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ANALYSIS OF LNG (LIQUEFIED NATIONAL GAS) PRODUCTION ECONOMICS IN NIGERIA

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ABSTRACT

The experiment revealed that corrosion rate decreases with an increase in distance from the gas flare point. That is, the farther the metal is away from the flare point; the less corrosive it becomes and the nearer the metal to the flare point, the more corrosive it becomes. Furthermore, the developed model when compared with the experimental results showed that corrosion rate increased with an increase in time and anodic current density and decreased with an increase in distance. The result also showed that out of the four different metals used for the experiments, only iron and zinc showed significant loss in weight whereas aluminum and steel showed little or no loss in weight.

Keywords: LNG, Conversion table, Production Economics.

I. INTRODUCTION

It has become evidently clear that Nigeria is heading for industrial colonization amidst enormous potentials to become industrial giant in Africa and the world at large. This truly calls for great concern. Enormous quantities of natural gas have been flared from the inception of oil exploration and production activities in Nigeria. Several problems ranging from health to environmental degradation such as skin cancer, global warming and the destruction of aquatic life which in effect, is more on the Niger Delta region of the country, is caused by gases incessantly flared into the atmosphere. Produced natural gas if technologically harnessed and adequately utilized would have yielded huge revenue for the federal government and increase her foreign reserve potentials, as well as creating job opportunities for the millions of jobless Nigerian graduates.

Nigeria is blessed with large reserves of natural gas: hence, it is expected that natural gas be the most available and cheapest source of fuel from which LPG can be adequately obtained and used in the country. Ironically, LPG and LNG are the least utilized. For LPG, it is one of the most expensive sources of fuel in which less than 15% of the citizenry depend on, while the rest sought after alternative sources of cheaper fuels owing to its cost and scarcity (NNPC ASB 2011).

The price of cooking gas also known as liquefied petroleum gas (LPG) may go higher as the Nigerian LNG and Escarvous gas plant (Chevron/NNPC) is not ready to leave some of its products for the local market. This leaves Nigerians totally dependent on imported cooking gas at a highly ridiculous prize. It is crystal clear that the major draw-back to the development of the local market in Nigeria can be traced to poor fiscal and regulatory policies, financing and inadequate gas infrastructure, particularly pipelines connecting the gas sources to the market. Current estimates suggest that very huge investment will be required to develop a national gas grid in Nigeria. Hence the need to source for alternative production and transportation means.

Federal government has indeed taken several measures in curbing the flare rate of natural gas whose sense of magnitude was only recently taken to cognizance. The Federal Government Promulgated Decree 99 of 1979 (known as GAS RE-INJECTION DECREE). It stipulated that all oil producing companies either re-inject associated gas into the reservoir to enhance production or explore and identify other means for its utilization by 1984. It also placed strict adherence that further flaring without permission will attract a penalty. However, none of these companies adhered to the provisions of decree 99.

As a result of this, federal government opted for the amendment of decree 99 with the imposition of a fine of 2 kobo per 100 standard cubic feet (2K/Msct) of gas flared after January 1, 1985. This could not also serve as a deterrent as the companies preferred to pay the fine rather than stop flaring. The fine was increased from 2 kobo to 50 kobo. It is hard to believe that yet, the flaring continued and the companies also declined to engage in projects that will promote flare-out to save health and environment. Finally, in 1998, the federal government announced 1,900 percent increase in the applicable penalty for gas flaring to ₦10 per 1,000 cubic feet and set a

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deadline for full flare-out in 2008. This effort has drastically reduced the flared percent to about 27 percent since 2006. This scenario has indeed prompted this work.

Past Review

LNG Production

A certain range of desired heating value for the LNG sold into the market is usually specified in most contracts. It then implies that in most cases, before liquefaction, certain fractions of the heavier hydrocarbon components found in natural gas be removed to ensure that the LNG does not exceed the upper limit on heating value. Some natural gases also require removal of the heavy ends to obviating operating problems in the liquefaction cycle, such as freezing of aromatic hydrocarbons at low temperatures.

