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Research Paper

Monetizing Stranded Gas: Economic Analysis of Gas to Liquid Technologies in Nigeria

Igbinere, Sunday Agbons[1, *]; *Eka, Marvellous Emuobosan*[2]

Department of Petroleum Engineering, University of Benin, Benin City, Nigeria[1, 2]

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Abstract: Nigeria, as a nation endowed with vast reserves of stranded hydrocarbon resources and she is faced with the challenge of monetizing these resources, which are often flared due to lack of appropriate infrastructures for utilization. This has led the country into exploring different innovative approaches to unlock the economic potential of these resources. Gas-to-Liquid (GTL) technology has been seen as one of the major technologies that provide answers that can assist the country to grow in its economy. This study delves into the economic analysis of Gas-to-Liquids (GTL) technologies to monetize stranded hydrocarbon reserves in Nigeria. The economic analysis of the GTL technologies in Nigeria was done taking the Fischer-Tropsch GTL (FT-GTL) plant in Niger Delta as a case study. It was economically evaluated for a plant capacity of 1,000 MMSCF/D of natural gas. This plant is primarily affected by the crude oil price. The major aspect of this economic analysis was done by using a Microsoft Excel template developed for this study. The template considered the various variables that affect the variability of the projects such as plant life, construction period, capital expenditure, tax, operating expenditure, depreciation schedules, etc. The economic model used four economic indicators namely net present value (NPV), internal rate of return (IRR), profitability index (PI) and payback period (PP) to analyze both projects in this study. The financial and economic analysis of each indicator was carried out using the technique of discounted cash flow (DCF) analysis. DCF analysis yielded project performance criteria such as net present value (NPV) and internal rate of return (IRR), which were obtained from the projects' cash flow under consideration. Sensitivity analyses were then carried out with different tornado plots by varying the values of some of the economic parameters and determining their impacts on the project performance criteria within predetermined ranges. The results revealed that the higher the CAPEX for each of the cases, the lower the NPV and hence the profitability of the project is seen. For GTL technology to be viable as a project and profitable, the CAPEX is a factor to be extensively considered and reviewed periodically to ensure that it is not unreasonably high. Furthermore, the results of the economic analysis obtained at the different case scenarios using the most likely values of the economic input parameters indicate that FT-GTL profitability is highly dependent on the crude oil price, capital expenditure (CAPEX), operating expenditure (OPEX) and discounting factors should each be given proper considerations and review before embarking on future GTL projects. Increased operating expenditures from the FT-GTL technology reduced the NPV and IRR thereby affecting project profitability and extending the payback period, increasing the time to recoup initial investments of the FT-GTL technology plant.

Keyword: *Fischer-Tropsch, Gas-to-Liquid, CAPEX, OPEX, Net Present Value, Internal Rate of Return, Stranded Hydrocarbon*

Introduction

Natural gas is one of the primary energy sources besides oil, condensate, coal, as well as nuclear energy and renewable source of energy, natural gas is a cleaner and more effective source of energy that is less expensive and emits less greenhouse gases. The current production from conventional sources is not sufficient to satisfy all demands for natural gas (Ikoku, 1992). According to the International Energy Agency (2022), the global annual gas consumption is expected to grow at an annual average rate of 0.8% from 2023 to 2025, reaching around 4240 billion cubic meters by the end of the forecast. Also, the National Oil Spill Detection and Response Agency (NOSDRA) records that

**Corresponding: E-Mail: agbons.igbinere@uniben.edu, Tel: +234 09070858395*

oil and gas companies operating in Niger Delta region flared 92.3 million standard cubic feet (Mscf) of gas, between January and April 2023 and this represents an increase of 79.5% against 50.3 Mscf of gas flared in 2022. The need to meet its flare down targets and promote production and use of environmentally friendly fuels serves as a drive for investment in the gas sector of the Niger Delta region economy. Also, with the global depletion of existing oil reserves, there is a drive towards finding the most economically viable way of commercializing our abundant gas reserves in this location. Glebova, (2013) looked at the history and future of Gas-to-liquid (GTL) technology in utilizing stranded hydrocarbon. This GTL technology has been seen as an option for utilization of the significant quantities of natural gas reserves in Niger Delta and to assist its economy to grow, because it is more favorable to liquefied natural gas (Nagi *et al*., 2016). To help decision-makers, this research aims to assess the feasibility and economic effects of GTL technologies in Niger Delta. GTL technology includes synthesizing natural gas to create premium liquid fuels like diesel, jet fuel, and other chemicals with additional value. In the GTL process, natural gas is transformed into syngas and ultimately into high-quality hydrocarbon products. Additionally, GTL technology lowers greenhouse gas emissions and aids in reducing the harmful consequences of climate change.

Natural gas is considered one of the most abundant energy resources worldwide with proven reserves exceeding 6000 trillion cubic feet (Tcf), and approximately 60% of these reserves can be classified as stranded, furthermore, Nigeria is the 10th biggest natural gas holder on the planet and biggest in Africa representing about 3% of the absolute natural gas estimates of 6,923 Trillion cubic feet (TCF) and Nigeria had about 200.4 trillion cubic feet of proven gas reserves in 2019 which later increased to an estimate of about 206.5 trillion cubic (Tcf) of proved natural gas reserves (Chikwe *et al*., 2021). Following Nigeria's gas reserves currently estimated to be at 206.5 TCF (trillion cubic feet) with a projected growth rate of over 70% by 2025. Unfortunately, even with this huge gas reserve, not much has been accomplished in the effective exploitation and utilization of this abundant natural gas reserve of which some of these gas reserves are termed stranded, whose volume and location are often considered as non-commercial and difficult to exploit. Dry natural gas production in Nigeria averaged about 1.5 Tcf between 2012 and 2021, and dry natural gas consumption averaged 649 billion cubic feet (Bcf) over the same period. Significant amounts of natural gas production in Nigeria is either re-injected or flared or abandon (Chikwe *et al*., 2021). Domestically, natural gas is still very undervalued as a major energy resource and various sustainable economic projects can be built around natural gas to drive our economy (Idigbe & Onwuachi-Iheagwara, 2014). GTL technology has the potential to utilize natural gas or any other resource rich in methane *i.e*. refinery gas, gas hydrates and landfills for gainful utilization of the feed stock with value addition to yield middle distillates or any other fuel product, chemical or chemical feedstock (Ahmed *et al*., 2012). GTL technology has the tendency to produce more of lighter petroleum fractions (kerosene and diesel), compared to the refined oil barrel distillates fraction and these GTL distillates can be used immediately or blended with others (Stanley, 2009). According to Oredein, (2013) and Uzuegbunam (2014), the Escravous gas to liquid (EGTL) is expected to convert more than 325 MMcf/d of natural gas to 33,000 bbl/day of GTL diesel; GTL naphtha, which is a feed stock used in plastics manufacturing and liquefied petroleum gas (LPG). Some of Nigeria's oil fields lack the infrastructure to capture the natural gas produced with oil, known as associated gas. According to the most recent data by the World Bank's Global Gas Flaring Reduction Partnership (GGFR), Nigeria flared about 5.318 billion cubic meters (or 188 Bcf) of natural gas in 2022, making Nigeria the ninth-highest natural gas-flaring country in terms of annual natural gas-flaring volume. Some researchers have studied the comparison between LNG and GTL technologies in Niger Delta region (Akpomera & Oghenekevwe 2017).

