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ECONOMIC ANALYSIS OF MONETIZATION OF NATURAL (FLARE) GAS USING MODULAR GAS TECHNOLOGY (MGT) SYSTEM AS STRATEGY FOR MANAGING GAS FLARING IN NIGERIA

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ABSTRACT

Natural gas in association with oil is a source of revenue for Nigeria. Sadly, the Nation has not appreciably developed its flare mitigation policy. Gas flaring wastes resource that would have been captured and processed using Modular gas technology (MGT) system for power generation, petrochemicals, CNG or GTL projects, etc. The economic justification of flare gas monetization is seen in two considerations; the technologies must be technically feasible and economically profitable. The investment in flare technology for the harnessing of flare gas must be properly reviewed by considering changes in economic situations of the country. This paper examines the economic analysis of natural gas monetization in Nigeria using MGT as strategy for reducing gas flaring. The evaluation method comprises use of investment appraisal techniques such as Payout Time, NPV, IRR, etc. Since the project is considered long term, changes in economic situations foreseeable in the future were incorporated in the sensitivity analyses of the work. The results show that even for high tax rates and discount rates, the project is still profitable yielding positive NPV and IRR with low payout times. It further highlights that flaring of gas could be greatly reduced by monetization using MGT.

KEYWORDS: Natural gas, flaring, Economic analyses, Monetization, Revenue, Technology

1. INTRODUCTION

Nigeria has been identified as a country with ‘stranded’ gas reserves. This is because most of the gas is associated with oil production (Economides, 2006). In the past, exploration companies in the country have concentrated more on oil production and gas was treated as waste with an estimate of about 63MMscf of natural gas being flared daily(Ekejiuba, 2017). However, the government recently passed an anti-flaring legislation which was targeted at ending gas flaring by 2008. Penalties in form of taxes have been introduced for up to US 10cents/Mscf. This is intended to make gas flaring a costly activity, so that oil companies prefer to monetize the associated gas reserves (Ali, 2007). So far, pipeline flows between countries or continents have largely dominated the international gas trade. It suffices to recall that LNG only accounts for 22% of international trade (only 5.6% of world natural gas demand). However, the rebalancing of natural gas markets, via gas pipelines, is often faced with technical, economic, even political limitations (Hedman, 2008).

The need to generate revenue from otherwise flared gas resources has increased the need for gas exploitation. The country loses estimated annual revenue of $2.5billion to gas flaring (Noah, 2012). The recognition of this economic loss has instigated the government into setting strategies for exploiting the abundant natural gas resources to enhance economic development. The government planned to raise revenue earnings from natural gas to 50% of oil revenue by 2015 (Adegoke, 2005).
Sadly, this was not met because of lack of proper execution of gas flaring laws and lack of investors’ willingness to invest in monetization of flared natural gas. Also, with the advent of power sector reform in Nigeria, there is an envisaged domestic demand for natural gas for power generation. This will ensure the stability of power generation through adequate, affordable and reliable supply of gas (Economides, 2006).

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This paper examines the economic evaluation of flared natural gas monetization in Nigeria. The evaluation was so considered to ascertain ranges of economic situations that would make the project non-viable. The investment appraisal technique was exhaustively considered.

Objectives

The objectives of this research work are;

- To identify the monetary value of the flare natural gas in Nigeria
- To estimate the revenue generated for certain volumes of gas flared
- To estimate the volume of products derivable from the flare gas stream
- To evaluate economically the viability of the flare gas monetization project
- To see the effect of changes in economic variables on the economic feasibility of the flare gas monetization project.

The whole of these objectives are geared towards encouraging investment by investors in gas flare monetization and highlighting the usefulness of the wasted stuff to the Nigeria economy.

All content should be written in English and should be in 1 column.

- Page type will be A4 with normal margin, word spacing should be 1.
- No space will be added before or after paragraph.
- This section should be typed in character size 10pt Times New Roman, Justified.

2. MATERIALS AND METHODS

In this section, the parameters for the economic investigation and analyses of the work shall be given and discussed.

The method of economic analysis in this work took the form of exhaustive quantitative investigation of economic parameters. The data source serve as feedstock to the computer simulator. In the calculation of pay out time, NPV and IRR, EXCEL spreadsheet functions were devised to generate the results rather than summing it manually and iteratively. Other functions developed for the purpose of this work which are peculiar to it are all embedded in the EXCEL application Ecsim.xlx. Also a MATLAB program Economic _Performance_Calculator was developed to help in the economic evaluation and sensitivity analysis to ascertain the effects of changes in the economic variables.

A fixed salvage value of zero for the equipment and a straight line method of depreciation calculation have been employed. In this work, various tax rates and discount rates have been analyzed to show the economic viability of the project. Tax rates of 35%, 60% and even as high as 70% and 80% have been analyzed, while discount rates of 15%, 25%, 30%, 35% and even as high as 45% have been considered.

Analytical Tools

Two main theoretical tools for this study are; **the variables to be analyzed** and the **evaluation model**.

(a) **Variables to be analyzed**: These include the following; (i) Cash Flow/Net Cash Recovery (NCR), (ii) Payout Time (POT), (iii) Net Present Value (NPV) and (iv) Internal rate of Return (IRR).

(i) Cash flow/NCR: - This shows the total cash outlay of a project. It shows the difference between the revenue received and cash disbursed over a given period of time. It is sometimes called the net cash returns of the investments.

(ii) Payout time (POT):- This is one of the methods of analyzing investments decisions. In this method, the goal is to ascertain the time (period) when the capital invested in the business or earmarked for the project will be recovered. If it will take a short period to recover the capital input in the project, then the project is viable, but if it will take a longer time to recover the capital input in the project, then the project is not viable.

(ii) Net Present Value (NPV):- This is another method of investment analysis. Here, the present value of money is considered, thus making it a better method than the payout Time (payback) method. It is a more realistic method of investment appraisal, in the sense that it makes use of a criterion discount factor, i, which is used to check if the project will be viable or not, basing it on the present value of money. The management or investor decides on the discount factor, i, to be allowed, that is, whether a 10%, 20%, 30%, etc. discount

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factors should be allowed to accommodate the time value of money. The discount factor, i, is the percentage that satisfies the decision maker in any investment. This discount factor is then multiplied by the cash inflow for that particular year to get that year's NPV. After considering the whole years the project is ran, that is the life of the project, the sum of the NPV's is added to the initial capital invested. If the value of the NPV is positive, then the project is viable, while if it is negative, the project is not viable. The following is the formula for calculating NPV

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0 \qquad (1)$$

Where:
C_t = net cash inflow during the period t
C_o= total initial investment costs
r = discount rate, and
t = number of time periods

(iv) **Internal Rate of Return (IRR):**- Other names for this method of investment analysis are; (a) Internal yield, (b) Profitability index, (c) Interest rate of return and (d) Discounted cash flow rate of return (DCFROR). It is similar to the NPV method, but the difference is that unlike the NPV, it requires a reasonable guess of the discount factors. Two criteria discount factors are chosen such that one has a positive NPV value and the other one, a negative value of NPV. From these two values, the discount factor that will make the value of NPV to be zero is obtained by interpolation. This discount factor (ith term) which makes the NPV = 0 is the Internal rate Return (IRR).