The removal of the heavier hydrocarbons from the natural gas is considered to be a feed conditioning step in most existing LNG plants, and is not integrated into the overall liquefaction scheme beyond the use of some of the high-level refrigeration from the LNG cycles. Improving the overall liquid recovery efficiency of the total LNG production cycle could be paramountly improved through careful integration of the hydrocarbon removal step into the LNG liquefaction process. This allows not only production of both LNG and a separate heavier hydrocarbon liquid product using significantly less energy than the current processes, but has the added benefit of producing a high quality co-product to generate a second revenue stream for the facility. Upon removal of $C0_2$ and any other sulphur compounds, the natural gas is dehydrated before entering the liquid removal section where heavier hydrocarbons are stripped off the natural gas, using high-level refrigerant to provide the cooling needed to condense the liquids and the residual gas is then liquefied, using high-level and low-level refrigerant.

Impurities: Raw natural gas condensate, water, hydrogen sulfide, carbon dioxide, mercury

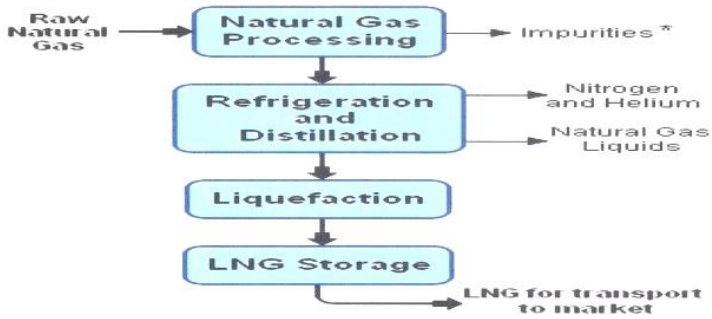

Figure 1: Liquefaction plant for the production of LNG

Nigeria is blessed with abundant reserves of associated and non-associated gas estimated in excess of 180 trillion cubic feet (tcf) (facts and figures on NLNG, 2011). The country is ranked 7th in terms of proven natural gas reserve in the world, the natural gas reserved production being estimated at over 100 years (facts and figures on NLNG, 2011). In terms of gas production, Nigeria currently produces an average of 5.1 Bcf of gas per day out of which 3.6 Bcfd representing about 71% is utilized and the remaining flared (Dakoru, 2005). However, in terms of associated gas produced, about half of the 2Bcfd associated gas produced in Nigeria is still flared (Shannon, 2006). Following this, the Nigerian LNG limited was incorporated in 1985 to produce and sell liquefied natural gas and natural gas liquid, using Nigeria's abundant natural gas reserves (Chris, 2005).

II. MATERIALS AND METHOD

The raw natural gas extracted from producing wells usually contains hydrocarbons and fluids. For this reason, it is imperative that the gas be well treated before it is used. The process of separating all of the various non-hydrocarbons that are not needed from the raw natural gas to produce what is known as "pipeline quality" dry natural gas is referred to as natural gas processing. The undesirable non-hydrocarbons that are usually removed during gas processing are; CO_2, H_2O, mercaptans (H_2S) below 1ppm and heavier hydrocarbons (pentane plus). Natural gas processing entails several stage of operation to arrive at the desired quality of gas. The stages as shown in figure below are,

- Gas receiving
- Gas treating

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- Liquefaction
- Storage
- Transportation