Gas-to-Liquid (GTL) technology refers to a process that converts natural gas or other gaseous hydrocarbons into clean burning liquid hydrocarbon products. It involves transforming gas molecules into long chain hydrocarbons, such as synthetic crude oil or transportation fuels like diesel or jet fuel (Al-Shalchi, 2006). While Dodaro, (2015) described the Fischer-Tropsch process as a gas to liquid (GTL) polymerization technique that turns a carbon source into hydrocarbons chains through the hydrogenation of carbon monoxide by means of a metal catalyst. This study is also aimed at identifying which parameter such as CAPEX, OPEX, tax rate, GTL premium has the highest impact on the viability of GTL technology in Nigeria. Also to assess the feasibility and cost-effectiveness of GTL technologies in Nigeria and to determine which economic indicator such as the net present value (NPV) and internal rate of return (IRR) has the greatest impact on the viability of the GTL technology in Nigeria, and also to determine the profitability index and payback period.

Research Methodology

This study focused on the application of GTL technologies in Fischer- Tropsch GTL (FT-GTL) plant in Niger Delta, Nigeria. Microsoft excel was used to develop a template that was applied to some of the economic indicators. The template considered the various variables that affect the variability of the projects such as plant life, construction period, CAPEX, tax, OPEX, depreciation schedules, etc. The study model for this project developed from Microsoft Excel incorporated a plant life of 25 years and a construction period of 3 years, while the plant operating time of 330 days/annum, 5-year MACRS depreciation schedule and 100% owner's equity were adopted. A detailed list of all parameters used in this study is shown in table 1 below.

Table 1. Selected Economic Input Data (Capuano, 2018; Economides *et al.*, 2005; Gradassi, 2001; Uzuegbunam, 2014)

S/N	Parameter	Value
1	Plant useful life	25 years
2	Plant construction period	3 years
3	Plant construction spending period per year	25%, 35%, 40% (Year 1, 2 3 respectively)
4	Depreciation schedule	5 – years MACRS
5	**Tax Rates**	
	Company tax	30%
	Royalty rate	5%
6	Plant operating time	330 days per annum
7	Feed gas cost (Base cost)	$2.50/MMBTU
8	Discount ratio	10%
9	**FT-GTL Estimated CAPEX**	
	Gas utilization	1000 MMscf/d
	FT-GTL plant capacity	100,000 bbl/day
	FT-GTL plant CAPEX	$5.7 Bn
9	**OPEX**	
	LNG	0.5%/MMBTU
	FT-GTL	$6.00/bbl
10	Crude oil cost (Base cost)	$65.00/bbl
11	**FT-GLT Product Per Annum**	
	Diesel	$4.50/gal
	Naphtha	$3.00/gal
12	**Product Distribution**	
	Diesel	72%
	Naphtha	28%
13	FT-GTL shipping cost	$1.50/bbl
	Plant capacity	1000 MMscf/d

The Research Economic Measures of Profitability

The economic model incorporated four economic indicators, namely net present value (NPV), internal rate of return (IRR) and profitability index (PI) as well as payback period to analyze both projects in this study. The financial and economic analysis of each indicator was carried out using the technique of discounted cash flow (DCF) analysis. The DCF is any method of investment project evaluation and selection which adjusts cash flows over time for the time value of money. DCF analysis yielded project performance criteria such as net present value (NPV) and internal rate of return (IRR) which were obtained from the cash flow of the projects under consideration (Onyelucheya & Ibe, 2015). Sensitivity analyses were then carried out with different tornado and spider plots by varying the values of some of the economic parameters and determining their impacts on the project performance criteria within predetermined ranges. Furthermore, bar charts were also used to present the behavior of the different economic indicators and other economic parameters. This was to determine which economic indicator would have the greatest impact on the economics of the GTL project. The composition of the product range produced by a GTL plant can differ based on the specific technology and processes employed. In the case of the EGTL plant, Sasol technology is utilized for the processes. According to a study conducted by Smith and Asaro (2005), the product slate for Sasol technology consists of approximately 28% naphtha and 72% middle distillates. This research work assumed a product slate of 72% for diesel and 28% for that of naphtha.

Net Present Value (NPV): The present value (NPV) of an investment proposal is the present value of the proposal's net cash flows less the proposal's initial cash outflow. Net present value was obtained by summing the discounted cash flows for each year for the lifespan of the project.

$$NPV = -1 + \sum_{i=1}^{n} \frac{DCF_i}{(1+i)^n} \quad (1)$$

$$I = CAPEX + OPEX \quad (2)$$

Where NPV is the net present value, I is the project investment, DCF is the discounted cash flow, i is the interest rate, while CAPEX and OPEX are the capital expenditure and operating expenditure respectively.

Internal Rate of Return (IRR) or Discounted Cash-Flow Rate of Return (DCFROR): This is the interest rate that makes the cumulative NPV of the project equal zero. It is a measure of the interest rate the project can pay and still break even by the end of the project life. A project is judged to be worthwhile in economic terms if the IRR is greater than the cost of capital, otherwise it should be rejected (Gradassi, 2001; Nwankwo, 2008; Onyelucheya and Ibe, 2015). The general criterion used for economic evaluation of an investment by means of IRR is to compare the obtained IRR with a required rate of return known as the hurdle rate or discount rate and the discount rate was assumed to be 10%.

$$IRR = \sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^t} \quad (3)$$

Where IRR is the internal rate of return, CF_t is the cash flow at time t and t is the time period considered.

Profitability Index (PI): The Profitability Index (PI) is the ratio of the present value of future net cash flows to the initial cash out flows. It measures the ratio of the net present value to the initial investment or capital expenditure (CAPEX) of a project. It is also known as the benefit-cost ratio. The acceptance criterion for the profitability index of an investment proposal is to accept the proposal if the profitability index ($PI \geq 1$) or reject the proposal if otherwise.

Payback Period (PP)*:* The Payback Period is the time required for the cumulative net earnings to equal the initial outlay; it is the length of time required to get our investment capital back. It is the time until the cash flow recovers the initial investment or CAPEX of the project and it is estimated by dividing CAPEX into the profit after taxes results. The shorter the payback period, the higher the project is rated. On the other hand, if the calculated period is deemed too long, the project is rejected.

Evaluating the Capital Expenditure (CAPEX)

The capital expenditure (CAPEX) for this project using the FT-GTL plants was based on the cost of a gas to liquid (GTL) plant located in Niger Delta of Nigeria and which has started production. The current CAPEX for the EGTL plant is about $10 billion and it processes about 475 MMscf/d of feed gas (Uzuegbunam, 2014). It is also able to produce about 33,000 bbl/day of GTL product and the base cases to be used in this research work will be the CAPEX and capabilities of the GTL plants that will be capable of processing 1000 MMscf/d of feed gas. This will be done using the power law and sizing model.