Sensitivity Analysis

This would be carried out so as to explore the relative effects of changes or variations in some factors that contribute to cash flow on the economic viabilities of the chosen project. This analysis is necessary in order to point out some areas that are most critical to investors in terms of any uncertainty that may arise in the execution of this project and also indicates where confidence in the estimates made is most vital. This analysis will be made by;

a) Varying the discount factor (interest rate, i) for several tax rates
b) Varying the capital expenditure (CAPEX)
c) Varying the operating expenditure (OPEX)
d) Varying the product price

Results of the sensitivity analysis will be presented and compared with the project evaluation results in a tabular, and also in graphical manner.
The economic analysis shall consider the following

The Capital expenditure CAPEX: in this case the CAPEX is the total of the equipment cost which is the total cost of purchase of the modular gas technology which comprise the flare capture and processing technology and other expenses to mount it. The CAPEX here incorporates the overall cost of the equipment plus the cost of installation and commissioning.

The Annual operating cost OPEX: since operations of any facility changes annually according to the present economic situations of the country, the OPEX must be considered annually. In this work it is assumed that the annual operating cost is constant. The maintenance cost in this work is adjoined to the OPEX to simplify the economic analysis procedure

Model Simulation

The model simulation for this work was done with two programs.

- The EXCEL Ecsim.xlx spreadsheet application which computes the NPV, IRR, POT
- The MATLAB software program which uses calculator program to determine the results of all parameters when the variables are inputted and is suitable for the sensitivity analyses of the work.

The workbook for the economic simulation Ecsim.xlx calculates the NPV, IRR, POT, Depreciation and effects of the sensitivities on the project investment.

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Equation Development

The Revenue comprises the difference between the incomes and expenses incurred during the total life of the project. Since the project is long term, the economic indicators to be employed are those that considers the time value of money.

Total capital cost = Capital investment + Cost of installation and commissioning

Total operating cost (OPEX) = all other expenses incurred during the project apart from those captured in the total capital cost. The OPEX is considered on annual basis because it is recurrent.

Total expenses = total capital cost + total operating cost (OPEX) per year

Grand Revenue = total income from the sales of products or the total monetary value of the products.

Here the products are

- Dry gas
- LPG and
- Condensates

Net Revenue per year = Grand revenue – total expenses – other cost.

Other cost includes income taxes, royalties etc. calculated annually as part of the cash-flow calculations.

Depreciation

The straight line depreciation method was used to calculate Depreciation in this work

$$Depreciation = \frac{Equipment\ cost - Salvage\ Value}{Life\ period\ of\ Equipment} \quad (2)$$

Pay Out Time (POT)

The time to recover the investment cost is calculated using the equation below.

$$\boldsymbol{POT} = \frac{Investment}{Cashflow} \quad (3)$$

Present Value Or Discounted cash flow

Discounted cash flow (PV) = FV*1/ (1+i)^t (4)

Cashflow

The cash-flow for the project comprises the inflow which is revenue from sales of products and outflow which is expenses incurred.

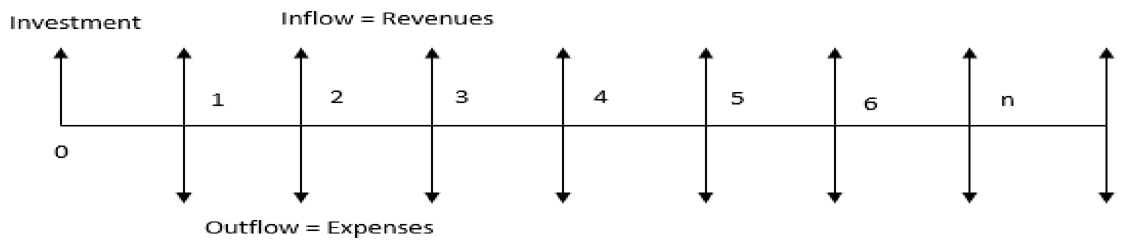

Figure 1: Cash-flow schematics

Gas Composition and Revenue

The gas composition for the inlet gas stream is given in the figure below, the volume of the products from the gas stream was calculated using a MATLAB program Revenue_Calculator. The Table 1 below contains the volume of three products recovered from the modular gas technology (MGT) on daily and annual basis. Also the revenue was calculated using the MATLAB program. For the Revenue, unit sale price of $3/Mscf of dry gas, $15/bbl of LPG and $50/bbl of condensates were used.

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Table 1: Expected Gas Products Recoveries

INLET GAS COMPOSITION			PRODUCT COMPOSITION			
Component	Inlet gas (mol %)		Products	Output Volume Per Day	Output Volume Per Year	
Methane	86.18		Dry gas	18mmscf/day	5616MMscf/year	
Ethane	4.15		LPG	1170.29bbls/day	365130.48bbls/year	
Propane	7.46		Condensates	247.445bbls.day	77202.84bbls/year	
Butane	1.61					
Isopentane	0.21		ANNUAL REVENUE			
Pentane	0.14		PRODUCT	UNIT PRICE	REVENUE/D	REVENUE/YEAR
Hexane	0.18		**DRY GAS**	$3/Mscf	54000	16848000
Heptane	0.1		**LPG**	$15bbl	17554.35	5476957.2
Octane	0		**CONDENSATE**	$50/bbls	12372.25	3860142
Nitrogen	0.1		**TOTAL REVENUE**		83926.6	26185099.2
Carbon dioxide	0.23					
Hydrogen sulphate	0		EQUIPMENT AND INSTALLATION COST			
Water	Saturated		Cost of Equipment		$15,500,000.00	
Oxygen	0		Annual Operating and Maintenance Cost		$2,000,000.00	
Total	100.36		Installation and Maintenance Cost		$1,870,000.00	
Flowrate	20MMsc/d		Total		$19,370,000.00	

Economic Parameters

In order to perform an economic analysis in this work, the various economic parameters are considered:

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
5. Installation and equipment cost of $1,870,000
6. Plant operating period of 15years
7. Salvage value of zero
8. Straight line depreciation is used
9. Income tax of 35%
10. Discount rates of 15%, 20%, 25% and 35%
11. 100% owner’s equity

Economic Variable calculation

Equipment cost: $15,500,000
Life period: 15years
Salvage value: 0
Using the straight line depreciation method

$$Depreciation = \frac{equipment\ cost - salvage\ value}{life\ period\ of\ equipment} = \frac{\$15,500,000 - 0}{15} = 1,033,333/year$$

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Base Case of 35% Tax Rate & 15% Discount Rate at Initial CAPEX and OPEX.
At discount rate i=15% and income tax rate of 35%

i. Cash flow/NCR

Table 2: Annual statement of account ($) at a tax rate of 35%

Description	Amount ($)
Annual revenue	26,185,099
- annual operating cost	-2,000,000
- depreciation	-1,033,333
Taxable income	23,151,766.00
- income @35%	- 8,103,118.1
Net income	15,048,647.90
Depreciation	1,033,333
Cash flow/NCR	16,081,980.90
POT	1.080090824

i) **Cash flow/NCR = $16,081,980.90**

ii) **Pay out time (POT) (*Without considering Time value of money*)**

$$\boldsymbol{POT} = \frac{Investment}{Cashflow}$$

$$\boldsymbol{POT} = \frac{\$17{,}370{,}000}{\$16{,}081{,}980.90}$$

$$\boldsymbol{POT\ (without\ consideration\ for\ Time\ value\ of\ money) =\approx 1.08}\ \textbf{Years}$$

iii) **NPV**

Capital Investment = $17,370,000
Annual cash flow = 16,081,980.90
Annual Interest rate = 15%
Estimated life of the project = 15yrs.

