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ESTIMATION OF REVENUE ACCRUING FROM MONETIZATION OF FLARE NATURAL GAS IN NIGERIA

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ABSTRACT

Natural gas is fast gaining dominance in the energy market as more uses of it are discovered frequently. Many Nations have placed stringent laws aimed at completely eradicating gas flaring. This trend has opened new windows in the natural gas industry as investors seize this opportunity to monetize the flared gases. The pertinent issues for investors are what volumes of useful products are recoverable from a given volume of flared unprocessed associated natural gas and the costs of gas recovery and processing technologies. This paper describes in details, the cashflow movements in the life of flare gas projects, indicating areas of expenditures and revenues. It reveals the total financial outlays for a successful flare gas recovery, processing and monetization of 20MMscfd of gas at base conditions. From the work, three main products are recovered from the modular processing plant namely; Dry gas, Liquefied Petroleum gas and Condensates. It also shows that wetter gasses yield more volumes of LPG and condensates than drier gases (C_1/C_2). The study further shows that the main factors affecting gross revenue accruing from the sales of natural gas products are the feed gas stream composition, sales price of the products and the feed gas flow rate.

KEYWORDS: Gas, Flare, Processing, Products, Monetization, Revenue

1. INTRODUCTION

The 21st century ushers us into a time where the immediate environment is held in high concern. Environmental degradation resulting from the production and conventional crude oil utilization for energy has become alarming. Crude oil pollutants have been one of the major contributors to greenhouse gases. There is an urgent global shift to alternative energy sources which are regarded as cleaner and more environmentally friendly.
Natural gas is a good source of alternative energy. It burns with almost no fume and leaves very low carbon footprints. It is also very abundant in the world. Most nations including Nigeria have enormous proven reserves of natural gas.
Before, natural gas was regarded as a by-product of oil production and was flared or vented. This was mainly due to the fact that the available technology then was designed to handle only oil, hence natural gas was seen as a nuisance and unwanted product. Lack of a ready market and demand for natural gas were some factors that also hindered the usage of natural gas in the past.
Currently, the key driver in gas utilization plan is the growing demand for energy from the expanded economy with a challenge to improve technologies for the production, transportation and conversion of this resource. Thus, most economies of the world are diversifying away from oil to gas as energy source (Barnes et al., 2006).
This recent global awareness for alternative energy have prompted the development of the gas industry, there are now technologies to handle gas for transportation, storage and utility. Also industries and homes now rely on natural gas as source of energy and power.
The Nigeria government has enacted laws prohibiting gas flaring in a bid to achieve zero flaring, which will mitigate the challenges of environmental unfriendliness. Thus, with this embargo, operating companies are frequently asked to device means to contain their excess gas production. Moreover, the gas can be used as a secondary drive to enhance depleted oil reservoir, so they are forced to re-inject the excess gas for production of their crude oil reserves like the case of Mobil Oso Gas condensate plant which provides gas for reinjection into nearby oil reservoirs, methane as fuel to power their gas turbines and send the remaining propane plus to their natural gas liquid (NGL) plant at Bonny Island instead of flaring, and as such, wasting the natures resource. Despite the efforts, Nigeria still

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flares most of its associated gas, the financial outlay of the flared gas runs in millions of dollars annually. Aside the financial implications in terms of lost revenue, there is a severe environmental implications resulting from the flaring of gases in the host communities especially in the Niger Delta. Operating companies in a bid to appease the occupants of affected zones have resulted to giving stipends to community leaders and youths. More often, this has resulted in youth restiveness and damages to major operating facilities. This flared gas could be harnessed and monetized and yield revenue to the nation.

This paper describes means to harness the associated gas flared during oil production. The natural gas is captured, processed and sold to buyers who would use it either for power generation, fertilizer production or for industrial purposes. The technology to apply here is the modular gas capture and processing technology which has the advantage of portability and scalability among improved performance as compared to the conventional J-T technologies for gas processing.