The Power Law and Sizing Model*:* This is also known as the exponential rule or the six-tenth rule. It is a nonlinear correlation that's frequently used to estimate the cost of a new process facility based on the cost of an existing known capacity (Hendrix and Au, 2003; Kerzner, 2001). Power law (equation 4) will estimate the CAPEX of the FT-GTL plant capable of processing 1000 MMscf/d. Shown below in equation 4 is the mathematical expression of the power law and sizing model.

$$C_b = C_a \left(\frac{Q_b}{Q_a}\right)^m \quad (4)$$

Where C_a is the cost of existing facility, C_b is the estimated cost of new facility, Q_a is the capacity of existing facility, Q_b is the estimated capacity of new facility and m is the correlation exponent, ($0 < m < 1$). For most equipment, m is approximately 0.5, and for chemical processing plant, it is approximately 0.6 (Mian, 2010).

***Estimating Operating Expenditure (OPEX)**:* The annual operating expenditure (OPEX) used in this research work includes the cost of materials and supplies as well as the cost of labour, utilities and maintenance, except the cost of feedstock which was separately estimated. Al-Saadoon (2005) gave the annual operating expenditure for large projects to be in the range of 5-7% of the capital expenditure. While Toochukwu *et al*. (2019) and Ubanozie *et al*. (2021) stated that GTL plant OPEX is 5% of CAPEX (excluding the cost of natural gas and cost of O_2 or CO_2). Economides *et al*. (2005) reported the FT-GTL OPEX to be $5.00/bbl while Gradassi (2001) gave the OPEX for FT-GTL as $4.00/bbl. Patel, (2005) reported the operating costs of the FT-GTL plant to be between $4.00/bbl and $5.50/bbl. This research work adopted $6/bbl as the OPEX for the FT-GTL plant project.

***Feedgas Cost and Shipping Cost**:* According to Capuano, (2018) of the United States Energy Information Administration (EIA) and Annual Energy Outlook (AEO) in 2018, the annual cost of natural gas used as feed gas in chemical plants is $4.80/MMBtu compared to the original price of $3.80/MMBtu as at 2012. It was projected that the cost will even increase further to $7.65/MMBtu in 2040. Gas prices of $1.00/MMBtu, $2.5/MMBtu and $5.0/MMBtu were adopted for the purpose of this analysis while the base case price shall be $2.5/MMBtu. While that of the shipping cost for the FT-GTL plant project was taken to be $1.50/bbl. For this particular value, two other values were investigated using the tornado graph to analyze the effect of high and low values from the base case on the economics of the GTL project.

Other economic factors considered in this study include sales revenue, product pricing, plant load factors and plant operating time. While others are plant useful life, tax rate, depreciation, plant capacity as well as plant construction schedule. The individual data adopted for these economic factors were based on current international standard values and from literatures. The summary of these parameters is presented in tables 1 to 3.

Table 2. Parameters for the Sensitivity Analysis for FT-GTL

Parameters	Low Case	Base Case	High Case
Crude Oil Price ($/bbl)	30	65	100
Feed Gas Cost ($/MMBTU)	1	2.5	5
OPEX ($/bbl)	4.5	6	10
Shipping Cost ($/bbl)	0.5	1.5	2.5
Discount Rate (%)	8	10	12
Tax Rate (%)	15	30	35
GTL Diesel Premium ($/gal)	3	4.5	6.5
GTL Naphtha Premium ($/gal)	2	3	40
CAPEX ($M/bbl)	0.5	1.0	2.0
Production Capacity (bbl/day)	1,000,000	1,000,000	1,000,000

Table 3. Depreciation schedule

Recovery Year	MACRS Percentages (%)
1	20.00
2	32.00
3	19.20
4	11.52
5	11.52
6	5.76

Results and Analysis

This section features the results obtained from the analysis of the different economic indicators to determine the viability of the implementation of the GTL technology in Niger Delta, Nigeria. In the economic analysis of implementing Gas-to-Liquid (GTL) technology, it's essential to state that these results represent the project's financial viability under various scenarios: a low case, base case and high case as well as the sensitivity to crude oil prices. These results presented in tables 4 to 6 and in figures 1 to 22 were used to analyze the different economic indicators of GTL technology.

Net Present Value

a) **Low Case Scenario ($30/barrel)**: In the low-price scenario, the project may face challenges in achieving a positive NPV. Reduced crude oil prices can result in lower revenue, impacting the project's cash flow. The NPV may be close to breakeven or negative, indicating potential financial risk.
b) **Base Case Scenario ($65/barrel)**: At the base case scenario, with crude oil prices of $65 per barrel, the project exhibits a positive NPV. This suggests that, under current market conditions, the project is economically viable and can generate a positive return on investment.
c) **High Case Scenario ($100/barrel)**: In the high-price scenario, with crude oil prices at $100 per barrel, the project's NPV is significantly higher. The project appears highly profitable in this scenario, with the potential for substantial returns.

Internal Rate of Return

a) **Low Case Scenario ($30/barrel)**: The low-price scenario results in a lower IRR, which may be below the project's required rate of return. This could indicate that the project's economic feasibility is uncertain when crude oil prices are low.
b) **Base Case Scenario ($65/barrel)**: The base case scenario, with crude oil at $65 per barrel, leads to a reasonable IRR. The project appears capable of meeting or exceeding the required return, making it an attractive investment option.
c) **High Case Scenario ($100/barrel)**: In the high case scenario, the high-price scenario, the project's IRR is notably high, indicating strong potential for significant profits and meeting or surpassing investment expectations.

Capital Expenditure (CAPEX)

a) **Low Case Scenario ($30/barrel)**: The low-price scenario, it's crucial to scrutinize the project's CAPEX carefully. With potential challenges in achieving a positive NPV, cost control and efficiency become critical to improve project economics.
b) **Base Case Scenario ($65/barrel)**: At the base case scenario, the CAPEX is manageable and aligns with the expected returns. Project managers should continue to monitor CAPEX to ensure it remains within budget.
c) **High Case Scenario ($100/barrel)**: In the high-price scenario, the project's CAPEX may be easier to justify due to the expected higher returns. However, it's still essential to optimize CAPEX to enhance overall profitability.

The sensitivity analysis of crude oil prices demonstrates that GTL technology projects are highly sensitive to oil price fluctuations. It underscores the importance of risk management and strategies for hedging against adverse price movements. In the low-price scenario, careful cost management and operational efficiency are paramount to ensure the project's viability. The base case represents a reasonably safe investment with positive NPV and IRR. However, ongoing monitoring and adjustments to market conditions are necessary. While in the high-price scenario, the project becomes highly profitable, potentially attracting more investors. The sensitivity analysis provides valuable insights into the financial robustness of GTL technology projects under different crude oil price scenarios. It highlights the need for proactive risk management and cost optimization to ensure long-term economic viability and profitability.

The results presented in table 4 show the net present values for each of the cases over the period of 10 years. Generally, the values show clearly that the whole project requires re-evaluation of the project conditions and values as well as the fiscal policy under which the GTL project is executed. The low case has a total NPV of -$55,623,304,017.39; the base case has a total NPV of -$304,835,553,760.29, while the high case has a total NPV of -$1,543,792,616,284.73. These values indicate that the low case conditions for the GTL technology project execution is the most profitable. However, the negative NPVs show clearly that the project has a lot of financial risk and needs critical reevaluation at every point of the project execution.