Table 3: Calculation of NPV and IRR at a Tax Rate of 35% using Excel spreadsheet application

Year	Cash Flow ($)	Discount rate of 15%	Discounted Cashflow	Cumulative Discounted Cashflow
0	($17,370,000)	1	($17,370,000)	($17,370,000)
1	16,081,980.90	0.869565217	$13,984,331	($3,385,669)
2	16,081,980.90	0.756143667	$12,160,288	$8,774,619
3	16,081,980.90	0.657516232	$10,574,163	$19,348,783
4	16,081,980.90	0.571753246	$9,194,925	$28,543,707
5	16,081,980.90	0.497176735	$7,995,587	$36,539,294
6	16,081,980.90	0.432327596	$6,952,684	$43,491,978
7	16,081,980.90	0.37593704	$6,045,812	$49,537,791
8	16,081,980.90	0.326901774	$5,257,228	$54,795,019
9	16,081,980.90	0.284262412	$4,571,503	$59,366,521
10	16,081,980.90	0.247184706	$3,975,220	$63,341,741
11	16,081,980.90	0.214943223	$3,456,713	$66,798,454
12	16,081,980.90	0.18690715	$3,005,837	$69,804,291
13	16,081,980.90	0.162527957	$2,613,771	$72,418,063
14	16,081,980.90	0.141328658	$2,272,845	$74,690,907
15	16,081,980.90	0.122894485	$1,976,387	$76,667,294
	NPV		**$76,667,294**	

NPV at i=15% = **$76,667,294**

Pay out time (POT) (C*onsidering Time value of money*)

(iv) $$POT_t = Year_m + \frac{\text{Cumulative Disc. Cashflow}_m}{\text{Disc. Cashflow}_n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where m = Year before cumulative discounted cashflow value of zero (0) is reached

n = Year during which cumulative discounted cashflow of zero (0) is obtained

$$\mathbf{POT_t} = 1 + \frac{3,385,669}{12,160,288} = 1 + 0.278$$

$$\mathbf{POT_t}\ (\textit{with consideration for Time value of money}) = \mathbf{1.28yrs.}$$

(v) Calculation of IRR @ tax rate of 35% and discount factor of 15%

Using the Excel spreadsheet, **IRR** at discount factor of 15% = **93%**

Sensitivity Analyses

In the sensitivity analyses, the economic variables are varied to see their effects on the POT, NCR, NPV, and IRR. The variation shall take place in the following areas

- 1 - Varying the tax rate at discount rate of 15%
- 2 - Varying discount rates at varied tax rate of 35%, 60%, 70% and 80%
- 3 - Varying CAPEX at various tax rates and discount rates
- 4 - Varying OPEX at various tax rates and discount rates
- 5 - Varying Revenue at various tax rates and discount rates

Case 1: Varying the Tax Rates at a Discount Rate of 15%

The MATLAB program Economic_Performance_Calculator calculates the depreciation, the NCR, the NPV, the POT, the IRR at different discount rates and tax rates.

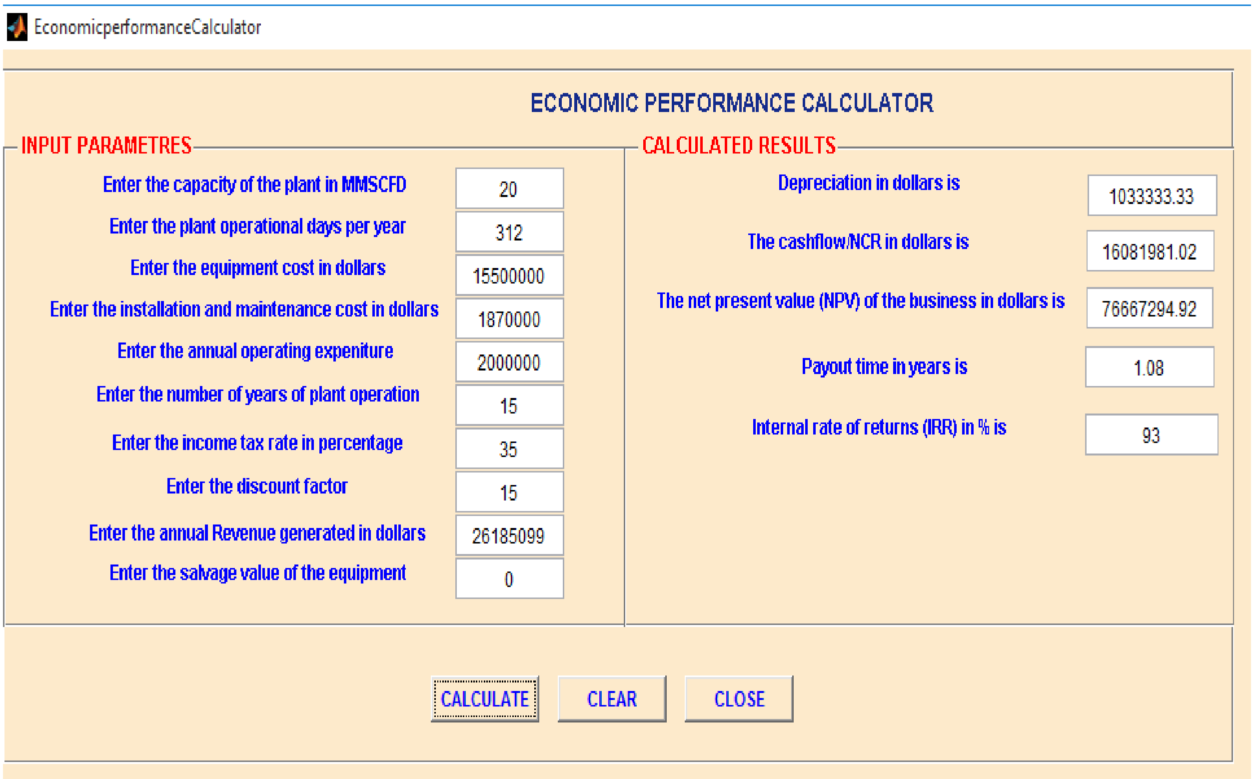

Figure 2: MATLAB program showing input parameters and calculated results

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From the MATLAB program Economic_Performance_Calculator, the values for the economic parameters are

1. NCR = $16,081,981.00
2. POT = 1.08years, POT_t= 1.28 years
3. NPV = $76,667,294.92
4. IRR = 93%

Furthermore, the tax rate was increased to 70% and 80% while maintaining the discount factor of 15%, the results for the various tax rate is given in the table below.

