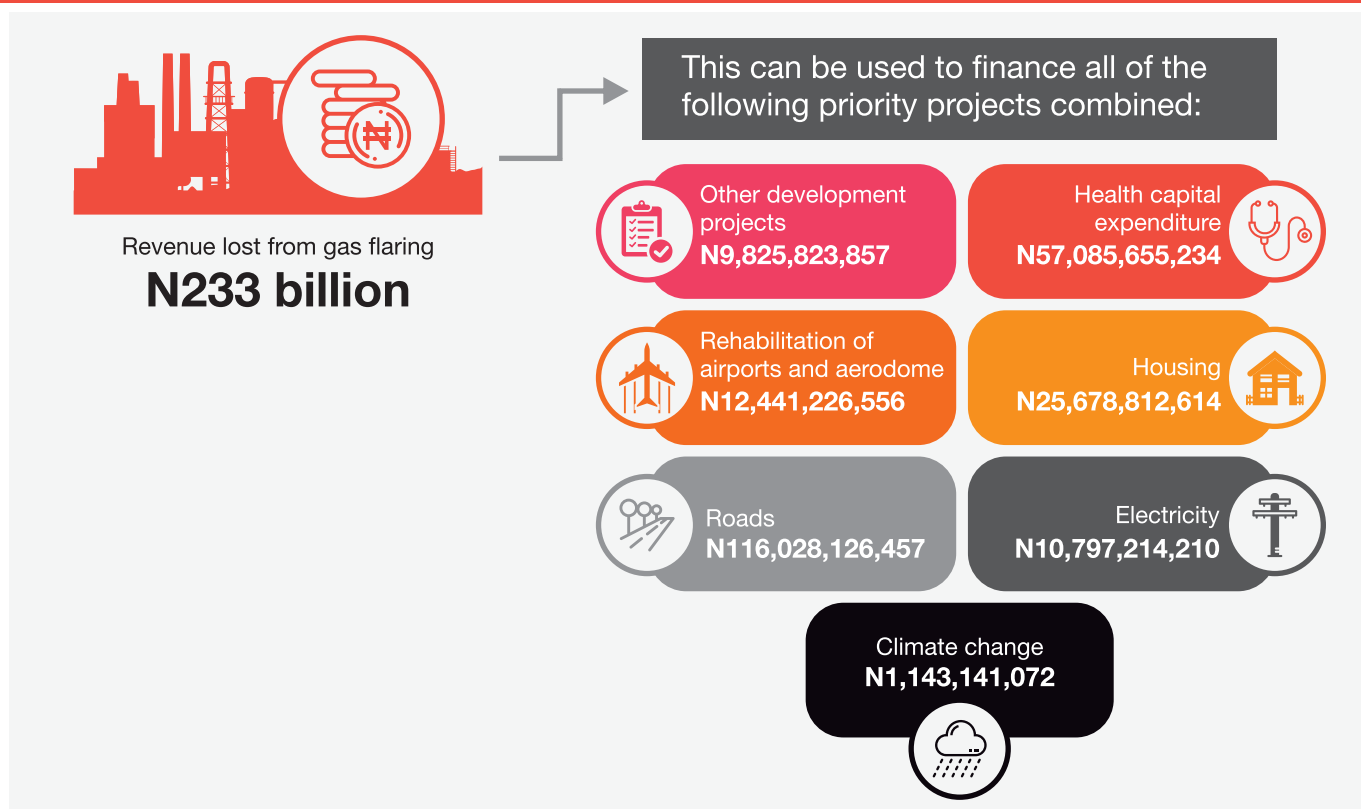
The economic effect of gas flaring is quantified in terms of the lost amount of revenue that could have been generated from utilizing the volume of gas flared.

Consequently, Nigeria lost N233 billion from gas flaring in 2018. The revenue lost in other years are shown in the table below:

	Volume of gas flared per thousand scf	Average price of gas per thousand scf	Revenue lost in \$	Revenue lost in Naira
2018	282,080,000	2.70	761,616,000	233,054,496,000
2017	324,192,401	2.70	875,320,000	267,847,920,000
2016	288,917,198	2.60	751,185,000	229,862,610,000
2015	330,933,000	2.40	794,240,000	243,037,440,000
2014	393,839,836	2.50	984,600,000	301,287,600,000