Table 4. NPV Analysis for 10 years for Three Case Scenarios

Year	Low Case ($)	Base Case ($)	High Case ($)
1	2,619,888,888.89	3,500,681,818.18	-12,670,714,285.71
2	3,737,720,164.61	3,079,876,033.06	-32,324,846,938.78
3	3,520,389,117.51	-727,669,045.83	-57,840,062,864.43
4	2,118,307,552.48	-7,452,023,085.85	-88,254,360,552.89
5	-333,069,962.40	-16,680,708,052.11	-122,744,598,831.36
6	-3,711,855,513.78	-28,052,136,056.84	-160,607,784,462.17
7	-7,908,461,203.16	-41,249,765,514.84	-201,244,775,481.42
8	-12,824,445,717.63	-55,996,899,236.19	-244,146,097,430.02
9	-18,371,464,289.19	-72,052,056,037.02	-288,879,606,793.55
10	-24,470,313,054.73	-89,204,854,582.84	-335,079,768,644.40
TOTAL	**-55,623,304,017.39**	**-304,835,553,760.29**	**-1,543,792,616,284.73**

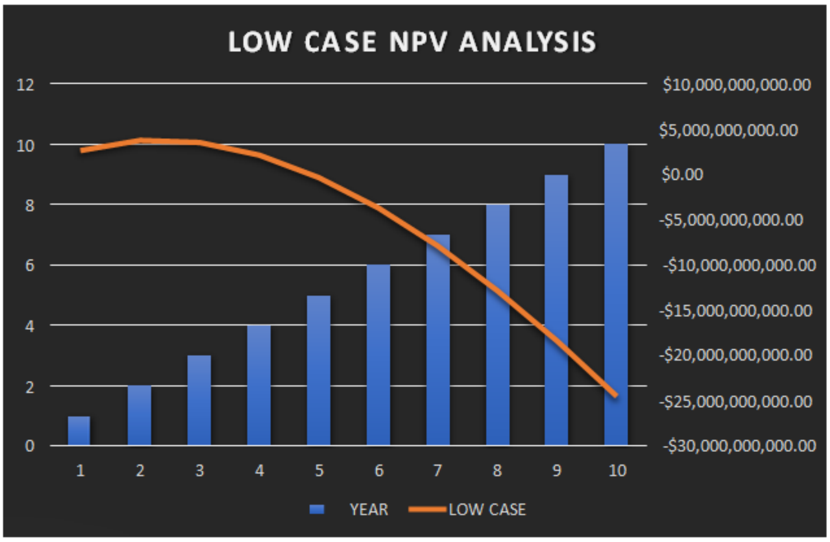

Figure 1. Low Case NPV Analysis for 10 years at $30/bbl

The results presented in figure 1 is a graphical representation of the low case NPV, after a period of 10 years, and it can be seen that there is decline in the NPV as the year of the project progresses. The final value of NPV in the tenth year is -$24,470,313,054.73. This is due to several factors of which the price of crude oil per barrel is a significant factor.

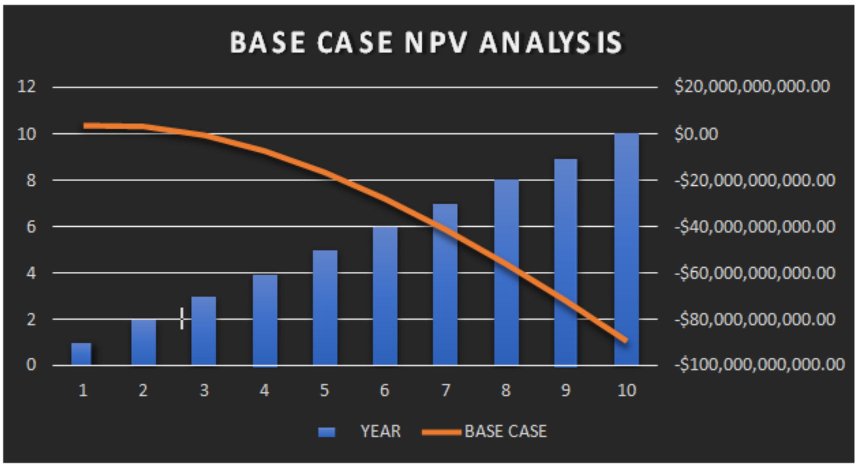

Figure 2. Base Case NPV Analysis for 10 years at $65/bbl

Figure 2 is a graphical representation of the base case NPV, it can also be observed that there is decline in the NPV as the year of the project progresses, but this decline is somewhat more than the low case decline. The final value of NPV at year 10 is -$89,204,854,582.84. This is due to several factors of which the price of crude oil per barrel is also a significant factor.

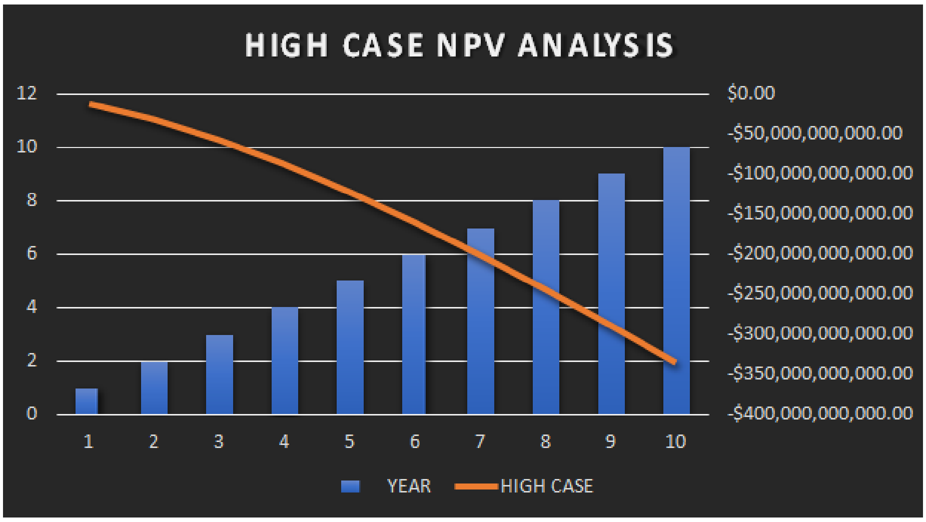

Figure 3. High Case NPV Analysis for 10 years at $100/bbl

Figure 3 is a graphical representation of the high case NPV, it can be seen that there is decline also in the NPV as the year of the project progresses, but this decline is somewhat more than the base case decline. The final value of NPV at year 10 is -$335,079,768,644.40. And which is also due to several factors of which the price of crude oil per barrel is also a significant factor. The results in figure 4 represent the IRR for different case scenarios at different crude oil prizes, and this economic indicator revealed that low crude oil prizes promote the viability of an FT-GTL technology in Niger Delta gas to liquid plant. Internal Rate of Revenue (IRR) is another factor for determining the viability of a project. NPV alone cannot be used to determine the viability of an oil and gas project. A high discounting factor shows a viable project. This means that the low case IRR of 0.1 is the most viable. This might be somewhat different from what is expected as it is believed that at higher crude oil prices, the project should be more viable but it should be noticed that as the prices of crude oil increases for the different cases, other factor also increases as well. NPV and IRR cannot contradict themselves but rather explain and complement themselves. IRR of 0.094 of the base case is also good value as it is very close to 0.1.