Table 4: Summary of project evaluation at tax rates of 35%, 60% and 70%

Tax Rate	**Cash Flow/NCR**	**Net Present Value (NPV)**	**Pay Out Time (POT) Years**	**IRR**
35%	**$16,081,980.90**	**$76,667,294**	**1.28**	**93%**
60%	**$10,294,039.40**	**$42,823,058**	**2.09**	**59%**
70%	**$7,978,862.80**	**$29,285,364**	**2.84**	**46%**
80%	**$5,663,686.20**	**$15,747,669**	**4.43**	**32%**

Note: Time value of money was considered in the calculation of POT

Case 2: Varying Discount Rates at Varied Tax Rates of 35%, 60%, 70% & 80%
Here we look at the changes in economic variables when the discount rate is varied for 15%, 25%, 30%, 35% and 45% each for tax rate of 35%, 60%, 70% and 80%

Using the MATLAB program Economic_Performance_Calculator, the results for this are tabulated in the table below.

Table 5: Values for NPV, POT and IRR for various discount rates and Tax rates

Tax Rates	NPV at i=15%	NPV at i =25%	NPV at i =30%	NPV at i =35%	NPV at i=45%	POT (Yrs)	IRR
35%	$76,667,294.24	$44,694,586.00	$35,189,310	$28,068,875	$18,232,027	1.28	93%
60%	$42,823,058.18	$22,357,400.35	$16,273,095.10	$11,715,320.64	$5,418,776.42	2.09	59%
70%	$29,285,363.76	$13,422,526.09	$8,706,608.96	$5,173,898.84	$293,476.25	2.84	46%
80%	$15,747,669.33	$4,487,651.83	$1,140,122.81	($1,367,522.96)	($4,831,823.92)	4.43	32%

From the table above, NPV gave positive values except for the tax rate of 80% at discount rates of 35% and above.

Case 3: Varying CAPEX at Various Tax Rates and Discount Rates
Assuming the capital expenditure increase by 50% of its initial value.
Current CAPEX=1.5 x initial CAPEX
Current CAPEX = 1.5 x $17370000 = $26,055,000

Then the economic variables will change at various conditions of tax rate and discount rate from the base case. The table below gives the value for the increased CAPEX

Table 6: Varying CAPEX at Various Tax Rates and Discount Factors

Tax Rates	NPV at i=15%	NPV at i =25%	NPV at i =30%	NPV at i =35%	NPV at i=45%	POT (Ys)	IRR
35%	$67,982,294	$36,009,586	$26,504,310	$19,383,875	$9,547,027	1.620	62%
60%	$34,138,058	$13,672,400	$7,588,095	$3,030,321	($3,266,224)	2.531	39%
70%	$20,600,364	$4,737,526	$21,609	($3,511,101)	($8,391,524)	3.266	30%
80%	$7,062,669	($4,197,348)	($7,544,877)	($10,052,523)	($13,516,824)	4.600	20%

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The table above shows that even for 50% increment in value of CAPEX, the NPV shows a positive value for tax rate of 35% for all the discount rates considered. For tax rate of 60%, positive NPV is achieved when the discount factor is not greater than 35%, while for tax rate of 70%, the NPV is only positive for discount factors of 15% to 30%.

Case 4: Varying OPEX at various Tax Rates and Discount Rates
Increasing capital expenditure by 20% gives 1.20*2,000,000 =2400000

Thus new OPEX = $2400000
Because the OPEX is increased the NCR has to be recalculated

Table 7: Annual statement of account for increased OPEX at tax rate of 35%

Annual revenue	26,185,099
annual operating cost	2,400,000
depreciation	1,033,333
taxable income	22,751,766.00
income @35%	7,963,118.1
Net income	14,788,647.90
depreciation	1,033,333
Cash flow/NCR	**15,821,980.90**

The above table shows the annual statement of account when there is an increase in operating cost. This could be due to inflation or economic crisis whereby the cost of maintenance rises.

Table 8: The NCR at various tax rates

Tax rate	NCR
35%	$15,821,980.90
60%	$10,134,039.40
70%	$7,858,862.80
80%	$5,583686.2

The calculated results for the NPV, POT and IRR are given in the table below.

Table 9: Values For Reducing OPEX By 20% Various Tax Rates and Discount Factors

Tax Rates	NPV at i=15%	NPV at i =25%	NPV at i =30%	NPV at i =35%	NPV at i=45%	POT (Years)	IRR
35%	$75,146,978	$43,691,178	$34,339,576	$27,334,257	$17,656,443	1.098	91%
60%	$41,887,479	$21,739,918	$15,750,181	$11,263,248	$5,064,571	1.714	54%
70%	$28,583,679	$12,959,415	$8,314,424	$4,834,845	$27,822	2.210	45%
80%	$15,279,880	$4,178,911	$878,666	($1,593,559)	($5,008,927)	3.111	32%

It is clearly seen from the table above that the NPV gave positive values for all tax rates and discount rates considered, except at 80% tax rate for which the negative NPV begins to be felt at 35% discount rate and above.

Case 5: Varying the Price of Recovered Products
If for any reason, there is reduction in the prices of the gas products from the base case, the reduced prices will affect the revenue generated and hence, the profitability. Thus to properly study economic viability of the project when we have this scenario, we simulate this situation and carry out our evaluation.

Assuming the prices of the products were to change from the base case to;
Dry gas = $2/Mscf (instead of $3/Mscf base case)
LPG = $10/bbl (instead of $15/bbl base case)
Condensates = $25/bbl (instead of $50/bbl base case)

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Then the revenue generated from the sales of products changes as seen in the table below from $26,185,099.00 base case to $17,295,891.60

Table 10: Price changes for different products used

Products	**Output Per day**	**Price**	**Total Price/day**	**Price/year($)**
Dry gas	18MMscf/day	$2/Mscf	36,000.00	11,232,000.00
Lpg	1170.28bbls/day	$10/bbl	11,702.80	3,651,273.60
Condensates	309.31bbls.day	$25/bbl	7,732.75	2,412,618.00
TOTAL			**55,435.55**	**17,295,891.60**

Table 11: Annual statement of account for reduced annual revenue at tax rate of 35%

Annual revenue	17,295,891.60
annual operating cost	2,000,000.00
depreciation	1,033,333.00
taxable income	14,445,082.20
income @35%	5,055,778.77
Net income	9,389,303.43
depreciation	1,033,333.00
Cash flow/NCR	**10,422,636.43**
POT	***1.666564896***

To determine the NPV and IRR for the case of reduced revenue. Revenue is reduce when the prices of the products i.e. the dry gas, the LPG and the condensates fall. This is to ascertain the effects of changes in economic conditions on the profitability and viability of the investment. Here, only a reduction in price of products is considered which means a reduction in the annual revenue generated from the sales of the products, since an increase in the product price yields greater revenue which favours the project.