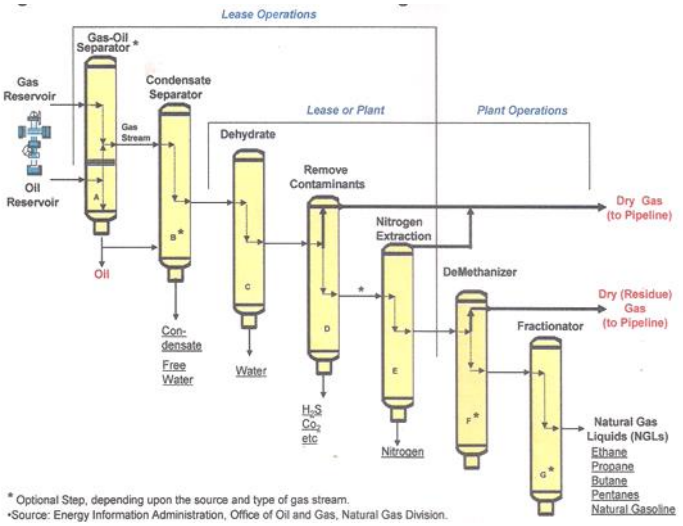

Figure 2: A generalized natural gas processing schematics

III. CONSUMPTION OF NATURAL GAS

Each country across the globe, has its own pattern of natural gas consumption based on accessibility. It has been noticed that, countries with large reserves tend to handle the raw material (natural gas) more generously, while the reverse is the case for countries with scarce or lack of resources. They rather tend to be more economical. Despite the considerable findings, the predicted availability of the natural gas reserves has hardly changed.

Physical Properties of LNG Main Component (CH_4)

COMPONENT	METHANE
FORMULA	**CH_4**
Molecular weight	16.043
Boiling point at 14.696 psia	- 258.69
Freezing point ^0F	-296.46
Vapour pressure (100^0F) psia	5000
Critical pressure (psia)	667.8
Critical temperature (^0F)	- 116.63
Critical volume (Cuft/1b	0.0991
Specific gravity air = 1	0.5539

For a successful production of LNG, a proper knowledge of their property is required for the achievement of a quality output and to minimize production hazards. Such properties are as shown in table above.

SOURCE OF LNG

The world has enormous quantities of natural gas but much of it is in areas too far from where the gas is needed. To move this clean – burning fuel across oceans, natural gas must be converted to liquefied natural gas (LNG), a process known as liquefaction. LNG is natural gas that has been cooled to $-260^0F(-162^0c)$, changing it from gas to liquid that is $^1/_{600th}$ of its original volume. This dramatic reduction in volume allows it to be shipped safely and efficiently abroad in specially designed LNG vessels. Upon arrival at its destination LNG is warmed to return it to its gaseous state before delivered to natural gas customers through local pipeline. In the year 2011, Nigeria produced total gas of 2,400,402,880 mscf out of which 1,781,370,022mscf was utilized and

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619,032,858mscf representing 25.79% was flared (NNPC ASB 2011). This fact suggests that LNG business will be very viable in Nigeria.

LNG PRODUCTION INFRASTRUCTURE

The major LNG production infrastructure is the LNG plants which consist of several sections through which the natural gas (feed gas) is processed to arrive at the desired product (LNG).

LNG Production/Exportation for Six Years

S/N	Year	Production Per Annum (MMT)	Export Per Annum (MMT)
	2006	17.00	17.00
	2007	22.00	18.2
	2008	22.00	18.1
	2009	22.00	18.00
	2010	19.00	18.1
	2011	19.00	18.7

Source: NLNG (2011), Facts and Figure.

The delay in processing the NLNG train 7 project, as well as the Brass LNG and OK LNG projects, had so far deprived Nigeria of raising its LNG production to a potential of 52 million metric tones per annum (NLNG Facts & Figure, 2011)

RESULTS

COST OF LNG PRODUCTION INFRASTRUCTURE

The major LNG production infrastructure in Nigeria is the NLNG gas plant in Bonny Island of Rivers State. According to the 2011 edition of NLNG facts and figure, the cost of the LNG plant in Bonny is broken down as follows:

S/N	Description	Amount
i.	Train 1 and 2 cost	$3.6bn ₦ 558,000,000,000.00 ₦ 5.58×10^{11}
ii.	Train 3 cost	$1.8bn ₦ 279,000,000,000.00 ₦ 2.79×10^{11}
iii.	Train 4 and 5 cost	$2.2bn ₦ 341,000,000,000.00 ₦ 3.41×10^{11}
iv.	Train 6 cost	$1.748bn ₦ 270,940,000,000.00 ₦ 2.7094×10^{11}
v.	Total cost of trains 1,2,3,4,5 and 6 will be = $9.38bn = ₦ 1,448,940,000,000.00 = ₦ 1.44894×10^{12}	

Cost of a Full Scale Crude Oil Refining Company

An agreement was signed on the 14th of May 2010 between Nigeria's state oil company, NNPC and the China State Construction Engineering Corporation (CSCEC) to build an oil refinery in Nigerian for $8.bn. The refinery

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will be built in the Lekki free zone of Lagos. In the deal, Chinese will cover 80% of the cost, and Nigeria (NNPC) 20%, while the state of Lagos will provide land and infrastructure.

