International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 11, Issue 04 (April 2015), PP.12-18

Economic Model In Exploiting Stranded Natural Gas In Niger Delta Offshore Fields

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Abstract:- *Worldwide demand for clean, reliable and affordable energy has never been greater. New technologies are needed to produce more oil and natural gas from remote or "stranded" locations. Gas to Liquids (GTL) conversion is an umbrella term for a group of technologies that can create liquid hydrocarbon fuels from a variety of feedstocks.*

This study reviews the conversion of natural gas into liquid fuels as an attractive option to commercialize abundant gas reserves in offshore Niger Delta. GTL, with virtually unlimited markets, offers a new way to unlock large gas reserves, complementary to other traditional technologies such as Liquefied Natural Gas (LNG), Compressed Natural Gas (CNG) and pipelines.

Natural gas utilization means (GTL, CNG and LNG) of exploiting some Niger Delta offshore associated gas fields were compared economically to determine the best option for investors.

In essence, GTL has the potential to convert a significant percentage of the world's estimated proved and potential gas reserves which today holds little or no economic value.

I. INTRODUCTION

A prevalent question in the oil and gas industry is what to do with the associated gas in fields where there is no gas pipeline. The oil industry has seemingly come to a point where new field developments will not be undertaken unless the associated gas problem is solved. Several such associated gas situations can be identified. The term stranded gas has been used for situations where the field to be produced is remote or where the field is located in deep water. The term marginal gas has been used for situations where the field is too small to justify a gas pipeline for long-term production. These associated gas situations apply also to non-associated gas.

The common practice of reinjecting stranded and marginal gas is increasingly being questioned. Ways are being sought to bring stranded and marginal gas to market. The most common current method of bringing non-associated gas to market from distant locations, is also being considered for stranded and marginal gas; that is, LNG (liquefied natural gas) technology. Recent examples include studies reported by Naklie (1997) and Hickman (1997). It was reported by Naklie (1997) that a floating LNG plant design has been developed, which is technically feasible, economical, safe and reliable. However, it was stated by Hickman (1997) that the key technical hurdle in offshore LNG is the development of a suitable safe and reliable loading system, for transferring of LNG at -162 C from the production facility to LNG carriers.

For marginal fields in Norway it was stated by Helgøy et al. (1997) that offshore LNG was not considered a competitive solution.

Converting stranded and marginal gas to liquid products other than LNG, has received considerable attention in recent years. For offshore conditions in Norway, both methanol and syncrude are considered viable to solve the marginal gas problem (Helgøy et al. 1997). Syncrude options for remote locations have been presented by Singleton (1997). Gas-to-liquids (GTL) technologies and projects have been presented by Knott (1997), Skrebowski (1998) and Thomas (1998).

Applying floating Gas-to-liquids (GTL) technologies will be a viable alternative to drastically minimize gas flaring in Niger Delta offshore fields.

For the foreseeable future, automotive fuels will still be largely based on liquid hydrocarbons. The specifications of such fuels will however continue to be adjusted as they have been and are still being adjusted to meet changing demands from consumers. Tighter legislative requirements are enforced and an increasing number of companies are subscribing to Responsible Care philosophies and practices.

Traditional crude oil refining underwent increasing levels of sophistication to produce fuels of appropriate specifications.

Increasing operating costs continuously put pressure on refining margins but it remains problematic to convert all refinery streams into products with acceptable specifications at a reasonable return.

The route of natural gas to synthetic automotive fuels, as practiced by i.a. Sasol, is technically proven and products with favorable environmental characteristics are produced. As is the case in essentially all natural gas to liquid conversion processes where air or oxygen is used for the utilisation or partial conversion of the energy in natural gas, the CO burden is a drawback as compared to crude oil.

In this work, the Fischer-Tropsch route to synfuels and chemicals is presented as a method, which can be used to utilize natural gas in an economical way. In doing so, under-utilized resources can be accessed and products of a high degree of environmental acceptability can be produced.

Natural gas can be used to produce bulk petrochemicals, including methanol and ammonia, but these are relatively small users of the gas reserves with limited markets. Liquid and other petroleum products are cheaper to transport, market, distribute to large markets. These can be moved in existing pipelines or products tankers and even blended with existing crude oil or product streams.

Further, no special contractual arrangements are required for their sale with many suitable domestic and foreign markets.

New technology is being developed and applied to convert natural gas to liquids in gas to liquids technology (GTL). The projects are scalable, allowing design optimisation and application to smaller gas deposits. The key influences on their competitiveness are the cost of capital, operating costs of the plant, feedstock costs, scale and ability to achieve high utilisation rates in production. As a generalisation however, GTL is not competitive against conventional oil production unless the gas has a low opportunity value and is not readily transported.

