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# Cost–Benefit Analysis of Associated Gas Flaring in the Niger – Delta Area of Nigeria (a case study of 1958 – 2004

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**ABSTRACT:** Associated gas flaring has been revealed as a significant contributor to the warming of the local climate of the communities where these flare stacks are located. Associated gas flaring has also been revealed as a major casual factor to the degradation of the environment, air pollution and consequent health effects of the inhabitants of these host communities. This study goes a step further to assess the economic benefit of total utilization of associated gas as an ante dote to these problems as it is been argued that flaring this gas is cheaper than total utilization. The research uses as its case study the Niger – Delta region of Nigeria a West African country with 1958- 2004 been the years under review. The study adopted the Cost – Benefit approach/ Method of analysis as well as relied on secondary face to face interview. Results from the study revealed that the economic benefit of total utilization of associated gas far outweighs the cost of flaring associated gas. Results from the study also reveal that if Nigeria had utilized the associated gas from crude oil exploitation from 1958 -2004; the country would be $32 billion richer. This is without the estimation of the multiplier effect of reinvesting these monies. The research further reveals that the country requires another Liquefied Natural Gas (LNG) plant 1.4 times the capacity of the Bonny LNG plant to totally processthese associated gases for onward utilization. In the light of these revelations the study recommends a strategic legal framework for the formulation of an act for the operation and governance of the Nigerian Liquefied Natural Gas (NLNG) be put in place by the government as this is a major bottleneck to the development of the sector. Also in the development of strategic plans and policy guidelines for the enactment of the act, the host communities should be in full participation. This is to ensure transparency and equity which will further result in total cooperation and compliance by all stakeholders. Furthermore, the study recommends a time frame be set for routine review of the plans and policy guidelines so as to update lapses for further and future development.

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**Keywords: Cost** – Benefit Analysis, Gas flaring, Total Utilization, Non Utilization, Utilization Economic Cost

## INTRODUCTION

In this age of unprecedented industrialization, urbanization and population growth, it is imperative that for sustainable development to be achieved the present generation must take conscious, appropriate and adequate steps to ensure strategic planning of environmental resources as well as anticipate future consequences of these steps. This stems from the fact that the irresponsible use of environmental resources will have its attendant consequences on our health, environment and economics, as we are the custodians of the earth's environment (UNFCCC, 1997; World Bank, 2002). The continuous neglect and abandonment of proper strategic planning, monitoring and noncompliance of environmental laws will eventually make us poorer than we were viz- a- viz our health, environment and economics. Studies have correlated environmental resource underutilization and wastage to the underdevelopment of developing and underdeveloped nations of the world; owing majorly to education, lack of infrastructure and non-implementation of strategic environmental planning (World Bank, 2007; 2008). Nigeria, a developing African nation with the fastest growing population growth and urbanization rate in the continent is endowed with vast amounts of environmental resources. Petroleum, (crude oil) been its major exploit accounts for over 90% of its Gross Domestic Product (GDP). Since its discovery in Olobiri in 1958, the oil and gas sector has brought with it benefits to the Nigerian people as well as costs especially to the Niger- Delta region of the country where this resource is been explored and exploited (Ishisone, 2003). Petroleum is a complex natural resource that its total exploitation constitutes quite a number of derivatives and they all have their respective benefits and costs to us as humans (Ishisone, 2003; Opafunso (2005). However, for focus and purpose this study will be emphasizing on the benefits of total utilization and costs of flaring associated gas from crude oil exploitation in the Niger- Delta region of Nigeria. The study keenly looks at the economics of gas flaring in terms of revenue lost as a result of non-utilization and

underutilization with regards to total utilization of this resource. The aim of this study is to assess the economic benefit of total utilization of associated gas in Nigeria from 1958 – 2004.