2. LITERATURE REVIEW

Barnes, J. et al (2006) said in their work that the trend of natural gas around the world is growing in importance as an energy source, with many uses - residential, commercial and industrial. Kojima, M. (2001) stated that there is even a possibility of producing vehicles that utilize natural gas as a fuel source which is currently being practiced in Edo State of Nigeria. The option of how to transport this commodity is therefore a challenge and as such, gas pipelines are used to convey the natural gas reserves to a close markets

Research has shown that about 20 percent of the primary energy requirements of the world are provided by natural gas. This development has been recorded in only a few years with the increased availability of the gas resources from different countries (Ikoku, 1992).

Stella Madueme (2010) did a work on Gas Flaring activities of major oil companies in Nigeria. Her empirical investigation was focused on finding out the amount of gas flared by several major oil companies in Nigeria. It also tried to show the general trends in gas flaring in seven major oil companies operating in Niger Delta area. Hence, the recommendation that there should be increased government taxation per cubic meter of gas flared in order to reduce its environmental negative implications.

Onwukwe (2009) worked on gas to liquid technology in Nigeria. His article examined the prospect of Gas-to-Liquid (GTL) conversion technology as a sustainable natural gas utilization option. He noted that this technology will make possible the chemical conversion of natural gas into clean diesel, naphtha, and kerosene and light oils, as marketable liquid products.

Iwayemi and Adenikinju, (2001) identify the theoretical condition linking resource rents to economic sustainability. However, despite the various ways in which natural gas can be used in Nigeria, approximately 75% (by 1998), 63% (by 2000) and 24.30% (by 2010) of the total gas output were flared. For instance, if you take gas which is flared in Africa which is around 40 billion cubic meters each year, with Nigeria contributing 46% and used that to generate power in efficient modern power plants, you could actually double the power production in sub- Saharan African, excluding South Africa (Kareem et al., 2012).

3. MATERIALS AND METHODS

Sources of Cost for the Project

The total cost for the flare gas capture and monetization is summarized below as;

Cost of Flare Gas Monetization = Cost of Acquiring Natural Gas + Cost of Processing Natural Gas (1)

(i) Cost of Acquiring Natural gas

This is the total cost of the acquisition of the otherwise flared gas from the operators. In some cases, the operating company may sell off the gas to companies that deal on gas monetization. These companies go into the processing of the natural gas. The price of the natural gas stream depends on the factors highlighted below.

- The volume of the gas
- The composition of the gas
- The level of impurities in the natural gas
- The BS/W of the natural gas.
- The remoteness of the area of production
- The current price of processed natural gas etc.

In some cases, the monetizing company may be part of the government initiative to handle flare gases by producers and as such the monetary value of the flare gas is usually on agreement between the operators, the government and the monetizing company.

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(ii) The Cost of Natural Gas Processing

This includes all the financial rundown starting from the acquisition of the gas to the point of sale to end users. This include many inter-stage processing which are highlighted below.

- Engineering, Procurement and Construction of Gas Processing Facility
- Cost of installation and commissioning of equipment
- Operating and maintenance costs

(a) Engineering, Procurement and Construction of Gas Processing Facility

To achieve optimum gas development, gas processing systems would be deployed. The system for this is combined. One for flare gas capture and the other for processing. In most situations, the two operations happen concurrently inside one system. Since the associated gas is usually wet and rich in liquids, the liquid ends must be separated out from the dry gas and stored. There could be further separation of the NGLs to achieve LPG and plant condensates. This are stored in separate storage facilities in the field awaiting sales or further usage.

Many technology are available for flare gas capture and processing, but we use the modular gas processing technology for this project owing to its ease of usage, portability, scalability and more enhanced performance. Natural gas from feed stream will have to pass through High pressure separators to knockoff pool condensates before the resulting gas enters into the modular gas processing system. The main resulting components from the processing plants are LPG (C_3+C_4), condensates and dry gas (C_1+C_2).

The major contributing cost for the Engineering, Procurement and Construction of Gas Processing Facility are from the following areas.

- Modular LPG Processing Plant cost
- Product Storage Tank and Measurement Systems cost
- Cost of Power Plant for the Operation of the Unit
- Shipping Cost
- Customs Clearing Cost
- Transportation Cost

(b) Cost of installation and commissioning

This includes the total expenses due to the installation and commissioning of the equipment. The areas include Mobilization, Procurement and Installation of Interconnecting piping, installation of units, community settlement, demobilization and contingences

(c) Operating and maintenance costs

The operating and maintenance cost includes all the expenses needed to run the entire facility. It includes fuel cost, workers' wages, maintenance cost etc. This is computed annually.