Gas-to-liquids (GTL) technology has the potential to convert a significant percentage of the world's proved and potential natural gas reserves - estimated to be upwards of 14,000 trillion cubic feet - into several hundred billion barrels of oil equivalent - enough to supply the world's needs for the next 25 years.

Emerging gas to liquid conversion (GTL) technologies may play a significant role in developing and monetizing large quantities of remote and stranded undeveloped gas in offshore fields in Niger Delta.

Offshore GTL technology applications are important because approximately half of the stranded gas in Niger Delta fields is located offshore.

GTL facilities can be used in small associated natural gas fields, for monetization of gas caps, short-term use as an early production system on large fields while a large permanent GTL is being built, and as a long-term solution for offshore gas in a range of water depths, including the expansion activity in deep water regions of Niger Delta.

The mobility of the floating GTL facilities would permit their use at multiple offshore locations, thereby providing access to fields that are otherwise too small to justify permanent GTL facilities. Such facilities could also enable conversion and monetization of natural gas that is normally flared or wasted.

By converting natural gas into liquid fuels, the technology greatly reduces high transport costs, which in the past has prevented its access to distant markets. This technology is destined to provide an important element in the future landscape of the energy industry. Every major oil and Gas Company is now energetically participating in further research and development of the technology." GTL not only adds value, but capable of producing products that could be sold or blended into refinery stock as superior products with less pollutants for which there is growing demand. Reflecting its origins as a gas, gas to liquids processes produces diesel fuel with an energy density comparable to conventional diesel, but with a higher cetane number permitting a superior performance engine design. Another “problem” emission associated with diesel fuel is particulate matter, which is composed of unburnt carbon and aromatics, and compounds of sulfur. Fine particulates are associated with respiratory problems, while certain complex aromatics have been found to be carcinogenic. Low sulfur content, leads to significant reductions in particulate matter that is generated during combustion, and the low aromatic content reduces the toxicity of the particulate matter reflecting in a worldwide trend towards the reduction of sulfur and aromatics in fuel.

II. STATEMENET OF THE PROBLEMS

As the development of oil and gas business continues to rise in Nigeria, investment in this sector is expected to increase as well. This will require the feasibility of developing floating gas to liquid technology (GTL) at Niger Delta offshore locations.

Operators need to be acquainted with the various gas to liquid plant on floating vessel techniques before they can adequately be fit to work in such gas project.

This research will study in detail; the different gases to liquid on floating vessel techniques for Niger Delta offshore stranded gas and serve as study guide to beginners and reference to experts.

III. OBJECTIVE AND SCOPE OF WORK

This project work will basically focus on the need of floating GTL technologies/facilities on offshore field in Niger Delta, putting into consideration;