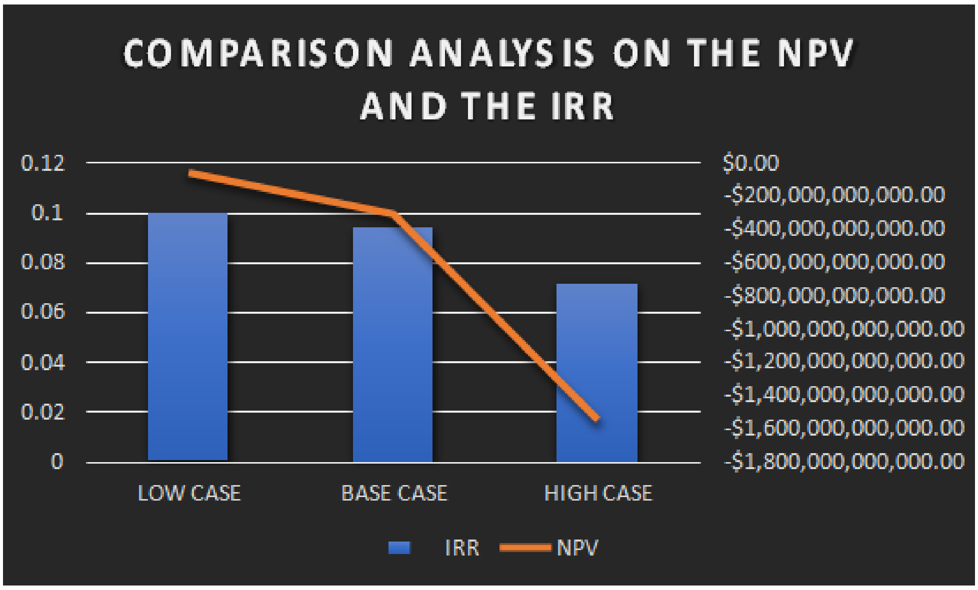

Figure 4: Comparison of NPV and IRR for Three Case Scenarios

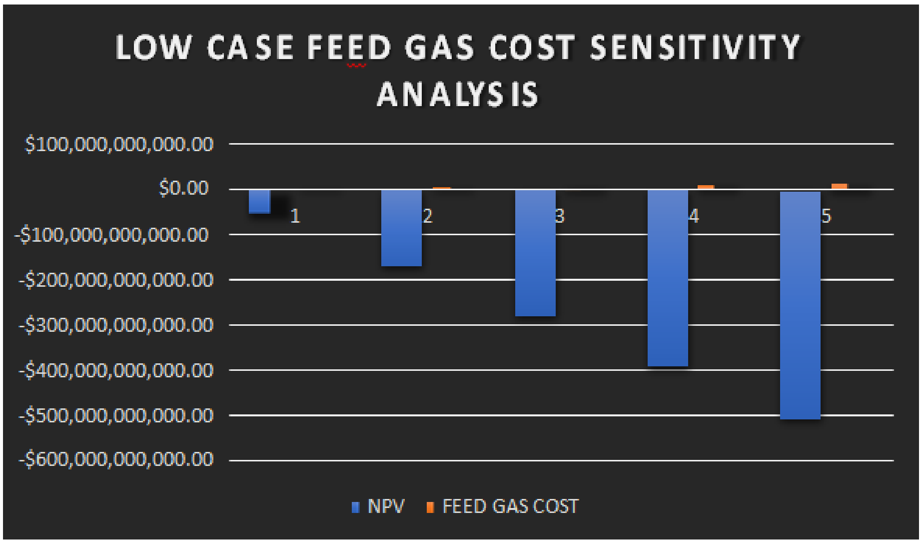

Figure 5. Effect of Feed Gas Cost on NPV for Low Case

Table 5. Analysis of the Feed Gas Cost and Net Present Value

Low Case		Base Case	
NPV ($)	**Feed Gas Cost ($)**	**NPV ($)**	**Feed Gas Cost ($)**
-55,623,304,017.39	4,088,000,000.00	-304,835,553,760.29	7,154,000,000.00
-168,043,304,017.39	6,132,000,000.00	-417,255,553,760.29	9,198,000,000.00
-280,463,304,017.39	8,176,000,000.00	-61,928,053,760.29	11,242,000,000.00
-392,883,304,017.39	10,220,000,000.00	-174,348,053,760.29	13,286,000,000.00
-505,303,304,017.39	12,264,000,000.00	-286,768,053,760.29	15,330,000,000.00

High Case	
NPV ($)	**Feed Gas Cost ($)**
-1,656,212,616,284.73	12,264,000,000.00
-1,768,632,616,284.73	14,308,000,000.00
-1,656,212,616,284.73	16,352,000,000.00
-367,397,616,284.73	18,396,000,000.00
-479,817,616,284.73	20,440,000,000.00
-592,237,616,284.73	22,484,000,000.00