Economic Evaluation of the Project

The three main products recovered from the flare gas processing facility are

- Dry gas
- LPG
- Condensates

The volume of recovered product depends mainly on the composition of the feed stream and also on the efficiency of the processing facility.

The following parameters are required to quantify the revenue generated from the entire project during the sale of the output products

1. Plant capacity of 20MMscfd
2. 312 plant operational days per year
3. Equipment cost of $15,500,000
4. Annual operating cost (OPEX) of $2,000,000 for 20MMscfd
5. Installation and equipment cost of $1,870,000
6. Plant operating period of 15years
7. 100% owner's equity

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The Composition of the Feed Gas

The composition of the feed gas stream is very important in the calculation of the volume of output products and also in the computation of the revenue generated. The more wet the gas is the more volume of the rich ends hence the liquid portion of it. Thus wetter gasses yield more volumes of LPG and plant condensates than gases with higher percentage of methane.

Case 1

Let us consider a sample feed stream of 20MMscfd. The composition of the gas is given below.

Table 1: Feed gas component and its composition in percentage

Component	Inlet gas (mol %)
methane	86.18
Ethane	4.15
propane	7.46
Butane	1.61
isopentane	0.21
pentane	0.14
Hexane	0.18
heptane	0.1
Octane	0
Nitrogen	0.1
carbon dioxide	0.23
hydrogen sulphate	0
Water	Saturated
Oxygen	0
Total	**100.36**

Calculations from table

1. Volume of dry gas in scf = (mol % of methane + ethane)/100 * total feedstream volume
2. Volume of LPG in scf = (mol % of propane, butane and isobutane)/100 * total feedstream volume
3. Volume of condensates in scf = mol % of C_5+/100 * total feedstream volume

Note: the volumes of LPG and condensates were given in their gaseous forms, to account for their liquid state volume we must multiply by their gas to liquid phase conversion factors for both the LPG and the condensates.

Table 2: The three main products and their constituent volumes

Products	Inlet Gas (Mol.%)	Total Vol. in Gaseous State (MMScf/d)	Total Vol. in Gaseous State (Scf/d)
Dry Gas	90.33	18.0012	18,001,195.70
LPG	9.07	1.8075	1,807,493.03
Condensates	0.63	0.1255	125,548.03

Note: Dry gas is methane and ethane, LPG is propane and butane while condensates are C5+.
Since LPG and condensates underwent change of state to become liquids, we have to calculate the liquid volume occupied by the cubic feet of LPG and condensates respectively.

For the case of LPG

From ideal gas law.

$$pv = nRT \quad (2)$$

$$p = \frac{n}{v}RT \quad (3)$$

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$density = \frac{mass}{volume}, \qquad \rho = \frac{m}{v}$ (4)

but $mass = number\ of\ moles * molecular\ mass,$

$$m = nM$$

Thus,

$\rho = \frac{nM}{v}$ (5)

Then

$pM = \rho RT$

$\rho = \frac{pM}{RT}$ (6)

For LPG, the components are propane and butane each contributing its volume according to the percentage composition in the natural gas inlet stream.
We will look at the propane and butane density when in the gaseous state.
For propane at normal conditions of 1atm and 25ºC
Molecular mass = 0.0441kg/m3
R= 0.000082m3atm/k
T= (273.15+25) = 298.15K

To calculate the density of propane in gaseous state at the given conditions

$$\rho = \frac{1*0.0441}{0.000082*298.15} = 1.803806\text{kg/m3}$$

Similarly for butane in gaseous state
Molecular mass = 0.0581kg/m3
R= 0.000082m3atm/k
T= (273.15+25) = 298.15K

The density of butane in gaseous state at the given conditions

$$\rho = \frac{1*0.0581}{0.000082*298.15} = 2.376443\text{kg/m3}$$

From literature, the densities of propane and butane in the liquid state are given as 508kg/m3 for propane and 599kg/m3 for butane respectively at conditions of 1 atm and 25oC.
From the formula