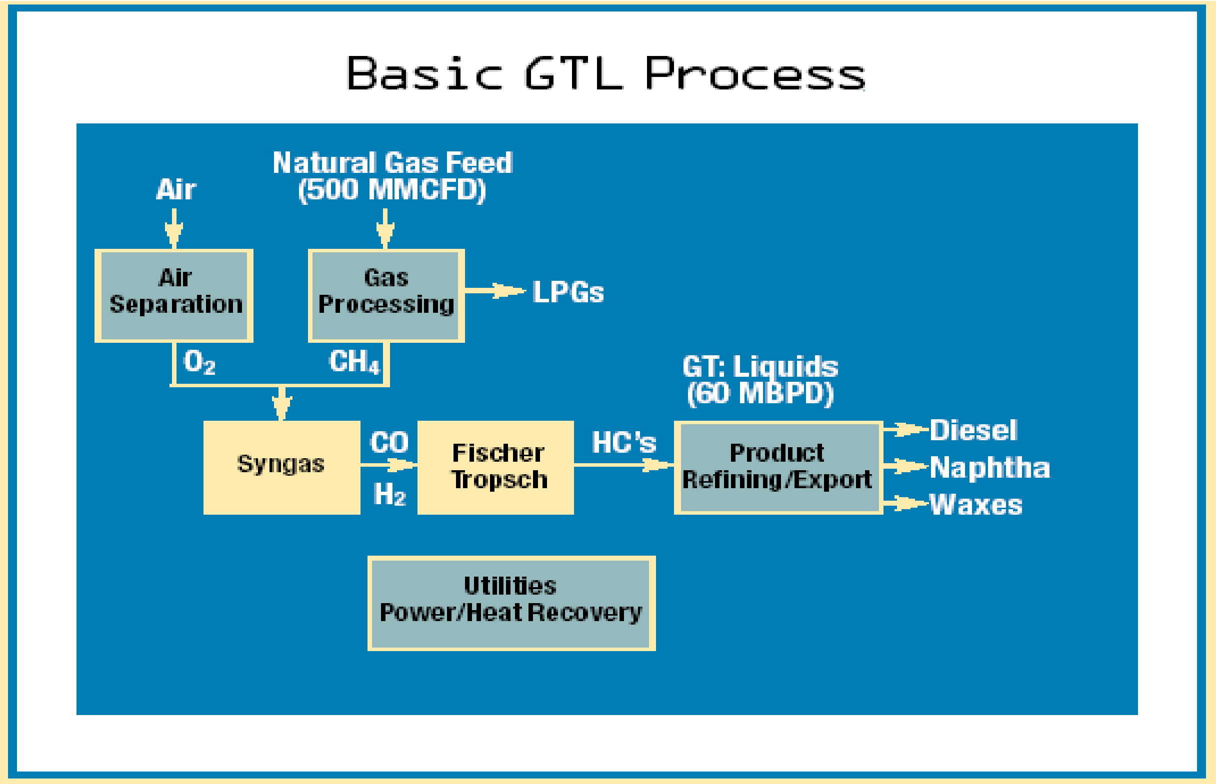
- 1.GTL technology becoming a viable alternative to offshore LNG plants
- 2.Comparing GTL technology to LNG and CNG technology as a better means of utilizing stranded gas reserves in Niger Delta offshore areas with respect to economic and technical analysis – bottom line.
- 3.GTL technology, which can be marinized, i.e. put on a ship, which is economical and attractive to operators of offshore fields in Niger Delta.
- 4.Means that will convert otherwise stranded natural gas from multiple offshore fields into environmental friendly hydrocarbon products ranging from synthetic crude to finished fuels.
- 5.GTL technology will equally provide a huge strategic economic value for Niger Delta areas and Nigeria in general where there is a willingness to avoid the environmental pollution and waste of natural gas through flaring.

IV. METHODOLOGY

An analytical approach was dopted in carrying out this research. In writing the report, four steps were taken to obtain the information required.

- Information were taken from literatures, libraries and from major oil industry, example (Chevron/Texaco GTL project in Nigeria)
- Another source was GTL related information from the Internet with addresses provided by others.
- SPE Journals and technical Papers on GTL technology.
- In addition, interviews were solicited from experts within the oil and gas industries by securing permit from the Department of Petroleum Resources (DPR) plus information that can be obtained from my lecturers.
- The information was reported and analyzed to meet up with the objective of this research.

BASIC GTL PROCESS



ECONOMIC ANALYSIS ON GTL versus LNG

This section shows comparative economic evaluation of both the gas to liquid processing and the liquefied natural gas processing. This is imperative in order to decide which processing method to accept or reject in a given oil and gas field. Selecting the best transportation and utilization method for stranded gas that will bring about maximum benefit and good return on investment.

ASSUMPTIONS AND ESTIMATES:

The following are the assumptions made in this section of the study:

(1) A fifteen-year service life is assumed.

(2) 15% discount is considered.

(3) Investment Cost of a GTL plant is estimated at $551 x 10^6 USD per B/D GTL product (Data from Sasol/Chevron-lagos)

(4) Investment Cost (Pipeline and gas processing) of a LNG plant is estimated at $735 x 10^6 USD per ton/yr of LNG product. (Data from LNG- Bonny).

(5) GTL operating cost is estimated at $2.25 x 10^6 USD per year.

(6) LNG operating cost is estimated at $3.40 x 10^6 USD per year.

FIELD DATA – from offshore field in Niger Delta

Two offshore fields in Niger Delta – Nigeria were compared which is operated using production-sharing contract (PSC) between the two partners. Gas produced from the fields is flared presently.

The analysis performed here is to compare and decide between the two mentioned gas-processing methods (LNG and GTL) that will maximize profit and have good return on investment.

The following are the field data gathered for the study:

- A reasonable distance, such as Nigeria to the U.S gulf coast is assumed.
- Gas reserve of 552MMMscf is estimated.
- Natural gas price of $15 per MCF is assumed.
- Oil reserved with associated gas of 19MMSTB is estimated.
- A price of oil equal to $55/barrel is assumed.

DEVELOPMENT OF ECONOMIC EVALUATION MODEL

Found below is a general model proposed to enable management compare the costs of investment in the gas to liquid processing and the liquefied natural gas processing and take decision.