## MATERIALS AND METHODS

### Study Area

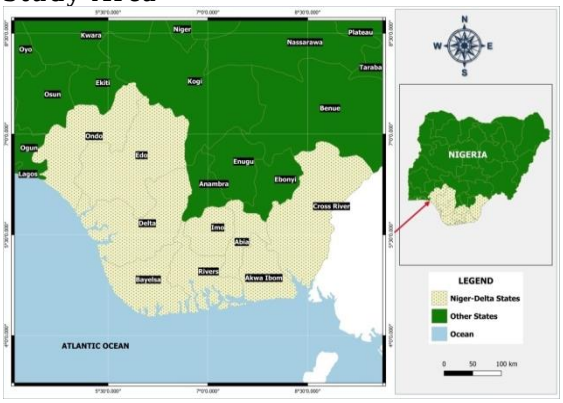


**Fig 1: Map showing the study area (Source: Researchers, 2020)**

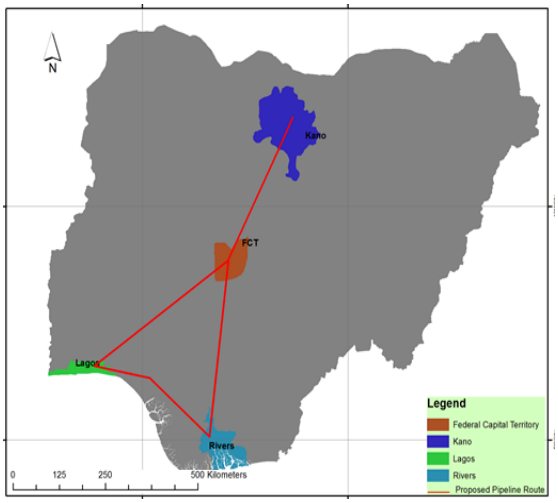


**Fig 2:** Map of the Federal Republic of Nigeria, showing major cities

*Data Type*: The research relied primarily on a review and analysis of secondary quantitative and qualitative data as well secondary face to face interview.

Data Source: The researchers sought and analysed annual gas flaring data compiled by the regulatory team of the Nigerian National Petroleum Corporation (NNPC) from 1958 – 2004). The data compiled was collected from all the oil and gas companies operational in the Niger- Delta area of Nigeria. These companies are mandated by the regulatory body in compliance with the gas flaring phase out directive of the Federal Government to submit routine reports on associated gas production and utilization of their respective operations. Studies carried out by Isihsone (2003) on gas flaring and case study on the economics of Nigerian liquefied natural gas (NLNG) project was also reviewed. Furthermore, a secondary face to face interview was reviewed. The review however was to help put in proper perspective the total operations and governance of the LNG sector in Nigeria; As well as buttress the findings of the quantitative analysis conducted.

*Method of Data Analysis:* Cost- Benefit Analysis (CBA) was adopted for the analysis in this study. Cost-Benefit analysis is a tool for analyzing data in the field of environmental resource planning and management (Field and Field, 2006 and Rodreck *et.al.,* 2006). It involves the use of statistical analysis of quantitative data as well as creating assumptions and deductions from qualitative data. Microsoft Excel software was used in analysis. The pay back method on investment was also adopted. In estimating the total gas pipeline infrastructure to be developed between four Nigeria's major cities, distance calculator software was employed.

