# Technical Analysis of Gas Utilization Strategies in Remote Locations

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**ABSTRACT**

*Worldwide energy demand has been growing exponentially over the decade. There is therefore need not only to increase worldwide energy supply but also to maximize the current supply. Natural gas tends to play a huge role in supplying required energy but it is however marred by some activities that prevents its maximization such as gas flaring. Gas flaring not only wastes valuable resources but also contributes to greenhouse gas emission. Gas flaring is still practiced today in many locations around the world especially in Nigeria due to lack of gas utilization infrastructures, unsustainable exploitation practices and location of gas production facilities. A holistic review of different technologies used in converting, storing and transporting recovered flare gas from remote locations to processing facilities was done in this paper. At the end of the review, it was concluded that Compressed Natural Gas (CNG) Technology is the most viable technology for the transportation and effective utilization of small volumes of recovered flare gas produced in remote locations.*
*Keywords: Gas Utilization Strategies, Remote locations, Technology and Transportation.*

## 1.0: INTRODUCTION

Primary energy demand of the world is rapidly increasing at an accelerating rate. This increase has motivated extensive research on developing new unconventional energy sources like the renewables. Although renewables will help in reducing the world's reliance on fossil fuels experts have projected that for oil, gas, and coal will be a predominant energy source for at least a few decades. Currently, these three resources (oil, gas and coal) account for more than 80% of the total world energy needs (BP, 2020). Of the three, natural gas is the cleanest, has the largest heat of combustion relative to the amount of CO2 formed, the lowest Carbon to Hydrogen ratio and thus lower carbon, nitrogen and sulfur emissions compared to oil and coal. Despite these advantages over other energy sources, large quantity of global natural gas reserve has not been used to the same extent as petroleum crude. In Niger Delta region of Nigeria for example, there are gas fields not explored primarily because of the high cost of infrastructure

needed to utilize the gases that will be produced from the field. The cost of infrastructure does not only affect gas fields but also associated gas produced in oil and gas production and processing fields. Because many oil fields in Nigeria lack the infrastructure to convert associated natural gas to useful product and/or market it, it is often flared.

In addition to the lack of infrastructure, other factors which are a combination of historical, economic and geographical issues also make gas utilization a challenge. Some of the issues are;

- Cost of developing a network of gas pipelines.
- Low industrial and technological base for energy consumption.
- Limited gas market (both regional)
- Inadequate policies to encourage investment etc.
- Difficult terrain of the Niger Delta

According to the World Bank (2020), Nigeria flares approximately 282 Bcf of natural gas annually. This act according to PwC (2020) costs Nigerian economy about $761.6 million annually which translates to 3.8% of the global total cost of Gas flaring.

Nigerian Government has been working tenaciously to end natural gas flaring for several years. Some of the efforts and projects initiated be Nigerian Government are;

- The Nigerian Liquefied Natural Gas Project – completed in September 1999.
- The West African Gas Pipeline Project – commissioned in April 2008.
- The Escravos Gas to Liquids project – initiated in 2014
- The Ajaokuta-Kaduna-Kano (AKK) Trans-Nigeria Gas Pipeline – Commissioned in July 2020; Expected to be completed by 2023
- Judicial and Legislative Acts such as National Domestic Gas Supply and Pricing Regulation of 2008 and Petroleum Industrial Bill (PIB) introduced in 2008 and expected to be implemented in 2021 (Nairametrics, 2021).

Though these projects have gone a long way in reducing gas flaring, it has not been able to achieve zero routine flaring. In order to achieve zero routine flaring, there is need to find the most suitable model fit for converting and utilizing gas produced in oil and gas production and processing facilities especially those located in remote locations.

## 2.0: LITERATURE REVIEW

### 2.1: GAS STORAGE IN REMOTE LOCATION

Since the beginning of 21st century, there has been an increasing interest in reducing flaring based on environmental considerations regardless of the economics (Peterson et al., 2007). Different techniques have been applied such as;

- Injection / reinjection into oil fields for enhanced oil recovery;
- Collection and delivery to a nearby gas-gathering system or treatment plants before subsequent use
- Using as an onsite fuel source;
- Using as feedstock for producing petrochemicals
- Converting to liquefied petroleum gas (LPG)
- Converting to Liquid (Gas-to-liquid - GTL)
- Converting to fuels and chemicals
- Generating electricity by burning the gas in incinerators and collecting the exhaust heat for further use such as generation and co-generation of steam and electricity.