Cost, C = -CAPEX – OPEX ………………………………………………..…. (4.1)

That is, for Gas to liquid (GTL):

$C_{GTL} = -(CAPEX + OPEX)_{GTL}$ ……………………………………………… (4.2)

And for Liquefied natural gas processing (LNG),

$C_{LNG} = -(CAPEX + OPEX)_{LNG.}$ ……………………………………………. (4.3)

The cost, C is then discounted at 15% to obtain the present value,

PV given by:

$$PV = \frac{C}{(1+i)^n} \quad \ldots\ldots \quad (4.4)$$

That is, for GTL

$$PV_{GTL} = \langle C/(1+i)^n \rangle_{GTL} \quad \ldots\ldots \quad (4.5)$$

And that for LNG is given by:

$$PV = \langle C/(1+i)^n \rangle_{LNG.} \quad \ldots\ldots \quad (4.6)$$

Where i = interest rate, n = number of the year

The Net incremental Present Value (NPV*) is then calculated.

This is done by using the model:

$NPV^* = PV_{GTL} – PV_{LNG.}$ ………………………………………………….. (4.7)

Hence, substituting for PV_{GTL} and $PV_{LNG.}$ gives:

$$NPV^* = \langle C/(1+i)^n \rangle_{GTL} - \langle C/(1+i)^n \rangle_{LNG.} \quad \ldots\ldots \quad (4.8)$$

Since both denominators are expected to be the same, it is generally concluded that:

$$NPV^* = \sum_{n=1} \langle \frac{C_{GTL} - C_{LNG.}}{(1+i)^n} \rangle \quad (4.9)$$

Discount factor (D) is expressed as:

$$D = \frac{\text{Present value (PV)}}{\text{Future income}} \quad (5.0)$$

When the NPV* is calculated, decision is made as follows:

(i) If NPV* is positive or above the line, select Gas to liquid (GTL).

(ii) If NPV* is negative or below the line, select Liquefied natural gas (LNG).

(iii) If NPV* is zero or on the line, select either of them

Table 4.4 below is the table of undiscounted cost for GTL and LNG processing methods:

YEARS FROM START	GTL PROCESSING			LNG PROCESSING		
	CAPEX ($) x 10^6	OPEX ($) x 10^7	COST x 10^6	CAPEX ($) x 10^6	OPEX ($) x 10^7	COST x 10^6
0	551	0	(551.00)	735	0	(735.00)
1	0	2.25	(2.25)	0	3.4	(3.40)
2	0	2.25	(2.25)	0	3.4	(3.40)
3	0	2.25	(2.25)	0	3.4	(3.40)
4	0	2.25	(2.25)	0	3.4	(3.40)
5	0	2.25	(2.25)	0	3.4	(3.40)
6	0	2.25	(2.25)	0	3.4	(3.40)
7	0	2.25	(2.25)	0	3.4	(3.40)
8	0	2.25	(2.25)	0	3.4	(3.40)
9	0	2.25	(2.25)	0	3.4	(3.40)
10	0	2.25	(2.25)	0	3.4	(3.40)
11	0	2.25	(2.25)	0	3.4	(3.40)
12	0	2.25	(2.25)	0	3.4	(3.40)
13	0	2.25	(2.25)	0	3.4	(3.40)
14	0	2.25	(2.25)	0	3.4	(3.40)
15	0	2.25	(2.25)	0	3.4	(3.40)
			(584.7500)			***(786.0000)***

below is a table of discounted cost at 15% PV. This shall be used by substituting into equation 4.9 to make our decision on which is more economical gas utilization between GTL processing and LNG processing.

YEARS FROM START	GTL PROCESSING			LNG PROCESSING		
	CAPEX ($) x 10^6	DISCOUNT FACTOR	15% PV($) x 10^6	CAPEX ($) x 10^6	DISCOUNT FACTOR	15% PV($) x 10^6
0	(551.00)	1	(551.0000)	(735.00)	1	(735.0000)
1	(2.25)	0.8957	(1.9565)	(3.40)	0.86957	(2.9565)
2	(2.25)	0.75614	(1.7013)	(3.40)	0.75614	(2.5709)
3	(2.25)	0.65752	(1.4794)	(3.40)	0.65752	(2.2356)
4	(2.25)	0.57175	(1.2864)	(3.40)	0.57175	(1.9440)
5	(2.25)	0.49718	(1.1187)	(3.40)	0.49718	(1.6904)
6	(2.25)	0.43233	(0.9727)	(3.40)	0.43233	(1.4699)
7	(2.25)	0.37594	(0.8459)	(3.40)	0.37594	(1.2782)
8	(2.25)	0.3269	(0.7355)	(3.40)	0.3269	(1.1115)
9	(2.25)	0.28426	(0.6396)	(3.40)	0.28426	(0.9665)
10	(2.25)	0.24718	(0.5562)	(3.40)	0.24718	(0.8404)
11	(2.25)	0.21494	(0.4836)	(3.40)	0.21494	(0.7308)
12	(2.25)	0.18691	(0.4205)	(3.40)	0.18691	(0.6355)
13	(2.25)	0.16253	(0.3657)	(3.40)	0.16253	(0.5526)
14	(2.25)	0.14133	(0.3180)	(3.40)	0.14133	(0.4805)
15	(2.25)	0.12289	(0.2765)	(3.40)	0.12289	(0.4178)
	(584.75)		***(564.1565)***	***(786.00)***		***(754.8811)***