$\rho = \frac{m}{v}$, then $m = \rho v,$

$m_g = \rho_g v_g$ for gas, and $m_l = \rho_l v_l$ for liquids

Since mass is constant during the liquefaction process, then

$\rho_g v_g = \rho_l v_l$

Then, $\frac{\rho_l}{\rho_g} = \frac{v_g}{v_l}$ (7)

For the propane butane mix, we have to determine the density of C_3/C_4 mix in the gaseous state and the LPG density in the liquid state taking into consideration the percentage compositions of propane and butane respectively.

The percentage compositions of propane and butane in the mix is calculated in the table below.

Table 3: C_3/C_4 mix and its mol%

Products	**C3/C4**	**Propane**	**Butane**
% Composition in Natural Gas	9.07	7.46	1.61
% Composition in C3/C4 *mix*	100	82.2	17.8

The C_3/C_4 *mix* is calculated as follows:

$$Density\ of C3/C4\ \ mix\ in\ gas\ phase\ = \frac{(density\ of\ C3H8 * mol\%) + (density\ of\ C4H10 * mol\%)}{100}$$

$$Density\ of C3/C4\ mix\ in\ gas\ phase = \frac{(1.803806 * 82.2) + (2.376443 * 17.8)}{100}$$

=1.905735kg/m3

Similarly the density of the LPG in liquid phase is gotten below

$$Density\ of\ LPG = \frac{(508 * 82.2) + (599 * 17.8)}{100}$$

= 524.198kg/m3

To calculate the liquid gas expansion ratio, recalling (7)

$$\frac{\rho_l}{\rho_g} = \frac{v_g}{v_l}$$

Then the ratio is

$$\frac{\rho_l}{\rho_g} = \frac{524.198}{1.905735} = 275.0634$$

Therefore, the expansion ratio of the C_3/C_4 mix at 25ºC and 1 atm from liquid to gas is 1: 275.0634.
Then gas volume of 1807493.03scf will yield 1807493.03SCFt/275.0634 of liquid.
Which is equal to 6571.187scf of LPG.
Then converting to barrels, we divide by 5.615 which is 6571.187/5.615 = 1170.29bbls

For the case of Condensates

Since condensates contain many constituents, the condensates-Gas ratio determination is somewhat difficult to calculate since it depends on a variety of parameters such as the mol% of constituent, the PVT of the components etc.

But for this work the CGR is given as 90.36 in consistent units.

For C_5+ volume of 125,548.0271scf, the volume of condensates produced in liquid state is 125548.0271/90.36109 = 1389.40368scf

Converting to barrels we divide by 5.615 i.e. 1389.40368/5.615 = 247.445bbls.

From the data table above, there are three main products derivatives and their product composition are given in the table 4.

Case 2:

Considering Gas Feed streams of 16MMscfd, 12MMscfd and 8MMscfd

Let us consider a sample feed stream of 16MMscfd, 14MMscfd, 12MMscfd, 10MMscfd and 8MMscfd corresponding to 80%, 60% and 40% of the base inlet gas volume (20MMscfd) respectively. The same capital and operating cost used for case 1 is assumed. This is done to determine the revenue change accrued when the plant is subjected to production that is less than its intended capacity. The composition of the gas is same as the case of the 20MMscfd as given below

Table 5 is the result generated for liquid volumes of the three products at different gas feed streams.

Case 3:

Let us consider a sample feed stream of different gas composition (that is, flare gas stream from a field with different gas compositions) at same Feed rate of 20MMScfd. The composition of the gas is given below.

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Table 4: Feed gas component and its composition in percentage

Component	Inlet gas (mol %)
methane	65.24
Ethane	3.12
propane	15.23
Butane	5.61
isopentane	3.76
pentane	2.45
Hexane	2.76
heptane	1.56
Octane	0
Nitrogen	0.1
carbon dioxide	0.23
hydrogen sulphate	0
Water	Saturated
Oxygen	0
Total	100.06

Table 5: The three main products and their constituent volumes

Products	Inlet Gas (Mol.%)	Total Vol. in Gaseous State (MMScf/d)	Total Vol. in Gaseous State (MScf/d)	Total Vol. in Gaseous State (Scf/d)
Dry Gas	68.36	13.66380172	13663.802	13,663,801.72
LPG	20.84	4.1655007	4165.5007	4,165,500.70
Condensates	10.53	2.104737158	2104.7372	2,104,737.16

For LPG (C_3/C_4)

The percentage compositions of propane and butane in the mix are calculated in the table below.