## RESULTS AND DISCUSSION

Table1 summarizes the total gas produced, utilized and flared during the period under review. The analysis considers the total national revenues lost from the inception of the crude oil production in Nigeria to 2004; a summation of variables representing the raw natural gas produced, utilized and flared produced annually by the oil producing companies operating in the Niger Delta and their respective yearly natural gas price obtained from CBN statistics. The acquired data shows that from 1958 to 1966 all the natural gas produced were flared. From 1967 to 1969, an average value of about 93.64% of the natural gas produced was flared. The percentage difference was used for gas re-injection. From 1970 to 1977, an average value of about 98.50% of the natural gas produced were flared which was about 5% higher from the gas flared from the previous years. From 1978 to 1979, a fairly constant value of about 95.49% of the natural gas produced were flared which was about 3% less compared to the previous years. From 1980 to 1987, there was a gradual increase in the percentage of gas flared. In 1988, there was a sharp increase in the percentage of gas flared; about 7% increase from the previous year. 1n 1989, a slight decrease in the percentage of gas flared; about 4% lower compared to the previous year. In 1990, a slight increase in the percentage of gas flared of about 5% compared to the previous year. From 1991 to 1994, there was a slight increase in the percentage of gas flared of about 1.5%. From 1995 to 2004, there was a sharp decreased in the percentage of gas flared and as at 2004 the value has decreased to about 31.325%.

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**Table 1**: Gas production and utilization from 1958 to 2004 (in millions)

