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Full Length Article

Economics of gas to wire technology applied in gas flare management

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ABSTRACT

Our environment is increasingly being endangered by the introduction of greenhouse gases which are continuously produced from gas flaring processes. Currently, total volume of gas flared globally amounts to 100 billion cubic meters (BCM) annually. Nigeria flares about 18.27 BCM and loses approximately $2 billion yearly. This statistics indicates the urgent need to conduct research aimed at addressing both the environmental impact of gas flaring and the economic implications. This research studies the economic viability of using gas to wire (GTW) technology as an integral component of gas flare management. The investigation critically evaluates the cost implications and impact of the GTW technology. The research method involves the interview of key experts and practitioners in the field. The interviews are structured to obtain information on the total volume of gas produced, utilised and flared in two major gas and electricity producing firms in Nigeria. The data obtained show that the gas producing company flares about 8.33% of its total production which is in excess of the 6.6 million cubic meters (MCM) utilised daily. This study demonstrates that in the Nigerian oil and gas sector, one unit of gas turbine having 0.93 MCM gas consumption capacity generates 150 MW of electricity daily. It is found in result evaluation that 50 turbines are sufficient to consume an average of 46.5 MCM of gas daily to generate 7500 MW of electricity. Economic analysis shows that there is an annual net profit of £2.68 billion gained from flare prevention and overall environmental protection.

1. Introduction

Gas flaring occurs in the process of crude oil processing and production. About 5% of global supply of gas is wasted due to flaring and or venting as a result of lack of processing facilities, thereby causing the release of about 300 million tons of CO_2 per year into the environment [17]. This volume of flared gas could be utilised for reasonable purposes, for instance electricity generation.

According to Energy Information Administration [15], Nigeria is the 6th largest crude oil producer. It is also one of the largest producers of natural gas in the world [32]. In Nigeria, the proven natural gas reserve is currently estimated at 5.3 trillion cubic meters (187 trillion cubic feet – TCF) [1,27]. This could possibly sustain the energy needs of the Sub-Saharan Africa for several decades Ahmed et al. [1] stated that large amount of global natural gas reserves have not been used in the same ratio as petroleum crude. This could be linked to the fact that large volumes are associated gas. Regardless of all these, it still remains a vital future energy source. Ironically, despite the abundant proven natural gas reserves, Nigeria is faced with electricity generation and supply problems which are characterised by load shedding, blackouts, and reliance on private electricity generators: and these create huge economic impediment [15]. Anomohanran [5] estimated that about 47% of the total gas produced in Nigeria is practically flared; while Nwankwo and Ogogarue [29] estimated a higher percentage of about 70% as being flared from the volume of produced gas in Nigeria. The quantity of gas flared annually could be as much as 15.2 BCM [26]. Even though there are variations in the estimation of volume of flared gas, it is undeniable that huge volume of gas is flared in Nigeria, and this contributes significantly to economic waste and environmental degradation [28,34].

About 100 Billion BCM of gas is flared globally on an annual basis and gas flaring continues to pose significant threats to the environment and economy of oil and gas producing countries, therefore it is vital for this global challenge to be addressed. This research presents the GTW technology as a vital and viable management system for the excessive waste of gas. This requires systematic gathering of potential flared gas and subsequent utilisation as fuel for gas turbines for the generation of electricity. The study also establishes the economics of gas to wire technology

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in reducing gas flaring in Nigeria. This encompasses carrying out a cost and effect analysis on GTW technology.

1.1. Gas reserves, production and utilisation

The global availability of natural gas is valued and expected to increase with time [18]. According to BP [8], the global proven gas reserve is stated to be 185.7 trillion cubic meters and the reserve/production ration is 55.1. This has led the countries responsible for these reserves to increase production level and has also created an opportunity for increase in gas utilisation, particularly from the importers of gas. According to [8] Russia, Turkmenistan, Iran and Qatar have the highest proven reserves as shown in Fig. 1.

These four aforementioned producing countries are in possession of 58% of the entire proven gas reserves, with Russia possessing 24% and Turkmenistan having 5%. As demonstrated in Figs. 2 and 3, the Energy Information Administration has projected that by the year 2025 the natural gas consumption will almost match the production due to estimated increase of gas utilisation emanating from electricity generation. This is because natural gas is gradually becoming the fastest growing component of world primary energy. Therefore, this also validates the importance of gas to electricity as a vital means of gas utilisation. Nigeria produces 33.21 billion cubic meters (BCM) of gas yearly and utilises 14.94 BCM, which signifies that about 55% of the total annual gas production is flared.