Table 12: Values for Reducing products prices at Various Tax Rates and discount Rates

TAX RATES	NPV at i=15%	NPV at i =25%	NPV at i =30%	NPV at i =35%	NPV at i=45%	POT (Years)	IRR
35%	$42,881,279	$22,395,826	$16,305,636	$11,743,453	$5,440,818	1.66	59%
60%	$22,031,664	$8,635,086	$4,652,372	$1,668,907	($2,452,736)	2.578	38%
70%	$13,691,818	$3,130,791	($8,933)	($2,360,911)	($5,610,158)	3.270	30%
80%	$5,351,972	($2,373,505)	($4,670,239)	($6,390,730)	($8,767,580)	4.470	21%

3. RESULTS AND DISCUSSION

The data and results in the table are analyzed by use of graphs.

From the graphical plots, discussion is made on the relationship between the plotted variables and how they correlate with each other.

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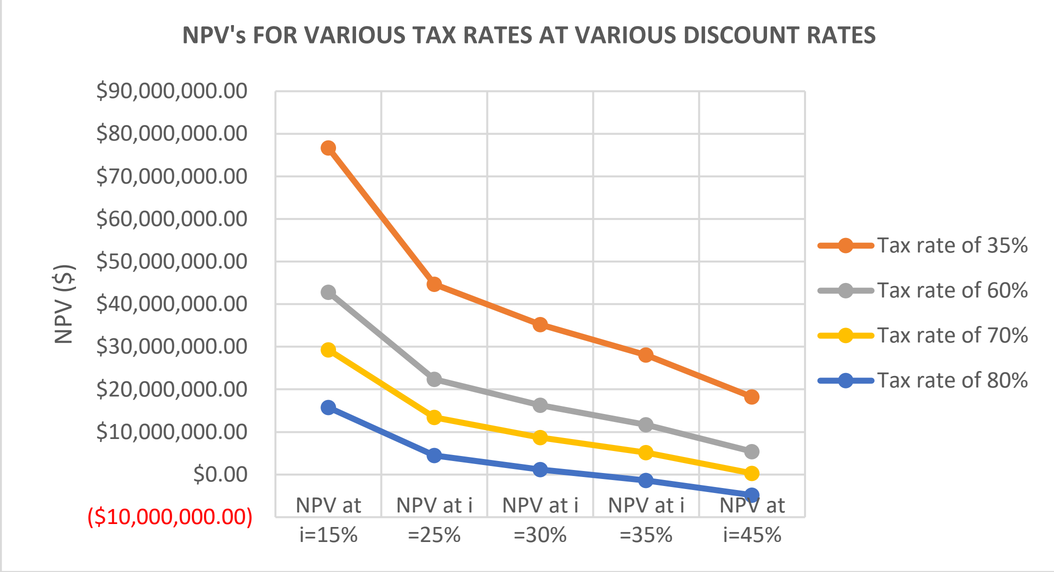

Figure 3: Graph of NPV at various Tax rate and at various discount rate at initial economic conditions

From the figure 3 above, it is seen that the project shows positive NPV even for tax from 70% and below for all discount rates. Even for a tax rate of 80%, positive NPV is also seen for discount rates of 15% and 25% showing the great economic viability of the project. Negative NPV started from the discount rate of 30% corresponding to a tax rate of 80%. Thus the project is not economically viable at a tax rate of 80%. It is even very rare to get such tax rate for projects of this nature.

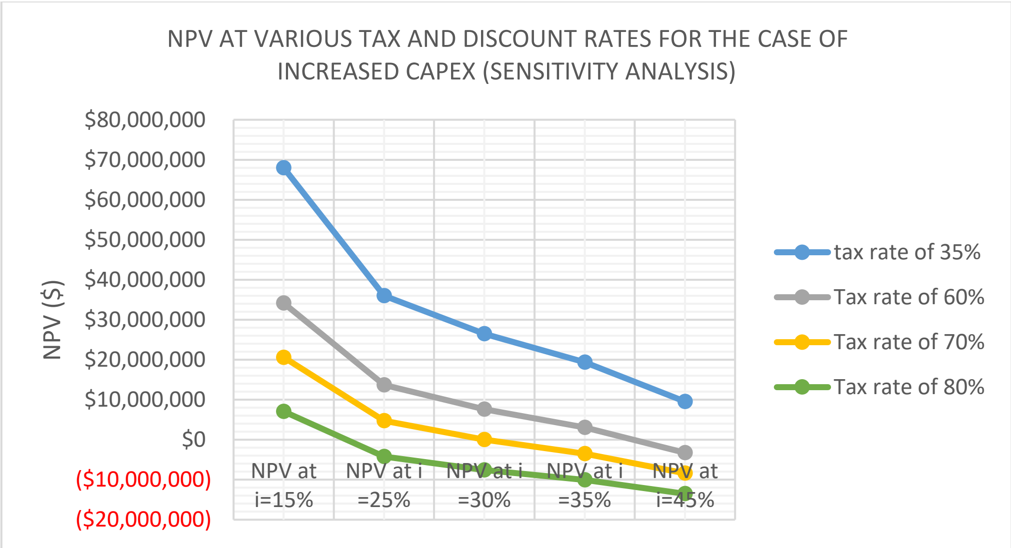

Figure 4: graph of NPV at various Tax rate and at various discount rate at increased CAPEX

The figure above shows that the lower the tax rate the Higher the NPV. It is observed that at higher tax rates, the trend lines flatten to an almost horizontal line. The higher the slope of the line, the better the project.

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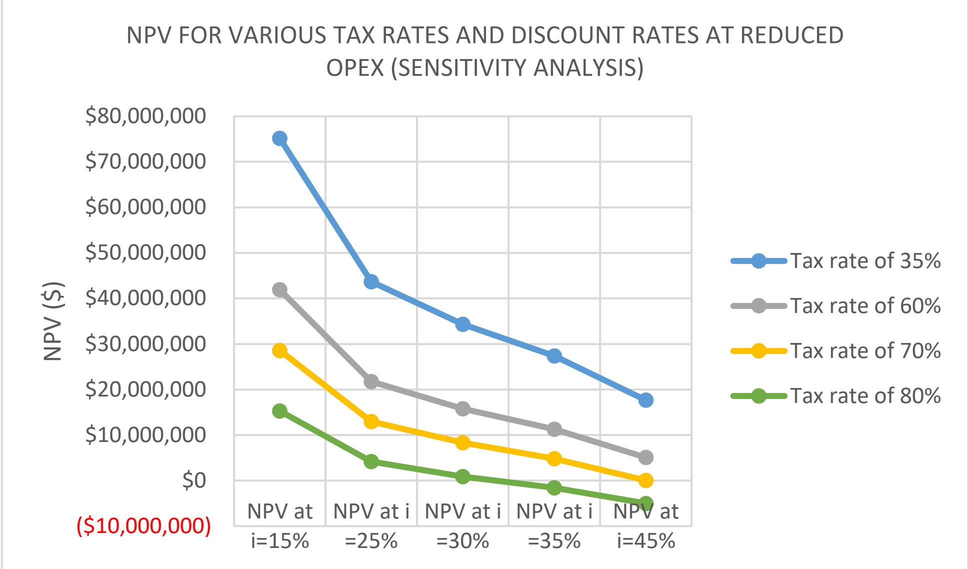