Substituting parameters into equation 4.9 gives:

$$NPV* = \frac{-584.75M. - (-786.00M)}{(1+0.15)^{15}}$$

Where M = 10^6.

$$NPV* = \frac{-584.75M + 786.00M}{(1.15)^{15}}$$

$$NPV* = \frac{201.25M}{8.13706}$$

$$NPV* = \$24.73M$$

- Hence, since NPV* is positive, select the GTL processing.

V. ECONOMICS ANALYSIS RESULTS:

The results of the LNG versus GTL comparison are shown in Table 4 and 5. The analysis provides a useful tool to compare relative returns from the two projects. For example, for an NPV of $564.16 x 10^6, a gas price of $3/MCF or a crude oil price of $55/bbl are required. At crude oil prices of ~$60/bbl and current gas prices of ~$6/MCF, the LNG and GTL projects seem to offer equal economic returns. Lower oil prices may render LNG more attractive, and higher gas prices may do the opposite. Besides, profitability of LNG production and GTL is very close, and there is no clear economic preference. Both projects compete well with each other. However, if LNG production already exists in a country – a case like Nigeria, a GTL project could be more attractive because it provides the opportunity to diversify the use of gas reserves into other products.

VI. RESEARCH BENEFITS

The following are some of the benefits that can be derived from this project:

1. The project will serve as a source of information to those desiring to acquire knowledge in Gas to liquid technology.
2. As a result of excellent processing of Natural gas using GTL technology, emission of harmful substances to the environment can almost be eliminated.
3. Help in ensuring that best quality fuels from GTL technology meeting the required environmental specification.
4. Utilizing the GTL technology as analyzed in this project will help in achieving the federal government goal towards zero flare in the year 2008.
5. Choosing the best gas utilization means (LNG, CNG & GTL) for a given gas reserve, water depth and offshore field distance to nearest land, using economic analysis.

VII. CONCLUSION

Nigeria is fortunate to have a large and balanced natural gas reserve base (associated and non-associated natural gas) giving a producing life of many years for proven reserves and for all estimated likely reserves should production rates remain at current levels. Should the Federal Government Nigeria (FGN) wish to harness this reserve base and increase production to a higher level, yet maintain a prudent production life for so many years for proven reserves, and then this is achievable, whilst still keeping to the flare out goals set for 2008 and positively change the lives and status of their population in the process. The issues facing the FGN are mostly time and cost driven, and as such, a coordinated comprehensive plan can be made to implement a set of building blocks that achieve maximum overall long-term benefit to Nigeria. Key institutional and regulatory reform is needed to allow progress to be made, a program with strict timelines should be put in place as soon as is practical to ensure the sustainability of the proposed solutions herein. It should be noted, however, that a complete set of actions must be carried out across the whole supply chain for it to be successful as any link not done breaks that chain.

The shortage of petroleum in Nigeria and in the whole world is a clear certitude for the next century. Alternative energy sources are available but the exploitation technologies are in general not as mature as for petroleum.

This has been shown to be the case of natural gas. Indeed, the feasibility of the upgrading of natural gas to valuable chemicals, especially liquid fuels has been known for years.

However, the high cost of the steam reforming and the partial oxidation processes, used for the conversion of natural gas to synthesis gas, has hampered the widespread exploitation of natural gas.

Fischer-Tropsch (F-T) gas to liquid (GTL) synthesis process was shown in this thesis to be an exciting and economical technology for maximum utilization of stranded natural gas after comparing it with other non pipeline options (LNG & CNG). This technology will increase the utilization of stranded natural gas reserves in Niger Delta through the conversion to liquid fuels, forming a viable alternative to LNG and equally decrease the Nigeria's dependence on imported refined petroleum products like diesel, Jet fuel etc. In longer term, natural gas can be substituted to petroleum.

BIOGRAPHY

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