| YEAR | Production (millions) | Utilization (MSCF) | Flared (MSCF) | Reserves (MSCF) | Flared (MSCF) | US $/1000CF | Us$/ 1000cm | Revenue lost due to flaring(millions) |
|---|---|---|---|---|---|---|---|---|
| **1958** | 1.75 | - | 1.75 | 2.250 | 0.049 | - | - | 0.21 |
| **1959** | 4.96 | - | 4.96 | 2.950 | 0.140452 | - | - | 0.644800 |
| **1960** | 5.1 | - | 5.1 | 3.270 | 0.144416 | - | - | 0.714 |
| **1961** | 10.94 | - | 10.94 | 4.550 | 0.309786 | - | - | 1.641 |
| **1962** | 17.18 | - | 17.18 | 4.380 | 0.486483 | - | - | 2.7488 |
| **1963** | 22.11 | - | 22.11 | 4.822 | 0.626085 | - | - | 3.5376 |
| **1964** | 36.33 | - | 36.33 | 6.370 | 1.028751 | - | - | 5.4495 |
| **1965** | 79.6 | - | 79.6 | 10.930 | 2.254021 | - | - | 12.736 |
| **1966** | 102.87 | - | 102.87 | 13.030 | 2.912954 | - | - | 16.4592 |
| **1967** | 120.022 | 7.627176 | 112.394824 | 13.960 | 3.182667 | - | - | 17.983171 |
| **1968** | 57.0579 | 3.594758 | 53.463142 | 15.120 | 1.513908 | - | - | 8.554102 |
| **1969** | 82.837765 | 5.328840 | 77.508925 | 17.210 | 2.194808 | - | - | 13.176517 |
| **1970** | 140.697350 | 1.757393 | 138.939957 | 44.550 | 3.934341 | - | - | 23.619792 |
| **1971** | 369.241239 | 5.186234 | 364.055005 | 51.204 | 10.30889 | - | - | 65.5299 |
| **1972** | 460.104284 | 6.607792 | 453.496492 | 60.744 | 12.841591 | - | - | 168.635019 |
| **1973** | 774.29 | 7.767183 | 766.522817 | 60.684 | 21.705509 | - | - | 168.635019 |
| **1974** | 961.4 | 9.876234 | 951.523766 | 58.322 | 26.944153 | 0.4 | 14.13 | 380.720875 |
| **1975** | 913.980083 | 13.522583 | 900.457500 | 75.598 | 25.498117 | 0.44 | 15.54 | 396.240737 |
| **1976** | 670.881599 | 16.807177 | 654.074422 | 76706 | 18.521325 | 0.58 | 20.48 | 379.316737 |
| **1977** | 774.248624 | 14.835373 | 759.413251 | 80172 | 21.504189 | 0.79 | 27.9 | 599.96686 |
| **1978** | 752.432560 | 36.973328 | 715.459232 | 99962 | 20.259549 | 0.91 | 32.14 | 651.141915 |
| **1979** | 987.080688 | 40.473194 | 946.607494 | 95085 | 26.804939 | 1.18 | 41.67 | 1116.961816 |
| **1980** | 983.731483 | 89.142195 | 894.589288 | 99369 | 25.331948 | 1.59 | 56.15 | 1422.38886 |
| **1981** | 607.464408 | 80.357219 | 527.107189 | 93421 | 14.926013 | 1.98 | 69.92 | 1043.626858 |
| **1982** | 546.944112 | 86.699478 | 460.244634 | 94021 | 13.032677 | 2.46 | 86.88 | 1132.278951 |
| **1983** | 532.373064 | 89.308532 | 443.064532 | 95000 | 12.546190 | 2.59 | 91.47 | 1147.600034 |
| **1984** | 569.172029 | 113.706283 | 455.465746 | 94150 | 12.897354 | 2.66 | 93.94 | 1211.577403 |
| **1985** | 655.1233 | 130.479407 | 524.643893 | 96726 | 14.856261 | 2.51 | 88.64 | 1316.858943 |
| **1986** | 661.772159 | 170.309943 | 491.462216 | 96096 | 13.916660 | 1.94 | 68.51 | 953.430389 |
| **1987** | 606.196748 | 175.339644 | 430.857104 | 95391 | 12.200515 | 1.67 | 58.98 | 719.586346 |
| **1988** | 916.30707 | 199.744645 | 716.562425 | 95141 | 20.290788 | 1.69 | 59.68 | 1210.954244 |
| **1989** | 887.402234 | 224.061229 | 663.341005 | 97762 | 18.783725 | 1.69 | 59.68 | 1121.012737 |
| **1990** | 1087.790899 | 224.734923 | 863.055976 | 103564 | 24.439024 | 1.71 | 60.39 | 1475.87264 |
| **1991** | 1112.434733 | 256.469011 | 855.965722 | 97947, | 24.23825 | 1.64 | 57.92 | 1403.879442 |
| **1992** | 1182.857926 | 268.937809 | 913.920117 | 106992 | 25.879336 | 1.74 | 61.45 | 1590.285182 |
| **1993** | 1192.210795 | 269.538108 | 922.672687 | 104954.47 | 26.127181 | 2.04 | 72.04 | 1882.202115 |
| **1994** | 1170.670114 | 245.39408 | 925.276034 | 107113.5 | 26.2009 | 1.85 | 65.33 | 1711.704765 |
| **1995** | 1240.099 | 287.106 | 952.993 | 116372.6 | 26.985757 | 1.56 | 4.74 | 127.912486 |
| **1996** | 1300.655072 | 353.497244 | 947.157828 | 114877.1 | 26.820523 | 2.17 | 76.63 | 2055.256671 |
| **1997** | 1264.455107 | 371.501952 | 892.953155 | 119888.4 | 25.285618 | 2.32 | 81.93 | 2071.650642 |
| **1998** | 1261.582696 | 402.17538 | 859.407316 | 128386.8 | 24,335705 | 1.98 | 69.92 | 1701.552503 |
| **1999** | 1378.987845 | 514.638823 | 864,349,022 | 136624.18 | 24.475,639 | 2.13 | 75.22 | 1841.057540 |
| **2000** | 1720.81 | 809.85 | 910.96 | 138107.68 | 25.795515 | 2.28 | 80.52 | 2077.054834 |
| **2001** | 1943.595973 | 962.937874 | 980.658099 | 171377.92 | 27.769145 | 2.37 | 83.7 | 2324.277433 |
| **2002** | 1878.019793 | 982.347204 | 895.672589 | 176456.22 | 25.362623 | 2.5 | 88.29 | 2239.266011 |
| **2003** | 1879.275535 | 1079.663471 | 799.612064 | 186748.483 | 22.642492 | 2.7 | 95.35 | 2158.961627 |
| **2004** | 2110.178044 | 1258.530242 | 851.647802 | 187442 | 24.11598 | 2.9 | 102.41 | 2469.717528 |
| | **36035.224231** | **9816.827961** | **26218.396270** | | | | | **41957.934916** |