Figure 5: graph of NPV at various Tax rate and at various discount rate at reduced OPEX

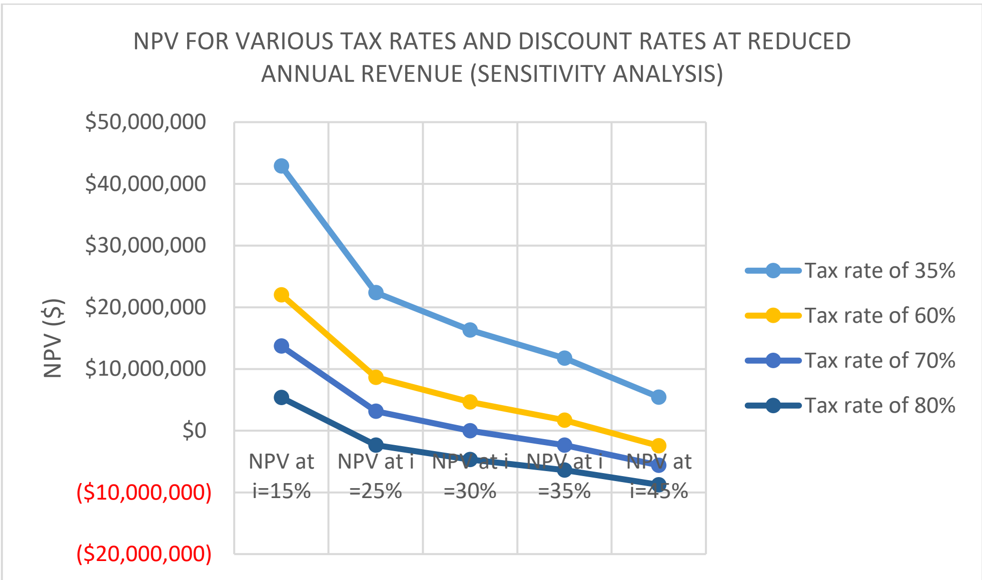

Figure 6: graph of NPV at various Tax rate and at various discount rate at reduced annual revenue

In the sensitivity analyses, in figure 4, figure 5 and figure 6 there have been great deviation from the initial economic conditions to see the effect on the NPV. The results show that even for high deviations from the initial CAPEX seen in the 50% increment, the NPV shows positive value for various tax rates and discount rates. It is seen that for the case of the increased CAPEX, negative NPV does not appear for all discount rates for a tax rate of 35%. For a tax rate of 60% negative NPV begins to appear at a discount rate above 38% and for a tax rate of 70%, negative NPV appeared only for tax rates above 30%. For tax rate of 80% all NPVs are positive for discount rates below 21%. When the OPEX is reduced by 20%, the NPV shows positive values for all tax rates and discount rates except for 80% discount rate where a negative NPV begins to appear at a discount rate above 32%.

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When the annual revenue was reduced, the sensitivity analyses showed that the NPV was all positive at tax rate of 35% for all tax rate. For a tax rate of 60% a negative NPV only begins at a discount rate above 38%, and for 70% for a discount rate above 30%. Also for tax rate of 80% a negative NPV only begins at a discount rate above 21%.

It is therefore advised that for all conditions that yield negative NPVs, the project should not be embarked upon.

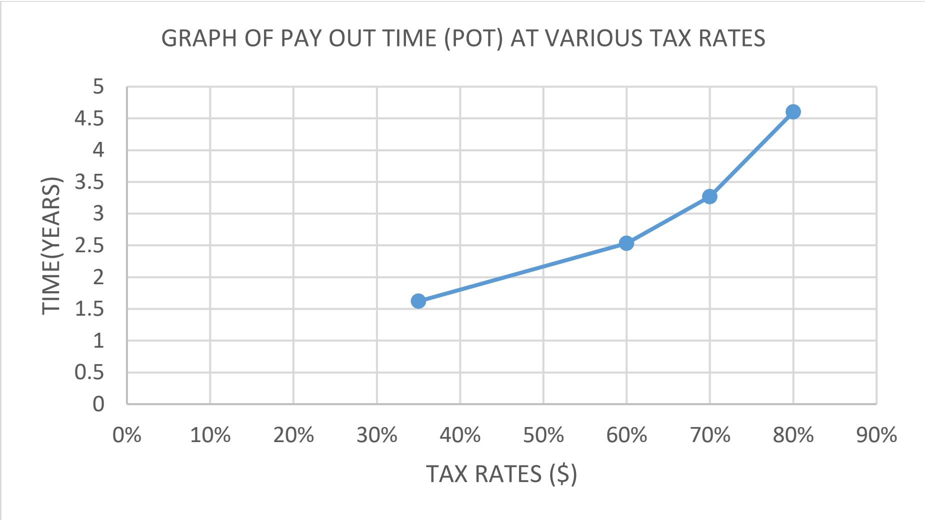

Figure 7: graph of POT at various tax rate and discount rate at initial economic conditions