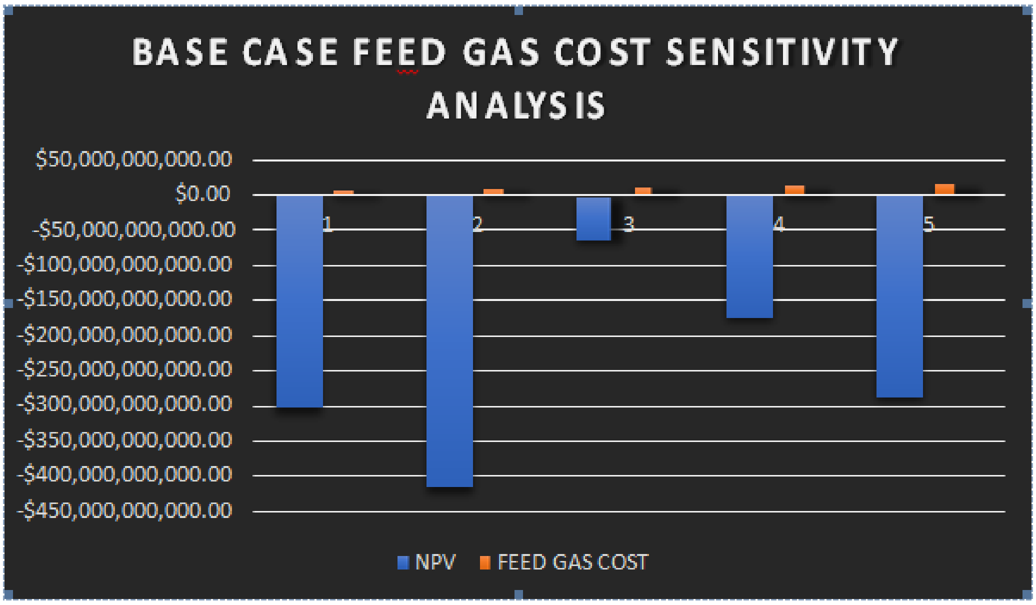

Figure 6: Effect of Feed Gas Cost on NPV for Base Case

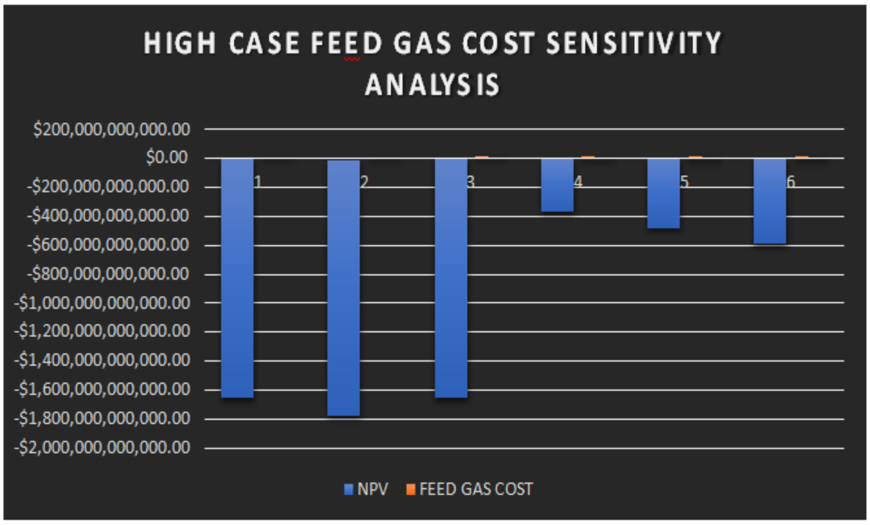

Figure 7. Effect of Feed Gas Cost on NPV for High Case

Figures 5 through 7 explains explicitly the effect of feed gas cost on NPV as it has a direct impact on the overall profitability of the project. At a low feed gas cost of $1/MMBTU, we can see the trend of the NPV. But there is increase in the feed gas cost due to increase in production as the year proceeds and this has a final effect on the NPV. It can be seen from table 5 that with a feed gas cost of $12,264,000,000.00 the NPV is -$505,303,304,017.34 for a low case scenario and this suggest that there is an inverse relationship between the feed gas cost and the NPV. As the feed gas cost increases due to increase in production each year, there is a corresponding NPV. While for a base case presented in figure 6, the feed gas cost of $2.5/MMBTU resulted in an increase due to increase in production, from table 5, the feed gas cost of $15,330,000,000.00 produced an NPV of -$286,768,053,760.29 and also established an inverse relationship between the feed gas cost and the NPV. Similarly from figure 7 and table 5, a high feed gas cost of $5/MMBTU also has the same trend as that of the previous cases. It can be seen here in the high case that with feed gas cost of $22,484,000,000.00 the NPV is -$592,237,616,284.73. This inverse relationship between the feed gas cost and the net present value for an FT-GTL technology is a clear indication of high operating expenses, reduced cash flows. When feed gas cost decreases, operating expenses fall, leading to higher cash flows and consequently results in increase in NPV. This relationship between feed gas cost and net present value is essential for maximizing net present value and maximizing the FT-GTL technology project profitability.

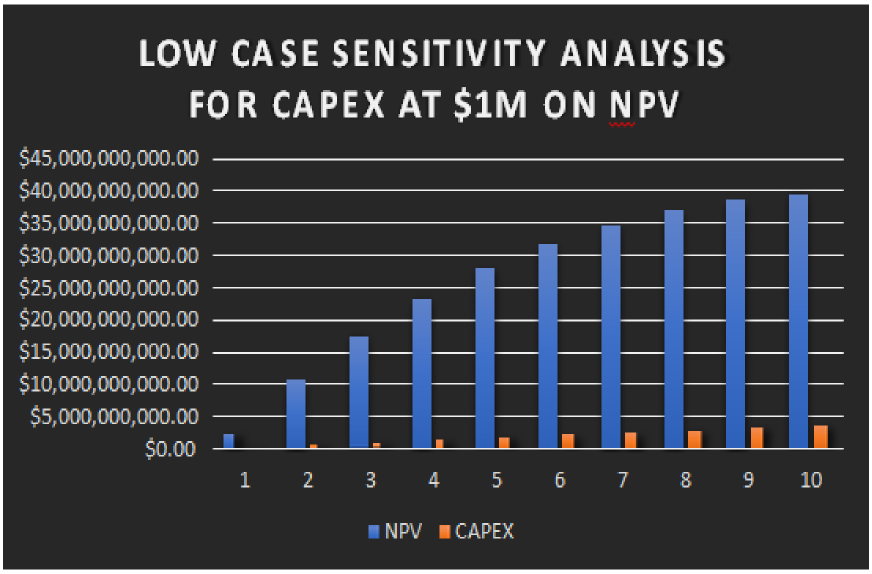

Figure 8. Low Case Sensitivity Analysis for CAPEX at $1M on NPV

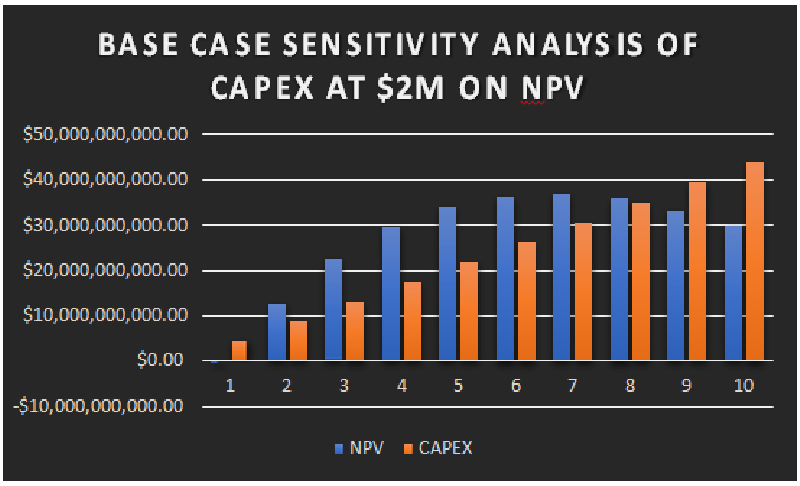

Figure 9. Base Case Sensitivity Analysis for CAPEX at $2M on NPV

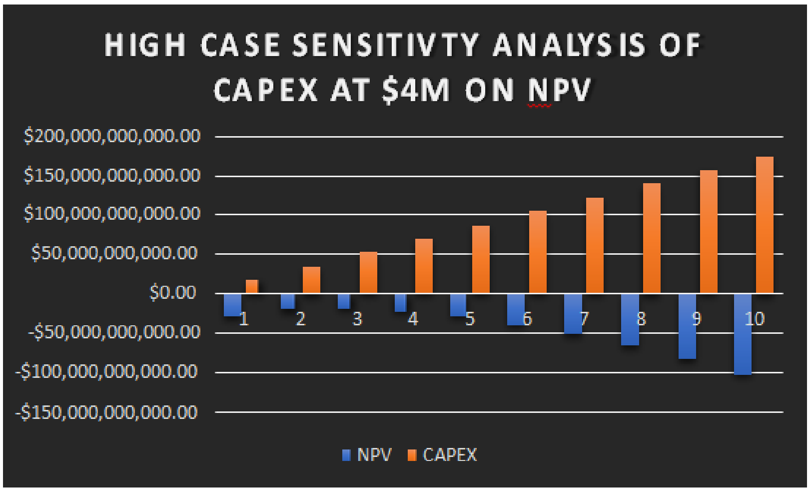

Figure 10. High Case Sensitivity Analysis for CAPEX at $4M on NPV

Capital Expenditure (CAPEX) involves all investments in terms of infrastructure and buildings in a bid to have smooth operation. The highest NPV came at the end of 10 years with a value of $39,733,186,945.27 and the CAPEX being the highest at this point too with a value of $3,650,000,000.00. Figures 4.9 and 4.10 also shows the sensitivity of NPV to increase in CAPEX at increasing CAPEX values.