Table 6: C_3/C_4 mix and its mol%

Products	C3/C4	Propane	Butane
% Composition in NG	20.84	15.23	5.61
% Composition in C3/C4 *mix*	100	73.08	26.92

The C_3/C_4 *mix* is calculated as follows:

$$Density\ of C3/C4\ mix\ in\ gas\ phase\ = \frac{(density\ of\ C3H8 * mol\%) + (density\ of\ C4H10 * mol\%)}{100}$$

$$Density\ of C3/C4\ mix\ in\ gas\ phase = \frac{(1.803806 * 73.08) + (2.376443 * 26.92)}{100}$$

=1.9556kg/m3

Similarly the density of the LPG in liquid phase is gotten below

$$Density\ of\ LPG = \frac{(508 * 73.08) + (599 * 26.92)}{100}$$

= 532.4972kg/m3

The liquid gas expansion ratio = $\frac{\rho_l}{\rho_g} = \frac{v_g}{v_l}$

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Then the ratio is

$$\frac{\rho_l}{\rho_g} = \frac{532.497}{1.9556} = 272.2934$$

Therefore, the Liquid to Gas expansion ratio of the C3/C4 mix at 25ºC and 1 atm is 1: 272.2934.

Hence, 4,165,500.70scf of gas will yield 4,165,500.70/272.2934 of liquid = 15,297.839Scf of LPG

Converting to barrels, = 15,297.839/5.615
= ***2724.4593bbls of LPG***.

For Condensate (C5+);
The Volume of condensate in liquid state = 2,104,737.16/ 90.36 = 23292.7973Scf
Converting to barrels = 23,292.7973/5.615
= ***4,148.3165bbls of Condensate***
Table 9 is the result of ***product composition and its cash flow analysis***

4. RESULTS AND DISCUSSION

(i) Results

Table 7: Product composition and its cash flow analysis

Products	**Output per day**	**Price**	**Daily Revenue ($)**	**Annual Revenue ($)**	**Total Revenue after 15Yrs ($)**
Dry gas	18MMscfd	$3/Mscf	54,000.00	16,848,000.00	252,720,000.00
LPG	1170.29bbls/day	$15/bbl	17,554.35	5,476,957.20	82,154,358.00
condensates	247.445bbls.day	$50/bbl	12,372.25	3,860,142.00	57,902,130.00
Sum			**83,926.60**	**26,185,099.20**	**392,776,488.00**

The above shows that the gross revenue generated from the sales of the product is $26,185,099.20 per annum.

A MATLAB program Revenue. Calculator was used to calculate the gross revenue of different composition of feed stream at different prices of output product.