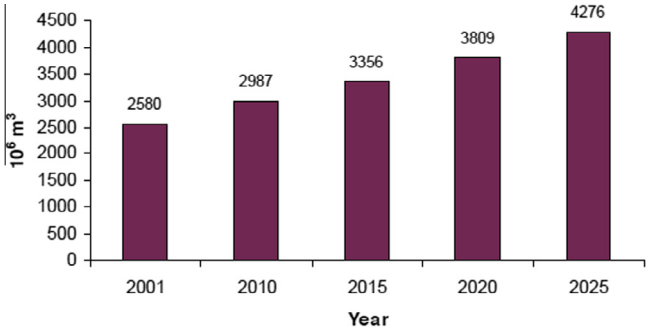

Fig. 2. Estimation of World Natural Gas Production from 2001 to 2025 [14].

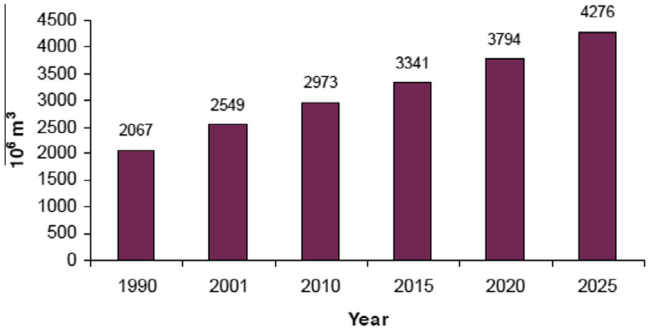

Fig. 3. Estimation of World Natural Gas Consumption from 2001 to 2025 [14].

1.2. Gas flare process

Gas flaring is referred to as a controlled system that involves the burning of gas [32], and could take place during crude oil exploration, in refineries or in chemical plants Rotty [39] identified and proposed the correlation between oil production and gas flaring and this has been in application since 1935 for the estimation of volume of flared gas Odumugbo [31] stated that there are two major options for reduction of associated gas flaring: the first is reinjection of gas into the ground for future reuse, while a second option is gas utilisation for domestic and commercial purposes, which could involve acquiring equipment for liquidification and transportation. The idea of flaring arises because it is the easiest and possibly cheaper (financially) in the short term [38].

In a lot of countries, the law prohibits gas flaring because it is harmful to the environment; although flaring could be permitted in rare cases where it is not avoidable such as in accidental breakdown of machinery and pipelines [12].

According to Oil and Gas Producers [32], gas flaring generally takes place due to the following reasons: (i) unburned process gas that results from processing, (ii) excessive gas that could not be supplied to commercial customers, (iii) vapours that are collected from the top of tanks during the filling process, (iv) production shutdown, whereby all available gas in the facility are temporarily flared to release high pressure, (v) during process upsets, maintenance and equipment changeover, and (vi) during start-up of the facility (such as olefin plants) due to safety and off-specification products.

Flared gas is made up of several compositions of which, Methane (CH_4) and Ethane have the highest mole fractions. In Table 1, the full compositions that make up flared gas are highlighted.

Fig. 4 shows the process leading to gas flaring as demonstrated by CCEI [10]. During crude oil exploration, crude oil and associated gas are produced. Crude oil is completely taken to the oil storage after treatment; while the associated gas faces two potential options – systematically gathered for utilisation or wasted through flaring. Regarding flaring, the gas is systematically channelled to the knockout drum from where gas is directed to the flare stack.

There is urgent need to manage gas flaring because the estimate by Energy Information Administration [14] predicts that annual flaring will increase by 60% from 1999 to 2020. Subsequently, it revealed that the greatest increase in gas production will emanate from Middle East (46%), seconded by Africa (18%), with the least coming from North America (3%) as shown in Fig. 5. Therefore this shows that the developing countries are highly affected by gas flar-

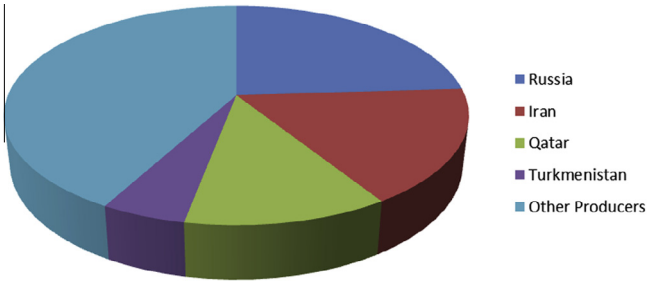

Fig. 1. Global natural gas reserves ratio [8].

Table 1
Composition of flared gas [6].

Component	Chemical formula	Volume fraction (%)	Weight fraction (%)
Methane	CH_4	81	60
Ethane	C_2H_6	5.5	7.7
Propane	C_3H_8	6.6	13.5
Butane	C_4H_{10}	4.0	10.8
Pentane	C_5H12	1.4	4.8
Nitrogen	N_2	1.0	1.3
Carbon dioxide	CO_2	0.17	0.33

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