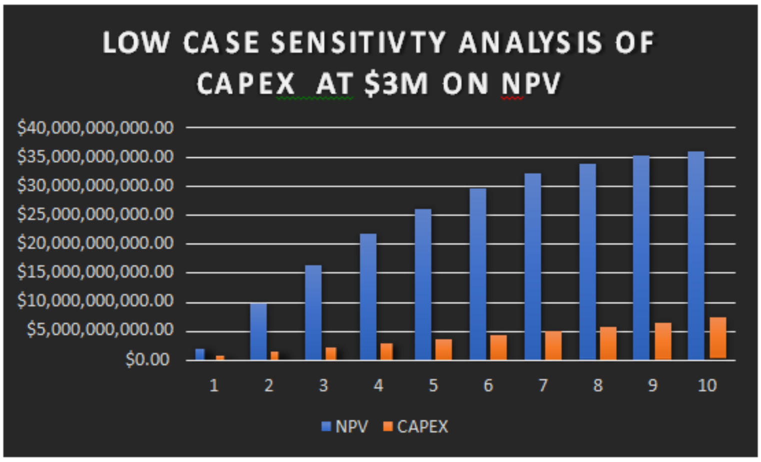

Figure 11: Low Case Sensitivity Analysis of CAPEX at $3M on NPV

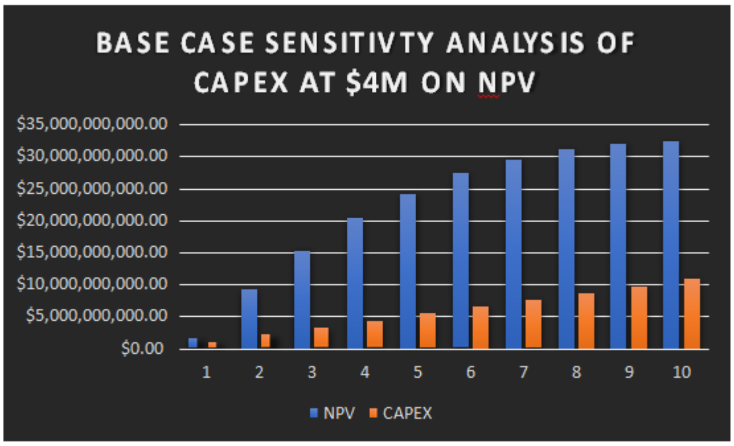

Figure 12. Base Case Sensitivity Analysis of CAPEX at $4M on NPV

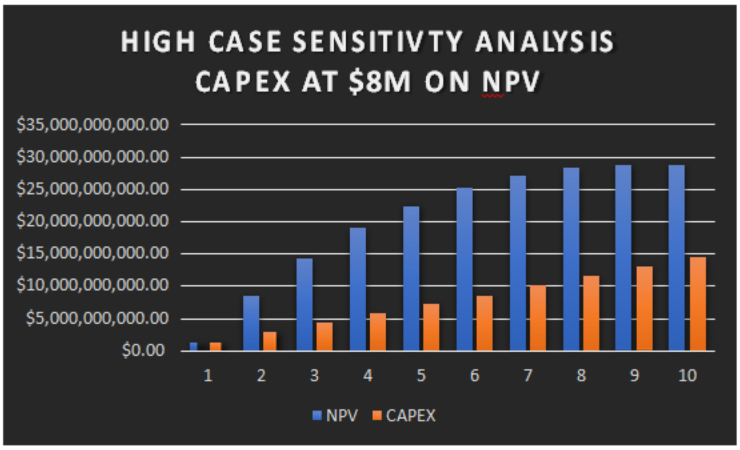

Figure 13. High Case Sensitivity Analysis of CAPEX at $8M on NPV

Figures 8 through 13 show the sensitivity of NPV to the different capital expenditures, also, it has been clearly established that CAPEX is very important to the profitability of a project. This is because CAPEX is part of the investment and this must be reviewed periodically throughout the life of the project to ensure that the payback period is fast and the profitability is maintained and ensured. The higher the CAPEX for each of the cases, the lower the NPV and hence the profitability of the project is seen. For GTL technology to be viable as a project and profitable, the CAPEX is a factor to be extensively considered and reviewed periodically to ensure that it is not unreasonably high.

Table 6. The Effects of Varying Crude Oil Prices on NPV

Low Case		**Base Case**		**High Case**	
Crude Oil Cost ($/bbl)	NPV ($)	Crude Oil Cost ($/bbl)	NPV ($)	Crude Oil Cost ($/bbl)	NPV ($)
40	63,683,927,976.81	65	-304,835,553,760.29	110	46,345,622,086.79
50	182,991,159,971.01	75	278,060,323,827.17	120	140,896,360,458.32
60	302,298,391,965.21	85	-92,873,416,455.76	130	235,447,098,829.85
70	421,605,623,959.42	95	13,107,652,196.51	140	329,997,837,201.37
80	540,912,855,953.62	105	119,088,720,848.77	150	424,548,575,572.90

From table 6, it is seen clearly that the higher the cost of crude oil, with other factors remaining constant, the NPV will appreciably increase and hence ensure the profitability of the project. The major work in the FT-GTL technology in assessing the viability is to increase the prices of crude oil per barrel and make other factors constant so as to have more revenue generated from the sales of hydrocarbon.