Source: DPR annual report, NNPC, PwC analysis

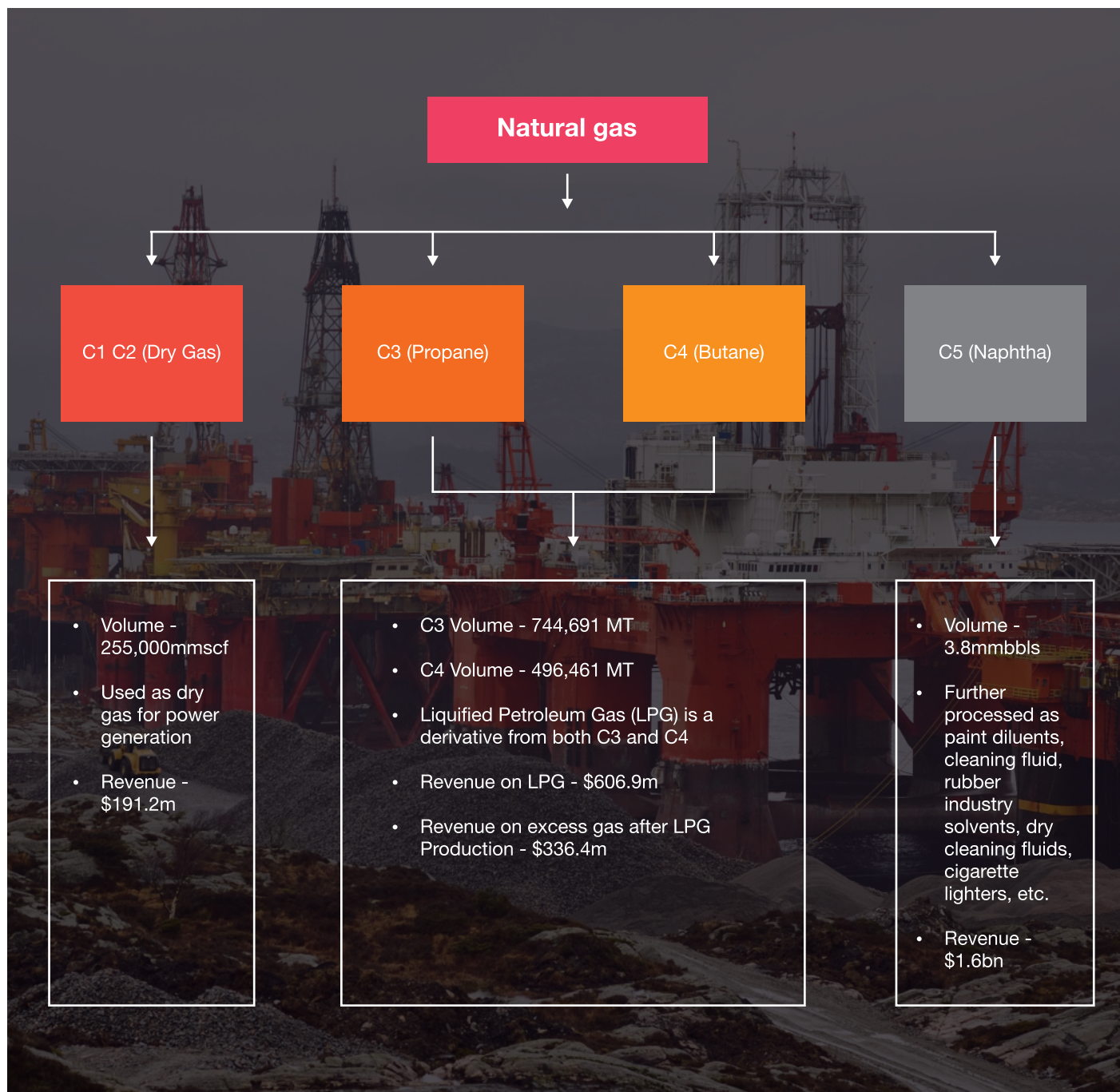
The N233 billion revenue lost from gas flaring could have been put to economic use in the following ways:



Economic value added from gas flaring

From our analysis, Nigeria has also lost value from the derivatives that can be produced if gas is transported to refineries for further processing.

Using the volume of gas flared in 2018, we have estimated the volume of the different derivatives and their revenue value. See chart below:



From the chart above, the monetary economic value addition that could have been recovered from derivatives of natural gas flared in 2018 is totalled at \$2.73bn.