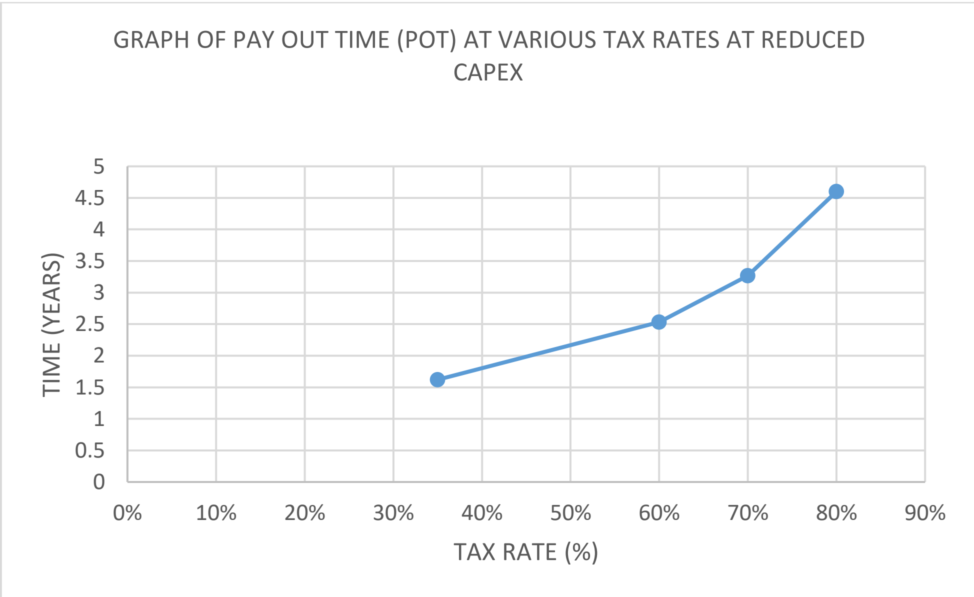

Figure 8: graph of POT at various tax rate and discount rate at increased CAPEX

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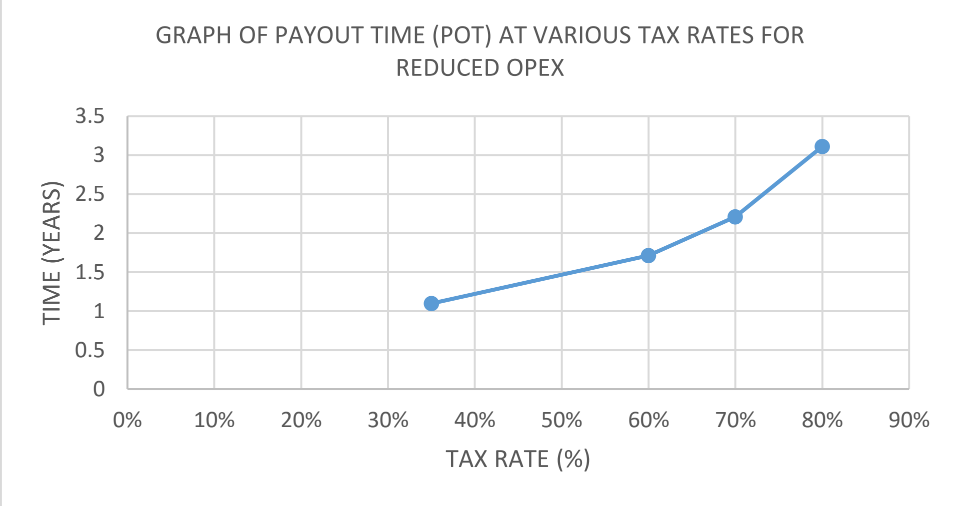

Figure 9: graph of POT at various tax rate and discount rate at reduced OPEX

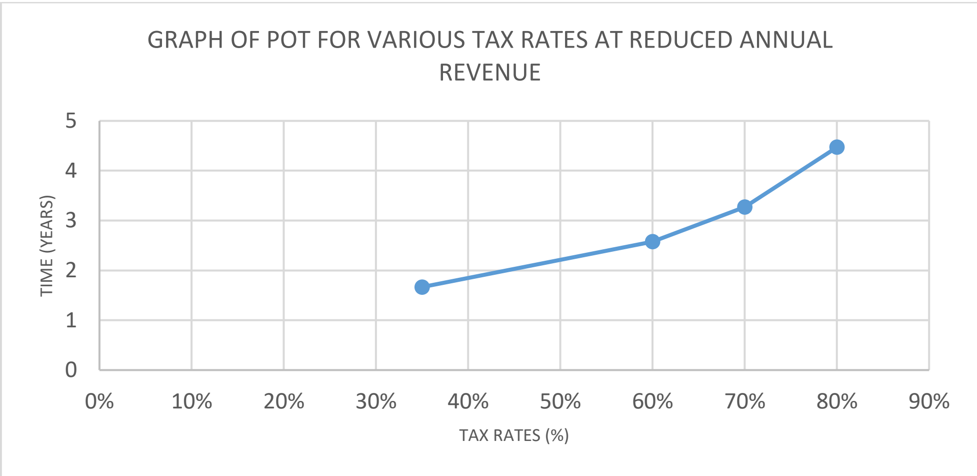

Figure 10: graph of POT at various tax rate and discount rate at reduced annual revenue

Analyses of effects of tax rates on POT for several economic conditions in figures 7 down to figure 10 show that there is a linear positive relationship of POT on tax rates.

The higher the tax rate the higher the POT. This means that an investment will take longer time to return the initial cost of investment in a country with higher rate of taxation.

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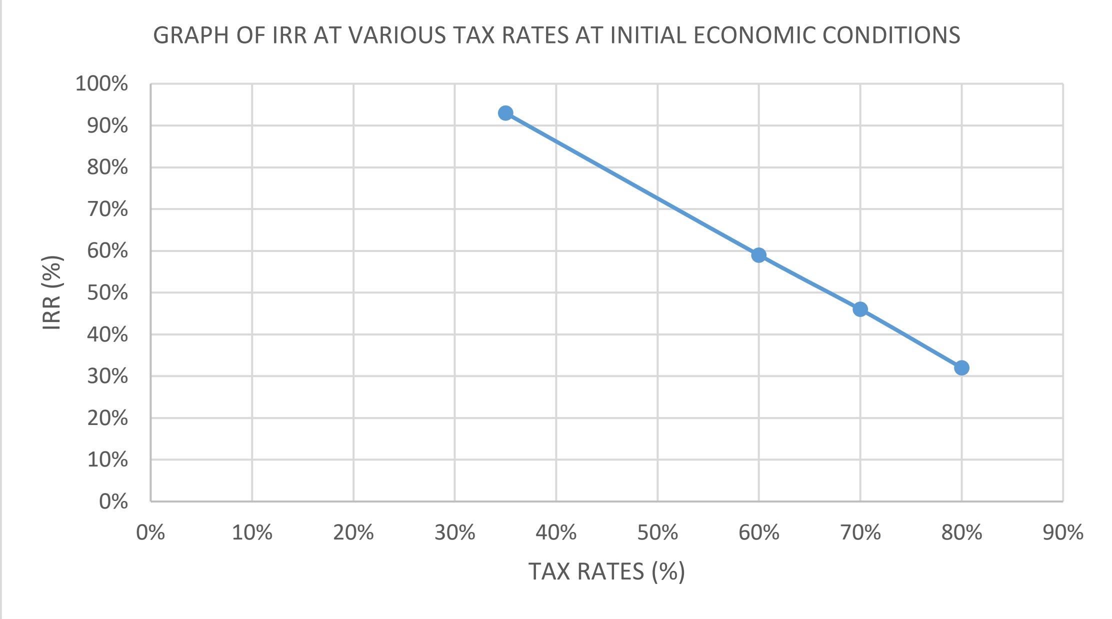

Figure 11: graph of IRR at various tax rate and discount rate at initial economic condition