Other techniques are temporary storage methods for transportation such as

- Converting to liquefied natural gas (LNG)
- Converting to Hydrates (Gas-to-hydrate - GTH)
- Compressing the gas (Compressed-Natural-Gas - CNG)

Despite all these methods, some facilities that are remote or in unfriendly terrain will encounter issues utilizing the gas produced from the location. Also, each oil/gas production/processing facility has a unique gas characteristic which the operators must have a good understanding of before the gases produced from such facility can be utilized.

In order to ensure that gas gotten from remote locations are properly utilized, there is need to identify the factors that enables utilization of recovered flare gas such as volume of gas produced, location/terrain of the production/processing facility and distance from production to processing station.

These factors are discussed below.

### 2.1.1: Volume of gas produced:

Most flared gas are usually unwanted by-products or associated gas. Since the gas is a by-product, the volume is usually small. The small volume of gas makes it harder to process and makes the cost of processing higher (Ishaya, 2018). Usually, when the volume of gas produced is much, it is usually processed in the location as economics of scale makes it profitable. However, when the volume is small, the production company will not be able to recover the cost of processing the gas as the income generated from selling the processed gas will be lower than the cost of processing the gas. This makes the only option available to be either flaring the gas or transporting it to another facility for processing (Thurber, 2019).

### 2.1.2: Location/terrain of the production/processing facility:

Most oil/gas production facilities are usually located in remote/offshore locations or terrains that are difficult to navigate. When excess gases that cannot be utilized are produced in these locations, the only option available is to transport it to another facility

for processing. If the terrain is difficult to navigate, it will be tough to transport the gas to another facility because the volume is too small. Also, conventional pipeline transport normally used will not be feasible due to the terrain and volume of gas that will be transported. The only transportation that might be applicable in this scenario is that which involves the use of smaller means of transport such as mini trucks, small scale marine transport vessels, etc.

### 2.1.3: Distance from production to processing station:

Different gas conversion and transportation methods have varying transport distance that are suitable for them. Usually, the distance from gas production to processing facility is less than 200 kilometers. This will not be suitable for any gas conversion and transportation method that is fit for long distance only as the cost of utilizing the produced gas will be higher due to economics of scale.

## 3.0: MATERIALS AND METHODS.

## 3.1: ANALYSIS OF GAS STORAGE AND PRODUCTION METHODS

### 3.1.1: Liquefied Natural Gas (LNG)

LNG is a gas transportation method that works by cooling Methane ($CH_4$) to –160°C, converting its from gaseous phase to liquid that is easily transportable with volume is approximately 600 times less than the equivalent volume of methane gas. LNG is usually stored and transported at cold temperatures and at low pressure to long distances where pipelines are

neither economic nor feasible. Transport by LNG is expensive. However, the cost per kilometer for a long distance is less than pipeline or other means of transport (Vivek, 2019)

### 3.1.2: Gas to Liquid (GTL)

Gas-to-Liquids (GTL) technology is a process used to convert natural gas to liquid products that is usually gotten from crude oil. These products are usually colourless, odourless and contain almost no impurity such as sulphur, nitrogen and aromatics that are found in crude oil. The major reason behind GTL is to produce liquid fuels which are easily transported when compared to methane as methane must be cooled below – 82.3 °C which is its critical temperature before it can be liquified under pressure.

Gas to liquid process usually require huge reactors and huge amounts of gas before it is able to yield profit due to economics of scale. This reason alone makes it impossible for Gas to liquid process to be used for small volume of recovered flare gas. However, mini-Gas to liquid Projects which are still in development stage might be a perfect solution for GTL process in the future (Ekwueme et al, 2019).

### 3.1.3: Compressed Natural Gas (CNG)

CNG is formed by compressing natural gas to a volume less than one percent (1%) of the volume it occupies at standard atmospheric pressure. CNG is then stored at a pressure of about 3600 psi in metallic cylindrical containers (Khan et al., 2015). It can be used to process small volume of gas and is usually cheap to store and easy to process. This is because it does not require complex equipment to process it (Nwaoha et al., 2013).