Further analysing the value chain across LPG production for cooking gas, assuming 12.5kg cylinders are needed to store gas by final consumers; from our analysis, and assuming total volume of LPG produced is being sold, it is estimated that 45 million 12.5kg gas cylinders are needed by final consumers

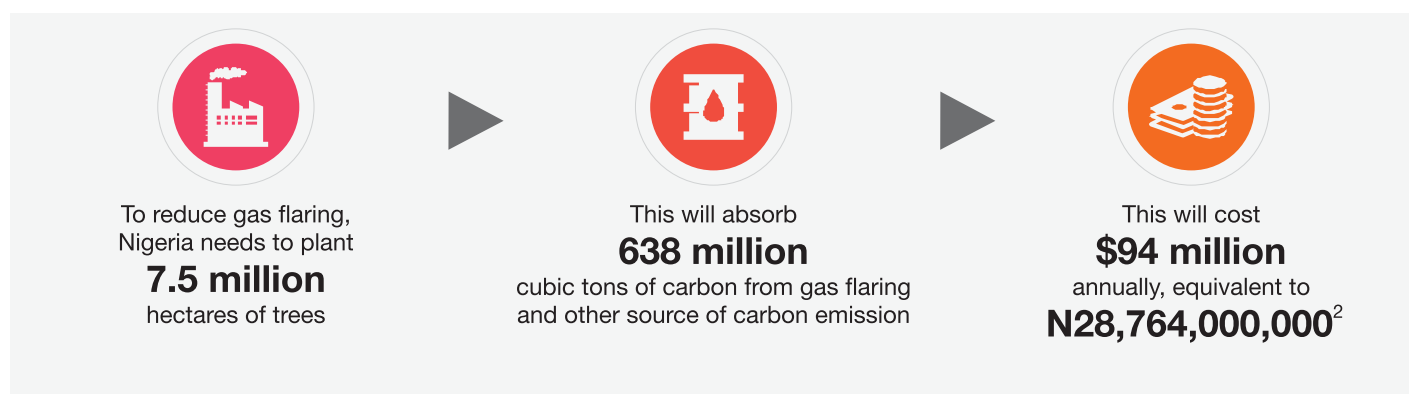
which will cost about 10,000 naira per cylinder hence adding a total gross value of about \$1.47bn to cylinder producers if they are produced locally.

Also, besides the revenue value from gas derivatives, there are other economic benefits if gas processing activities are carried out, such as more job opportunities, infrastructure development, etc.

Environmental cost of gas flaring

Gas flaring leads to pollution of the atmosphere which affects the environment. The environmental cost of gas flaring is estimated from the perspective of the cost of rejuvenating the

environment. The environmental cost of gas flaring according to the National Environmental, Economic and Development Study (NEEDS) for Climate Change in Nigeria is shown below



Source: National Environmental, Economic and Development Study (NEEDS) for Climate Change in Nigeria (2010), PwC analysis



2. This was converted at the rate of 306 Naira/\$1

A summary of the analysis in this section is highlighted below:

1. The economic cost of gas flaring was N233 billion in 2018.
2. The cost of the environmental effect of gas flaring is N28.76 billion in 2018.
3. The monetary economic value addition that could have been recovered from derivatives of natural gas flared in 2018 is totalled at \$2.73bn.





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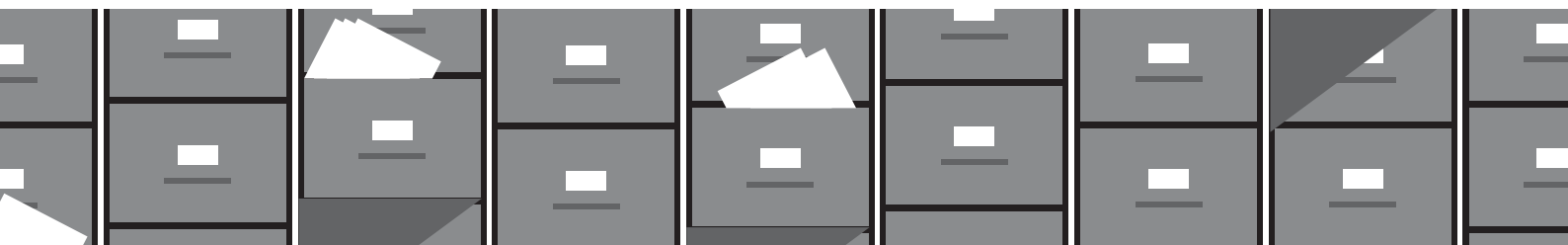


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