Under the aggregate of $23bn framework agreement signed in May, NNPC and CSCEC will also build two other refineries, in Bayelsa and Kogi, as well as a fuel complex.

The above record suggest that, building a full scale refinery with pipeline and other paraphernalia will cost $8bn which at an exchange rate of ₦ 1.00 :$155.00 will be three trillion, two hundred and fourthly billion naira (₦3,240,000,000,000.00).

Table : Comparative Summary of LNG Production Economies in Nigeria

EVENT	LNG
Total production for 5 years (2006-2011) (metric tons)	121,000,000
Average production per annum (metric tons)	20,166,666.67
Expected yearly production at full capacity (MT)	22,000,000
Production shortfall per annum at domestic level(metric ton)	1,833,333.33
Production shortfall at W/A sub-regional level (MT)	N/A
Percentage production in relation to the expected quantity at full capacity	92%
Production infrastructure in Nigeria	NLNG plant Bonny.
Cost of production infrastructure	$9.348bn (for trains 1,2,3,4,5 and 6).
Average cost of product in global market within the period under review	$11.00/MMBTU
Expected revenue at full capacity per annum(metric ton)	$12,584,000
Expected total revenue within the period under review(metric ton)	$75,504,000
Actual revenue generated within the period under review	$66,752,400
Ratio of revenue generation in relation to crude oil revenue generation	1 : 33
Payback period	1year
Profit to investment ratio (P/I) at 15% discount rate.	14.436
Net present value for the 6 years under review	36,635,385.98

IV. DISCUSSION

This research on LNG production has revealed that a good number of inherent factors by producer and regulating agencies have not done some things appreciably well such as capacity production, effective utilization, effective supply, availability, proper pricing and affordability.

Whereas LNG has met about 95% of its expectation in the nations' economy.

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Production – This research work reveals that, the refineries remain the only major source of local supply of LPG apart from importation. But unfortunately, the refineries have been operating far below installed capacity due to lack of maintenance of the operating units, resulting to regular downtime and enormous loss of man-hour. Whereas NLNG Bonny plays the major role in the production of LNG and has been considerably consistent, via proper maintenance of the operating units.

Infrastructures – This work also revealed that, although there are some gas plants capable of processing NGL, AG, to extract LPG, their original design cannot make it possible. A good example is the LNG plant in Bonny and the Escravos gas plants owned by Chvron/NNPC. They do not have storage facilities for local supply. As such, the little it produces (about 5, 250 barrels/day) are for export.

Distribution: Most of the gas plants are either on the coastal area or in the offshore. This is quite important as there are no pipeline network dedicated to LPG for its distribution.

Even the LPG produced in PHRC could only be carried to Lagos areas by coastal barges that are very expensive to maintain (about ₦80 million per annum for one). Tankers are used to distribute to Hinterland and Cities. One therefore has to pay the bridging price which is Quite un-economical. Where as LNG distribution is quite easy and straight, using the LNG Loading ships of different capacities and shapes.

Lack of Effective Energy Policy. It is quite surprising that up till now, government has not established any mode of operation for the active players in oil/gas exploration and exploitation by enacting effective laws and regulating their activities. This has affected the production of both LNG and LPG negatively at the domestic field.