Where pipeline infrastructure is limited or not feasible, CNG allows for ease of transportation of natural gas. In addition to that, CNG creates a ready to use fuel with limited initial processing

which consists of relatively simple process such as compression, cooling, dehydration, and removal of

Liquified petroleum gas (LPG). In addition to that, no processing is needed on the receiving end and it doesn't require complicated refining or additives.

### 3.1.4: Gas to Hydrate (GTH)

Gas hydrates are ice-like solid crystalline compounds of natural gas formed by mixing natural gas and water under high pressure and right temperature. Gas conversion to Hydrate is a relatively simple and low-cost process that does not entail complex procedure or require extreme pressure or temperature. According to Kanda (2006), it can also be used for small-scale projects, stranded gases and offshore location. The major challenge is that the technology is still in development stage and has not been fully deployed to be used for recovered flare gas.

### 3.1.4: Gas to Petrochemicals (Methanol)

The main feedstock in the production of chemicals like methanol and ammonia is Natural gas. However, before is it used in production of chemicals, it must first be converted into synthesis gas also known as syngas. This process usually accounts for about 60% of the cost used to convert gas to chemicals.

Methanol is the most commercial chemical produced from syngas. It has a huge market value as it is used as a fuel, solvent, and antifreeze and as ethanol denaturant.

Gas to petrochemical technology is rarely used to recover flare gas in remote location because it requires much volume of gas to function properly. However, where pipeline or other method of transportation is feasible, a Gas to Petrochemical plant can be set up in a centralized location to convert gas from different platforms.

## 4.0: RESULTS AND ANALYSIS

### 4.1: SUMMARY OF ANALYSIS

From the analysis of gas conversion methods above, we can see that different methods have suitable transportation distance, temperature, pressure and volume of gas best suited for them. However, not all of them perfectly fits being utilized for transporting recovered flare gas. This is because some of them are not feasible for transporting small volume of gas. In addition to that, some are not economically suitable for short distance transportation (< 200 km).

Table 1 below shows a summary of the suitability of different conversion methods in transporting small volume of recovered flare gas over short distance.

| S/N | Conversion and Transportation method | Suitable for transporting small volume of recovered flare gas<br><br>(< 300 cubic ft) | Can be transported in a difficult terrain using mini truck or small-scale marine vessel | Suitable for transporting gas over short distance<br><br>(< 200 km) |
|---|---|---|---|---|
| 1 | Liquefied Natural Gas (LNG) | – | ± | – |
| 2 | Gas to Liquid (GTL) | – | ± | – |
| 3 | Compressed Natural Gas (CNG) | + | + | + |
| 4 | Gas to Hydrate (GTH) | + | + | + |
| 5 | Gas to Petrochemicals | – | ± | + |

Key:

| Perfectly Suitable | Moderately suitable | Not Suitable |
|---|---|---|

| | | |
|---|---|---|
| | (Under certain conditions) | |
| + | ± | – |

From the table above, it could be seen that the best methods for utilizing recovered flare gas is Compressed Natural Gas (CNG) and Gas to Hydrate (GTH) Technology. Out of these two options, since Gas to Hydrate technology is still in the development stage, the most suitable method currently for storing and transporting recovered flare gas is Compressed Natural Gas Technology.

Other options can still be used but under certain conditions. For example, Liquefied Natural Gas (LNG), Gas to Liquid (GTL) and Gas to Petrochemicals can be used where there is a collection of gases from different remote fields. Also, if Mini Liquefied Natural Gas and Mini Gas to Liquid Technology which researchers are currently working on comes into play, they will be a great option for utilizing gas in remote locations.

## 5.0: CONCLUSION AND RECOMMENDATIONS

### 5.1: CONCLUSION

In this paper, different methods of utilizing flare gas recovered from remote locations have been analyzed. The analysis shows that for Compressed Natural Gas (CNG) Technology is the best method for effective utilization of recovered flare gas from remote location.

In addition to this, other advantages can be derived from using CNG technology such as;

- It is considered attractive for gas transportation when the transportation distance is below 2500 km (Charles, 2010)
- Its economics falls somewhere between that of offshore sub-sea pipeline and LNG transport alternatives (Rynn et al., 2007).

- The technology is easy to deploy with less requirements for facilities and infrastructure (Nwaoha et al, 2013).
- In case of accidents, it mixes easily and evenly in air. It is also less likely to ignite since the auto-ignition temperature is high (540 °C), and it has a narrow range of flammability (5 –15%) (Gail, 2009).

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