**S***ource: NNPC Gas Flaring Report, 2008*

**Table 2:** Revenues realizable from gas flare penalties, (1997 to 2004)

| Year | Gas Flared ($10^6$cm) | Penalty Rate N/1000cm | Exchange Rate Naira/US$ | Penalty Revenue US$ (millions) |
|---|---|---|---|---|
| 1997 | 25.285618 | 17.66 | 81.65 | 5.469002 |
| 1998 | 24.335.705 | 353.15 | 83.81 | 102.543304 |
| 1999 | 24.475639 | 706.30 | 92.34 | 187.211865 |
| 2000 | 25.795515 | 706.30 | 100.12 | 181.975349 |
| 2001 | 27.769145 | 706.30 | 111.52 | 175.872911 |
| 2002 | 25.362623 | 706.30 | 120.47 | 148.697774 |
| 2003 | 22.642492 | 706.30 | 129.22 | 123.760967 |
| 2004 | 24.115980 | 706.30 | 133.00 | 128.068547 |
| | | | | 1053.599719 |

The amount of gas flared between 1974 and 2004 had reduced to 50%. At the same time, the amount of gas utilised within the same time period has risen quite considerably, by the same amount of 50%. This can be attributed to infrastructure that has been put in place within the last 30 years; these include the Mboni LNG, Escravos gas projects (amongst others). A comparison of the magnitudes of the revenues lost to the flaring practice, as shown in the tableabove reveal that the gross revenue lost in the period of 56 years totals to about 42Billion US dollars. This staggering value of gross revenue lost reveals that the penalties paid by oil companies for gas flaring in Nigeria are grossly inadequate to cover the value of gas flared

*Revenues from Gas Flaring Penalties, (1985 – 1996*): The gas flare penalties imposed by the Nigerian governments which is backed up by the associated gas re-injection recommendation decree no.7 of 1985 (gas flaring penalties) was done in attempt to curtail the wastage of the associated gas been flared. The decree introduced a charge of (N0.02) per thousand standard cubic feet of gas flared only at field which did not have authority to flare. The charge was increased to 0.50 Naira per thousand of gas flared; in 1998 and 1999 the federal government increased the amount of the penalties to N10 and N20 respectively (Alaku, 2007). The total revenue realizable by the federal government from gas flare penalties between 1985 and 1996 was only $67.25 million (Alaku, 2007).

Computation of the annual revenues lost wastefully to flaring from 1958 to 2004 shows that Nigeria lost over $42.00 billion in 56 years due to gas flaring. Not only is gas flaring damaging the environment and human health which cannot be quantifiable in monetary terms but it is wasting the country's second most valuable natural resource. This energy wastage translates to about 45% of France' energy requirement (Osuoka, 2007). Table 2 reveals that the total amount realizable from gas flare from 1997 – 2004 totals $1,053,599,719. It also reveals that the annual penalties realizable were not a reflection of the total amount and that these penalties were not commensurate to the total gas flared during the period. In other words, this goes to depict the ineffectiveness of the gas flare penalty policy of the federal government which stems from the lack of enforcement by the regulatory body.

Case Study on the Economics of Nigerian liquefied natural gas (NLNG) project. There are various measures of profitability that can be used for assessing projects. These include the payout or payback period, the profit-to-investment ratio, the rate of return, the net present value, the discounted profit-to –investment ratio and the appreciation-of-equity rate of return. The payback method is used to estimate a payback period for the Nigerian LNG project. The economics of LNG calls for an emphasis on liquefaction, transportation and regasification. The liquefaction costs about $1.20 – 1.50/mBtu on average. It costs about 20 times more to ship LNG per Btu than it costs to ship crude oil. Regasification costs about $0.10 – 0.25/mBtu, depending on the losses and plant efficiency. The LNG train requires precision to remain viable. Because the up-front lump sum investment required for this project is very capital intensive, LNG projects tend to have long payback periods.