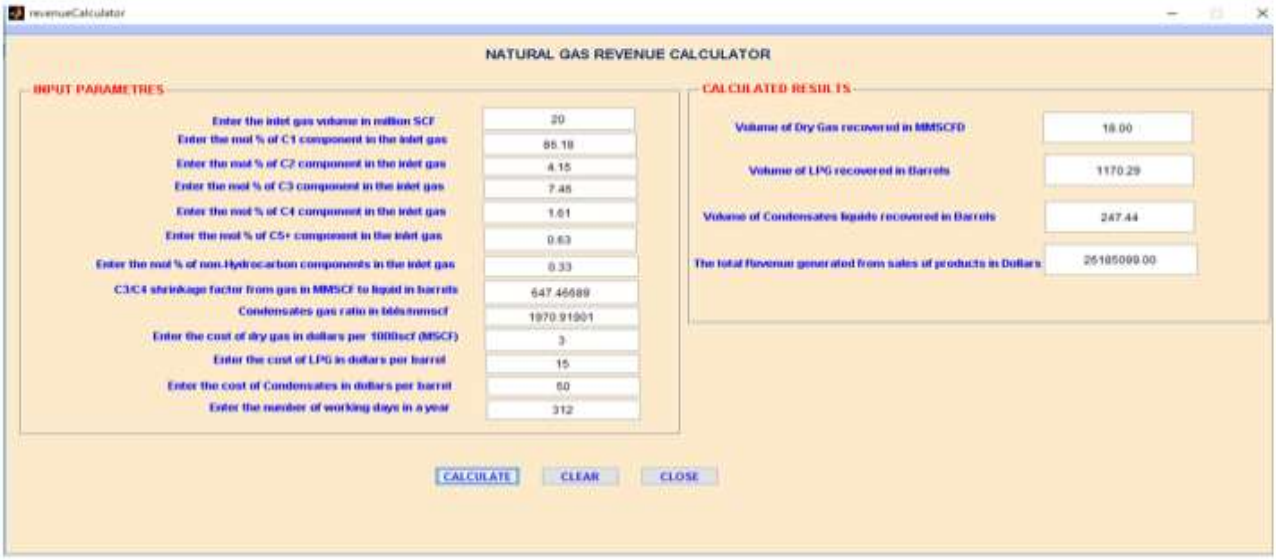

Figure 1: MATLAB program view of results for the revenue calculation of case 1

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Table 8: The three main products and their constituent volumes for different Gas feed streams

			20MMScf		*16MMScf*		*12MMScf*		*8MMScf*	
S/Nos.	**Products**	**Inlet Gas (Mol%)**	**Vol. (MMScfd)**	**Vol. (Scfd)**	**Vol. (MMScfd)**	**Vol. (Scfd)**	**Vol. (MMScfd)**	**Vol. (Scfd)**	**Vol. (MMScfd)**	**Vol. (Scfd)**
1	*Dry Gas*	*90.33*	18.0012	18001200	14.401	14401000	10.8007	10800717	7.2005	7200478
2	*LPG*	*9.07*	1.8075	1807500	1.4459	1445994	1.0845	1084496	0.7229	722997
3	*Condensate*	*0.63*	0.1255	125548	0.1004	100438	0.07523	75329	0.05202	50219

Recalling that LPG-Gas expansion ratio is 1:275.0634 and Condensate-Gas expansion ratio is 90.36, the tables below show the Products compositions and their Cash flow analyses;

(i) For 16MMScf/d

Products	**Output per day**	**Price**	**Daily Revenue ($)**	**Annual Revenue ($)**	**Total Revenue after 15yrs ($)**
Dry gas	14401Mscfd	$3/Mscf	43,203.00	16,848,000.00	202,190,040.00
LPG	936.23bbls/day	$15/bbl	14,043.45	5,476,957.20	65,723,346.00
Condensates	197.96bbls.day	$50/bbl	9,898.00	3,860,142.00	46,322,640.00
Sum			**67,144.45**	**20,949,068.40**	**314,236,026.00**

(ii) For 12MMScf/d

Products	**Output/day**	**Price**	**Daily Revenue ($)**	**Annual Revenue ($)**	**Total Revenue after 15yrs ($)**
Dry gas	10800.7Mscf	$3/Mscf	32,402.10	10,109,455.20	151,641,828.00
LPG	702.17bbls	$15/bbl	10,532.55	3,286,155.60	49,292,334.00
Condensates	148.469bbls	$50/bbl	7,423.45	2,316,116.40	34,741,746.00
Sum			**50,358.10**	**15,711,727.20**	**235,675,908.00**

(iii) For 8MMScf/d

Products	**Output/day**	**Price**	**Daily Revenue ($)**	**Annual Revenue ($)**	**Total Revenue after 15yrs ($**
Dry gas	7,200.5Mscf	$3/Mscf	21,601.50	6,739,668.00	101,095,020.00
LPG	468.12bbls	$15/bbl	7,021.80	2,190,801.60	32,862,024.00
Condensates	98.978bbls	$50/bbl	4,948.90	1,544,056.80	23,160,852.00
Sum			**33,572.20**	**10,474,526.40**	**157,117,896.00**