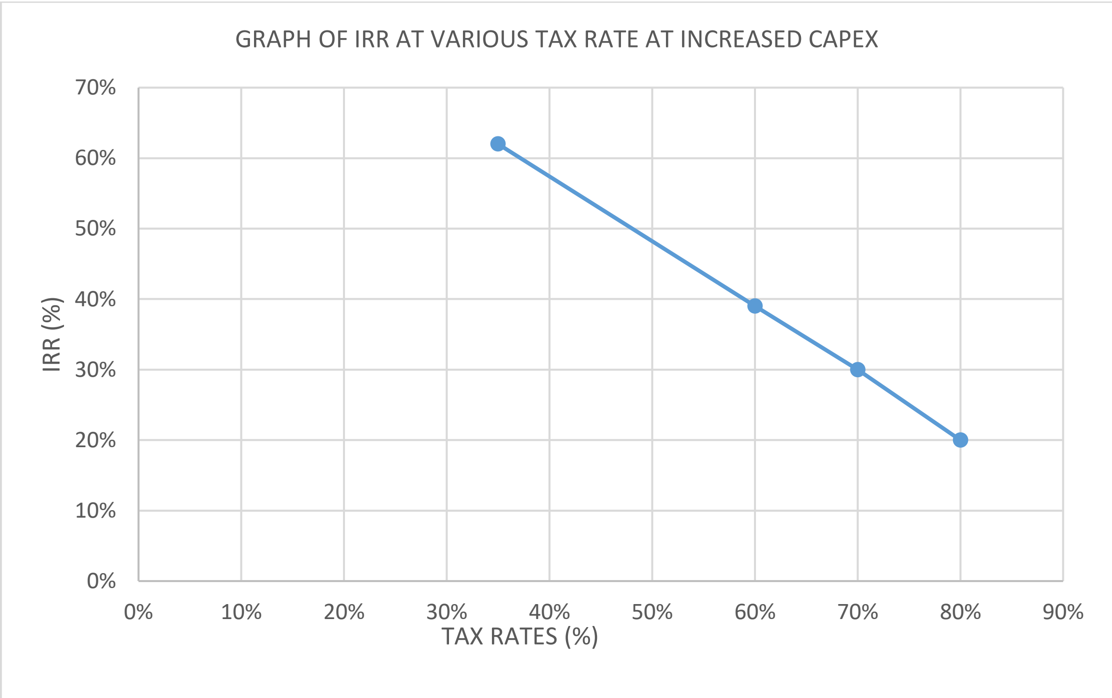

Figure 12: graph of IRR at various tax rate and discount rate at increased CAPEX

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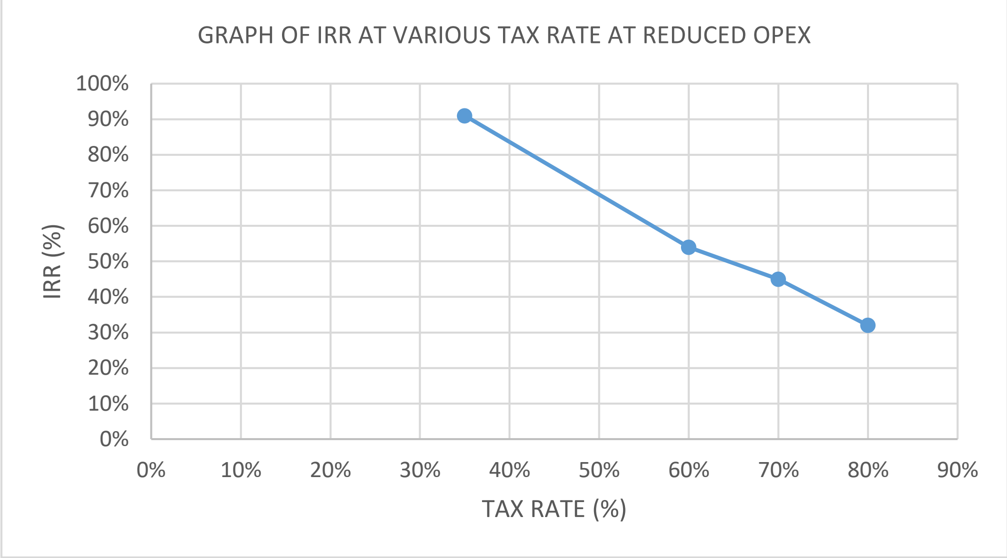

Figure 13: graph of IRR at various tax rate and discount rate at reduced OPEX

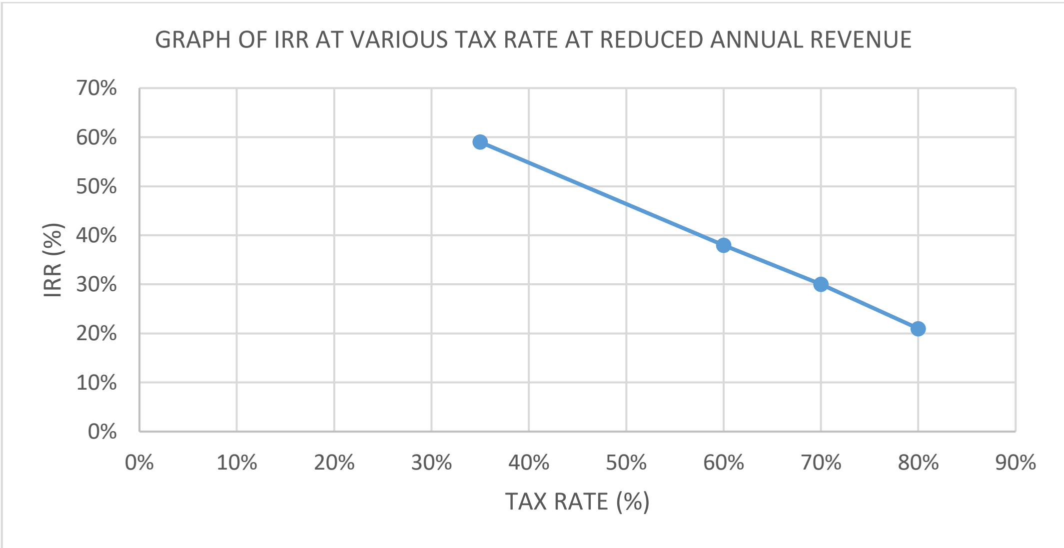

Figure 14: graph of IRR at various tax rate and discount rate reduced annual revenue

Considering the effects of tax rate on IRR in figure 11 down to figure 14, it is seen that there is a negative linear relationship of IRR on tax rate. Thus the higher the tax rate the less the IRR. Since investment opportunities with higher IRR are to be considered more, then the condition with lower tax rate is the best alternative.

Generally, the graph of POT and IRR against tax rates show that the higher the tax rates the higher the payout time (POT) and the lower the IRR. Investment with higher IRR and lower pay out time are to be considered.

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4. CONCLUSION

The determination of economic viability of flare gas monetization depends on many factors. These factors become variables in the economic analyses calculator used in this project. The changes in economic calculations of the investment appraisal methods indicate the high viability of the project. Several sensitivity analyses were done to determine situations under which the project may not be viable. It is seen that for even unfavorable conditions such as high tax rates and discount rates, the project still yields positive NPV. Furthermore, the effect of economic crisis and high inflation rates have been analyzed. This is seen in the 50% and 20% increment in the CAPEX and OPEX respectively which gave positive NPV for high discount rates and high tax rate.

In summary, the maximum tax rate upon which the project may yield returns under normal economic conditions is 70%. If there is further increase in tax rate, there should be further reductions in discount rate from 45% for the project to be viable under normal economic conditions.

NOMENCLATURE

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
LPG: Liquefied Petroleum Gas

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