The payback method requires the following information

Cash flows

Sales

Operating costs (except depreciation)

Taxes.

With the above information, the annual cash flows can be estimated. The point where the initial cost of investment is offset will be the payout time. For this computation, some assumptions are made due to lack of accurate date.

The following assumptions were made:

Annual operating revenue: 62% of total plant cost

Annual operating costs: 15% of operating revenue

Annual depreciation expense: 3.5% total plant cost

Annual taxes: 5% of total plant cost

Hence, Payback period = Cost of project / annual cash flow per year= 6.134 years

*Case Studies*: Studies carried out by the World Bank Global Gas Flaring Reduction Initiative (World Bank, 2002), revealed that Nigeria flares 17.2 billion cubic meters of natural gas yearly in conjunction with exploration of crude oil in the Niger- Delta. EIA (2003) on the other hand reported that in 1999 Nigeria completed its biggest gas project, "the West African gas pipeline (WAGP) as part of a gas flaring reduction scheme. In 2002, Commery stated that this project is a $500 million, 1033km pipeline which would transport the gas from the Niger – Delta through Benin Republic, Togo and Ghana to be used in those countries. The facility is expected to process 7.15 billion cubic meters of LNG as stated by EIA, (2003). For the purpose of viability of market the researchers selected the four major cities in Nigeria accordingly to their population density and purchasing power. The cities selected were Lagos, Kano, Port Harcourt and Abuja. Hence the researcher sought to determine the financial cost investment of embarking on a pipeline project linking these cities. Using distance calculator software the researchers determined the total distance between these four cities. The distance calculator

software revealed that the total distance between these commercially viable cities is 1813km or 1128miles by air and 2398km or 1490miles by road.

To determine the financial cost investment of connecting these four major cities with gas pipeline, the researchers first determined the cost of constructing one kilometer of gas pipeline using the financial cost investment of the West African Gas Pipeline case study project as stated in Commery (2002). Where;
1033km of gas pipeline= $500,000,000.00
Thus, using the farthest distance (this is to overestimate and create room to argument shortages) between these cities. The construction of a 2398km gas pipeline costs:
$1,160,696,985.80
To determine the total financial cost investment for complete utilization of associated gas in Nigeria, the researchers evaluated the total annual gas flared viz a viz the total process capacity of the NLNG project and the West African Gas Pipeline project which gave a total sum of;
= $9,560,696,985.90
The repayment period of the above sum if it were to be taken as a loan facility, would be;
= 16.75years ≈ 17years
The total economic cost of flaring associated gas in comparison with the benefit of total associated gas utilization was given as thus;
Cost = $10,681,546,704.90
The Net Benefit of total utilization of associated gas to Nigeria from 1958 – 2004 was given as;
Net Benefit = $31,680,572,153.10
The Benefit – Cost ratio = 3.96≈ 4.0