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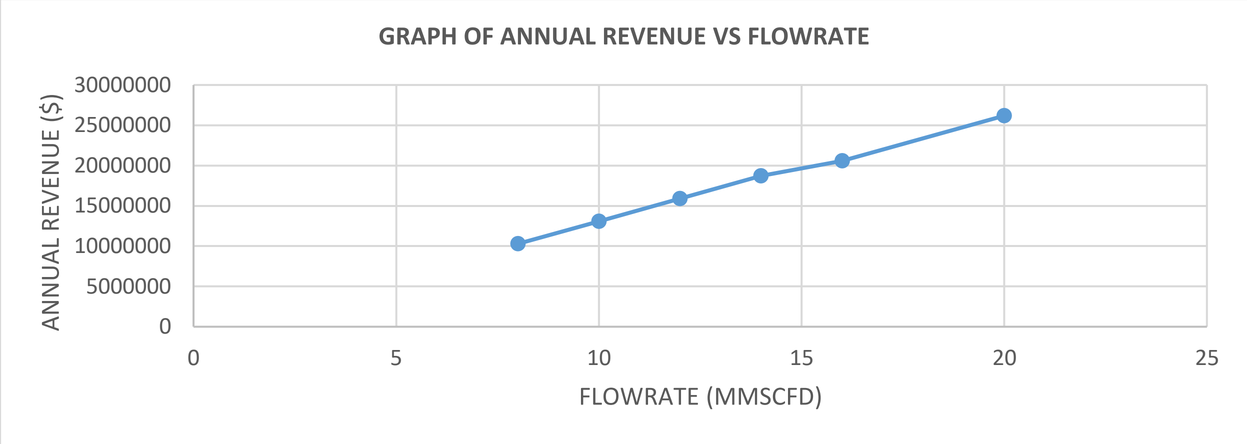

Figure 2: Graph of Annual revenue ($) from products and flow rate (MMscfd)

Table 9: Product composition and its cash flow analysis

Products	**Output per day**	**Price**	**Daily Revenue ($)**	**Annual Revenue ($)**	**Total Revenue after 15yrs ($)**
Dry gas	13,663.802Mscfd	$3/Mscf	40,991.41	12,789,318.67	191,839,780.08
LPG	2,724.4593bbls/day	$15/bbl	40,866.89	12,750,469.44	191,256,951.6
condensates	4,148.3165bbls.day	$50/bbl	207,415.83	64,713,737.40	970,705,944.00
Sum			**289,229.11**	**90,239,483.72**	**1,353,542,372.00**

The gas composition above indicates that the gas contains more of the rich components.
Using the MATLAB Software.

Figure 3: MATLAB program view of results for the revenue calculation of case 3

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(ii) Discussion

From figure 3 above gotten when the MATLAB program was ran, the annual revenue generated is **$90,239,483.72**. This is three times greater than the revenue from case 1. This change is due to the fact that the gas stream contains more of the richer hydro-carbon components (LPG and Condensate), and hence more of the richer components translate to more revenue.

Thus the main factors affecting the gross revenue from the sales of the gas products includes, the composition of the feed gas stream, the current sales price of the product and the feed gas flow rate.

From figure 2, it is seen that total revenue has a linear relationship with the flow rate of the inlet gas stream. This is true when the total expenditure is kept constant and the price of each product, i.e. dry gas, LPG and condensates is assumed to be uniform.

For all cases of changes in total expenditure and price of commodity, the graph is a straight line, the only change is the gradient of the line that differs as a result of changes in total expenditure or/and price of commodity.

Economic Analysis

From *Case 1*, 20MMscfd of feed gas stream of inlet gas yields revenue of $26,185,099.20 while the revenues for 16MMscfd, 12MMscfd and 8MMscfd feed gas streams are $20,949,068.40, $15,711,727.20 and $10,474,526.40 respectively**.**

When we consider the cost incurred in the overall process, the resulting net revenue will be an indicator of the viability of the project.

Assuming a 15 year project duration and 312 plant operational days, the table below summarizes the total products to be recovered from the flared gas for Case 1 (20MMscfd).