Conversion Table

1 Tonne of crude oil is equivalent to	7.4074 barrels
1 Tonne of crude oil is equivalent to	1,178 liters
1 Barrel of crude oil is equivalent to	159 litres
1 Barrel crude oil is equivalent to	5,800 scf of natural gas
1 Tonne of coals is equivalent to	4.789 barrels of oil
1 SCM of natural gas is equivalent to	37.3scf
1 Imperial gallon of gasoline is equivalent to	4.54 litres
1 US gallon of gasoline is equivalent to	3.79 litres
1 Tonne of premium motor spirit	1,361 litres
1 Tonne of automotive gas oil	1,182 litres
1 Metric tones of LPG is equivalent to	6bbl of oil (price)
1mm Tonne LNG	52 trillion btu LNG

ECONOMIC IMPLICATION

From table 3.5, it is observed that LPG production between 2006 and 2007 experienced a tremendous fall. On getting to 2008 through 2009, production stagnated at 25 thousand and some fractions in metric tons. In 2010, there was an increase in production, and peaked in 2011 at 106,603MT. This unsteady trend is due to the downtime of the refineries; obvious need to import in order to argument the shortfall become imperative.

Revenue Generation Analysis of LNG Production

Revenue generation at design capacity ($)	Revenue loss ($)	Ratio of crude oil Vs LPG & LNG product generation
LNG 75,504,000	LNG 8,751,600	LNG:OIL 1:33

Cost of Modular Refineries

In a bid to boost the refining of crude oil in the Country, the Federal Government of Nigeria signed an agreement with an American and Nigeria Joint Venture Group, Vulcan Petroleum Resources Limited and

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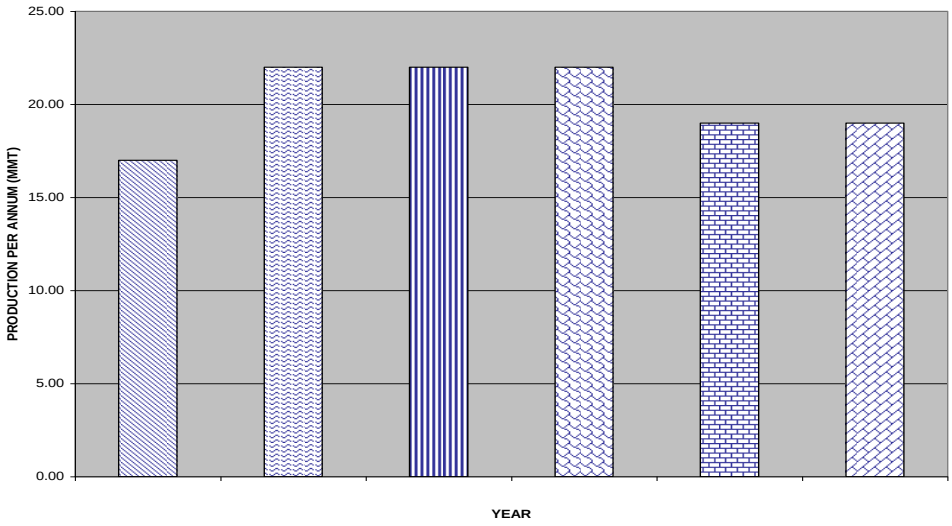
Petroleum Refining and Strategic Reserve Limited for the construction of six (6) modular refineries. The six refineries are estimated to gulp $4.5bn (₦697.5bn) with a combined capacity of refining 180,000 barrels of oil per day.

If six (6) modular refineries cost $4,500,000,000 which at an exchange rate of ₦ 1.00 = $155 = ₦697,500,000,000 then building one (1) modular refinery will cost $4,500,000,000÷6 = $750,000,000 = ₦116,250,000,000.00



V. CONCLUSION

Going by the findings in this research work, it is obvious that, the refineries remain the major source of LPG in Nigeria but unfortunately, they are producing far below their installed capacity due to some technical failures. The country therefore embarked on importation in order to sustain the demand though at a very high price. Consequently, LPG production for the period under review had been quite un-economical as production met only 9% of the expected.

On the other hand, the Bonny LNG gas plant has been the only source of LNG in Nigeria. The production within the period under review has been economical, based on its installed capacity. Though, there is still need and possibility to improve since the competition in the global market is becoming stronger by the year.

It was also observed that the price of LPG in the global market is higher than that of LNG.

If LNG train 7 is completed and operational, Nigeria will be better for it. This will increase production to 52 million metric tons per year as against the prevailing 22 millions tons per year.

LNG production for the period under review (2006-2011) is quite economical as production meets about 92% of the expected.

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