Results from the study show that associated gas flaring has been of grave financial loss to the Nigerian economy. It shows that for the period under review the nation would have benefitted approximately $32 billion from associated gas sales and/or utilization, which is approximately equivalent to its current foreign reserves. This is without consideration for the multiplier effect of reinvesting such huge sums into the economy. Results from the study also show that for the nation to totally process and utilize the current amount of associated gas flared it would have to build another LNG plant one and a half (1.5) times the current processing capacity of the Bonny LNG plant. Results also reveal that if a loan facility were to be accessed for the development of a new LNG plant it will take approximately 17 years to pay back the loan. In the light of these revelations the researchers opined that the government without wasting any more time set up modalities for the construction of another LNG plant as this will bring about huge economic gains for the country whilst reducing and/or eliminating the enormous environmental, social and health challenges currently faced by the indigenes of these communities (Ishisone, 2003; Christen, 2006). Furthermore, the member of staff of the NLNG opined that the current legal framework of the NLNG is not strategic enough and that government in collaboration with all stake holders including the communities should come together to develop adequate strategic plans and policies guidelines for the operations and governance of the NLNG. This is to help facilitate implementation, enforcement and foreign direct investment into the sector. He also recommends these plans and policy framework should be formulated as soon as possible and sent to the national assembly for promulgation in an act. From the economic analysis carried out, it is apparent that Nigeria has lost huge revenue from flaring associated gas and these wasted resources could be put into sustainable development and economic empowerment. There are three options to stop the gas flaring; by reinjection, utilization for local market, and utilization for export however, the oil companies operational in Nigeria would rather flare associated gas (Brown, 2003; Elvidge *et al.,* 2007). This is because these companies prefer to make short term economic profit taking advantage of the lapses in the laws of the oil and gas industry (Wami, 2006). Also is the fact that the instability and lack of transparency in the government of Nigeria has resulted in the noncompliance, improper implementation and enforcement of the laws of governing the industry (Ishisone, 2003). Furthermore, another hindering factor to the development of the associated gas utilization is the fact that Nigeria is said to have vast amounts natural gas deposit and that it is more economical to explore and utilize this non associated natural gas for energy source (Ishisone, 2003; Osuoka, 2007). This belief and mind set is a set back and creates a monumental waste of the nation's natural resources which is otherwise finite. This practice has so far underdeveloped the nation and impoverished its citizens by way of degrading their environment and creating the incidence of all manner of diseases (Christen, 2006; Osuoka, 2007). These driving forces has led to keeping oil flowing at minimal level without consideration for the local environment and people, and the gas flaring is a consequence of cost minimization strategy (Akeredolu and Sonibare, 2006).

On the other hand, Nigeria has the potential for the total utilization of associated gas produced in the country because of its huge population and high purchasing power of its citizens compared to the citizens of other West African nations (World Bank, 2007). This is to say that the West African Pipeline project would yield more economic value if the project

were to be carried out in Nigeria to link Nigeria's major cities instead of linking smaller countries that may not have equivalent viable markets (Commery, 2002). However, the researchers also recognize that it may not necessary be from the view point of viability of market but also governing barriers affecting the viability of such projects. These barriers include strong operational and governing laws as well as credible enforcement and regulatory bodies which today are found "wanting" in Nigeria (UNDP, 2006). Reduction and/ or elimination of associated gas flaring and the development of gas resources will not only improve the existing infrastructure, but also create opportunities for transfer of technological know-how to Nigerians (Akeredolu and Sonibare, 2004). Opportunities for indigenous entrepreneurs will abound in gas distribution, marketing and maintenance services. Skilled and enterprising youths will be meaningfully employed (Sonibare and Akeredolu, 2006). Furthermore, in the interview with an anonymous staff of the Nigerian Liquefied Natural Gas (NLNG), he opined that associated gas utilization is not just only economically gratifying but also environmental friendly. He also opined that the multiplier effect of developing the sector (for example in the creation of direct and indirect jobs which will in turn reduce and/ or eliminate the social menace in the local communities) cannot be quantified. The member of staff in his interview also reiterated that these plans and policy framework should be formulated immediately and sent to the national assembly for promulgation. This is to help facilitate implementation and enforcement of laws that will eliminate corruption which is the major culprit bedeviling the industry; as well aid local and foreign direct investment into the sector.

*Conclusion:* It can be seen that the challenges of solving associated gas flaring problem is enormous and capital intensive however, the lives of the citizens are priceless, hence stiffer regulatory methods. For example shutting-down oil producing fields that are not putting facilities in place to comply with the proposed flare-down deadline is recommended. The Government and the stakeholders should work out measures to ensure peace in the Niger Delta region. Furthermore, issues of the environment are sensitive and in dealing with these issues government would have to adopt comprehensive strategic measures that entail economic, political and social methodologies which are all encompassed in the cost – benefit approach.

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