Table 10: Expected Value for All Gas Products for Case 1

S/No	Gas Product	Expected Cumulative Production (BSCF)	Expected Cumulative Production (Bbls)	Unit Price of Product (USD)	Amount (USD)
1	**Dry Gas**	84.24	-	$3/Mscf	252,720,000.00
2	**LPG**	-	5,476,957.2	$15/bbl	82,154,358.00
3	**Condensate**	-	1,158,042.6	$50/bbl	57,902,130.00
		Total			**392,776,488.00**

The cumulative Dry gas, LPG and condensates yields are;
Dry Gas = 84.24Bscf
LPG = 5,476,957.2bbls
Condensates = 1,158,042.6bbls

The cost incurred in the process is summarized below
Total CAPEX Investment = $17.37M
Total OPEX = $2M * 15 for the 15 years plant operational period = $30M
Total Capital Investment = $ 47.37MM
Total Expected Gas Recovery = 93.6 BSCF (i.e. Dry gas = 84.24Bscf, LPG = 5.48MMbbls, Condensate = 1.16MMBbls)

For *Case 3*, using the same conditions, we have the table below.

Table 11: Expected Value for All Gas Products for Case 3

S/No	Gas Product	Expected Cumulative Production (BSCF)	Expected Cumulative Production (Bbls)	Unit Price of Product (USD)	Amount (USD)
1	**Dry Gas**	63.93	-	$3/Mscf	191,790,000.00
2	**LPG**	-	12,736,432.8	$15/bbl	191,046,492.00
3	**Condensate**	-	19,414,137.6	$50/bbl	970,705,944.00
		Total			**1,353,542,372.00**

The cumulative Dry gas, LPG and condensates yields are;
Dry Gas = 63.934Bscf
LPG = 12,736,432.8bbls
Condensates = 19,414,137.6bbls

The cost incurred in the process is summarized below
Total CAPEX Investment (Cost of Equipment + Cost of Installation) = $17.37M
Total OPEX = $2M * 15 for the 15 years plant operational period = $30M
Total Capital Investment = $ 47.37MM
Total Expected Gas Recovery = 93.6 BSCF (i.e. Dry gas = 63.93Bscf, LPG = 12.736MMbbls, Condensate = 19.41MMBbls)

Table 12: Product compositions and cash flow analyses of Gas feed Streams from Two (2) fields

	Field A				**Field B**			
Products	***Dry gas***	***LPG***	***Condenste***	***Sum***	***Dry gas***	***LPG***	***Condenste***	***Sum***
Output/d	18MMscfd	1170.39bbls/d	247.45bbls/d		13.67MMscfd	2,721.6bbls/d	4,148.3bbls/d	
Price	$3/Mscf	$15/bbl	$50/bbl		$3/Mscf	$15/bbl	$50/bbl	
Daily Rev. ($)	54,000	17,555	12,372	***12,372***	41,010	40,824	207,415	***289,249***
Annual Rev. ($)	16,848,000	5,477,452	3,860,142	***3,860,220***	12,795,120	12,737,08 8	64,713,480	***90,245,688***
Total Rev. after 15yrs ($)	252,720,000	82,161,378	57,902,130	***57,903,300***	191,926,800	191,056,320	970,702,200	***1,353,685,320***

5. CONCLUSION

The approach to revenue generation from flare gas monetization have been carried out in this work. The approach made use of modular gas technology because of its cost saving and high performance advantage.
The study shows that monetization of flare gas using modular gas technology is technically feasible and investment in such venture is economically profitable. Generally it is seen that the project is viable from the revenues generated from the sales of the processed flare gas products. Thus when investors or government veer into it, it will yield additional revenue to the country, provide jobs and keep our environment safe from the consequences of gas flaring.
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NOMENCLATURE

MGT: Modular Gas Technology
CAPEX: Capital Expenditure
OPEX: Operating Expenditure
NPV: Net Present Value
IRR: Internal Rate of Return
POT: Pay-Out Time
Mscf: Thousand standard cubic feet
MMscf: Million standard Cubic Feet
MMscfd/d: Million standard Cubic Feet per day
Bscf: Billion standard cubic feet
LPG: Liquefied Petroleum Gas

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