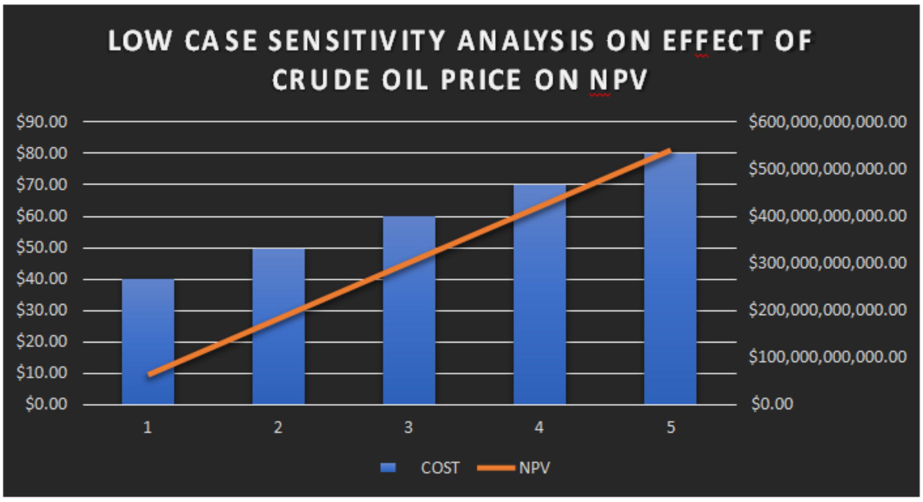

Figure 14. Low Case Analysis of the Effect of Crude Oil Prices on NPV

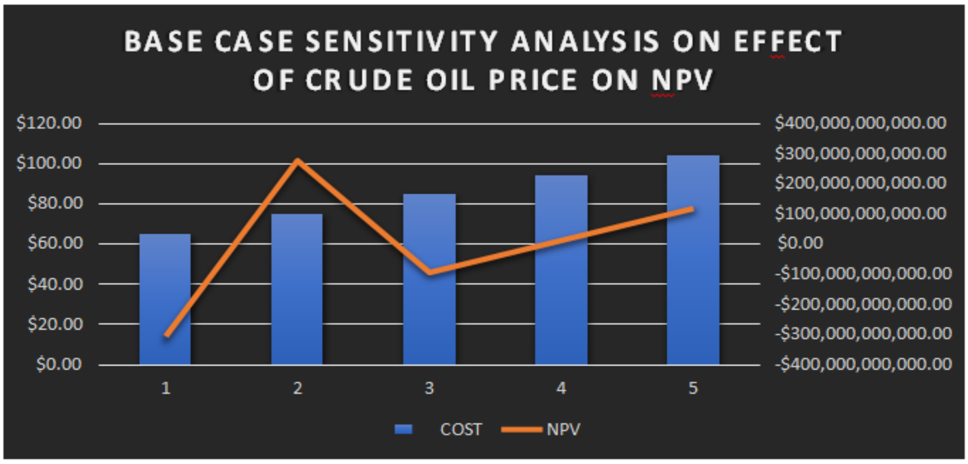

Figure 15. Base Case Analysis of the Effect of Crude Oil Prices on NPV

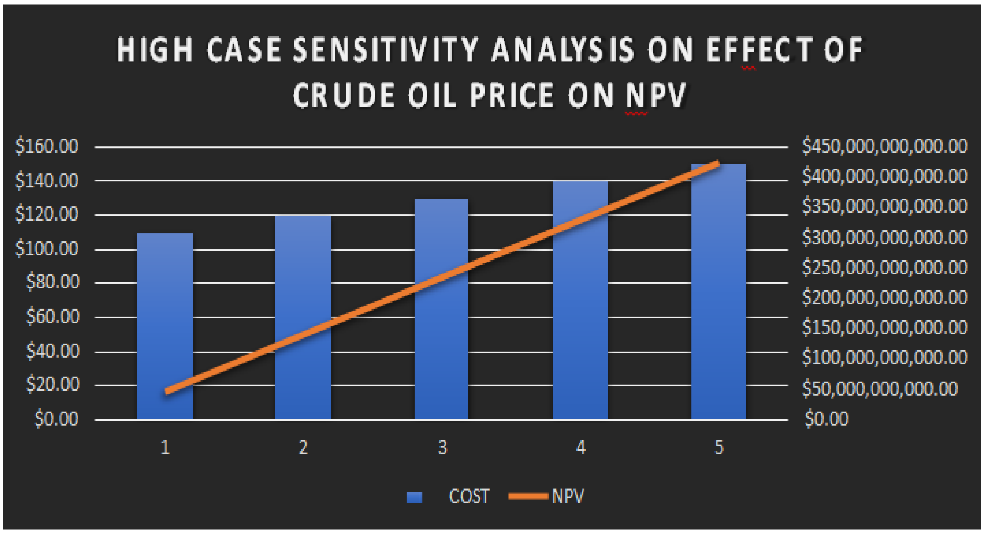

Figure 16. High Case Analysis of the Effect of Crude Oil Prices on NPV

Figures 14 to 16 also establish the direct relationship between the prices of crude oil and its NPV for all the cases considered. There is an upward rise in the NPV as the prices of crude oil increases and this is also shown in table 6.

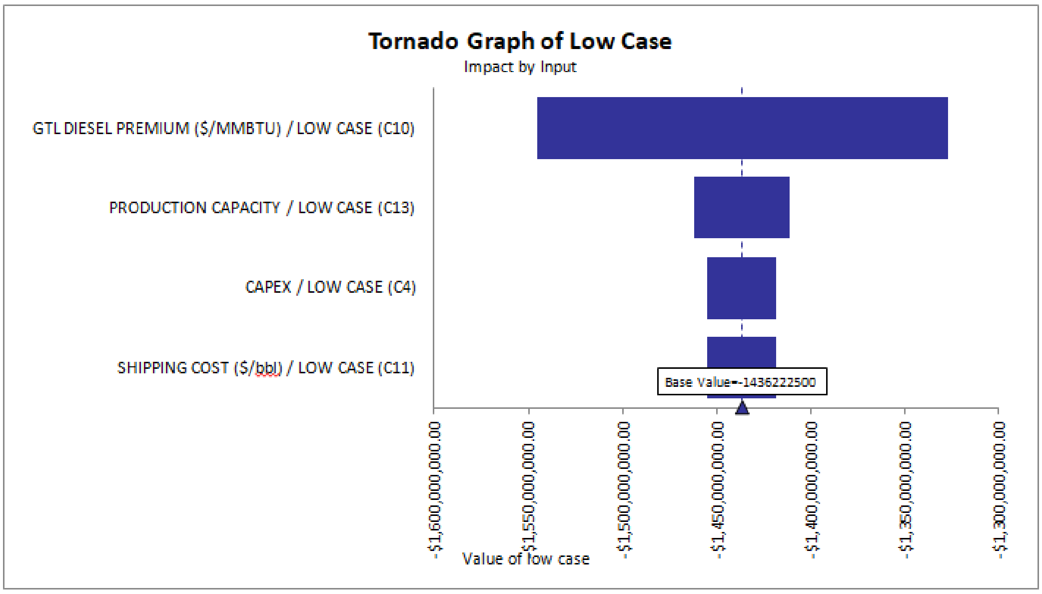

Figure 17. A Tornado Plot of Sensitivity of the Factors on NPV for Low Case

The results presented in figure 17 revealed the first three factors that have the highest impact on the NPV are the GTL diesel premium, the production capacity and the CAPEX. That was why as stated earlier that the increase in prices of crude oil will mean a commensurate increase in the NPV if other factors such as these are kept constant. For our case scenario considered in this GTL technology, the factors with highest impact are shown in the tornado plots. While for figure 18, the first three factors with highest impact on the net present value are GTL diesel premium, OPEX and shipping cost. Changes in these inputs variables greatly affect the NPV and the greatest impact is the GTL diesel premium. In the base case, OPEX is next in line in terms of its impact on NPV and the order of impact decreases from top to the bottom of the tornado plot. This is similarly seen in figure 19; however, the order of impact by these factors differs slightly.

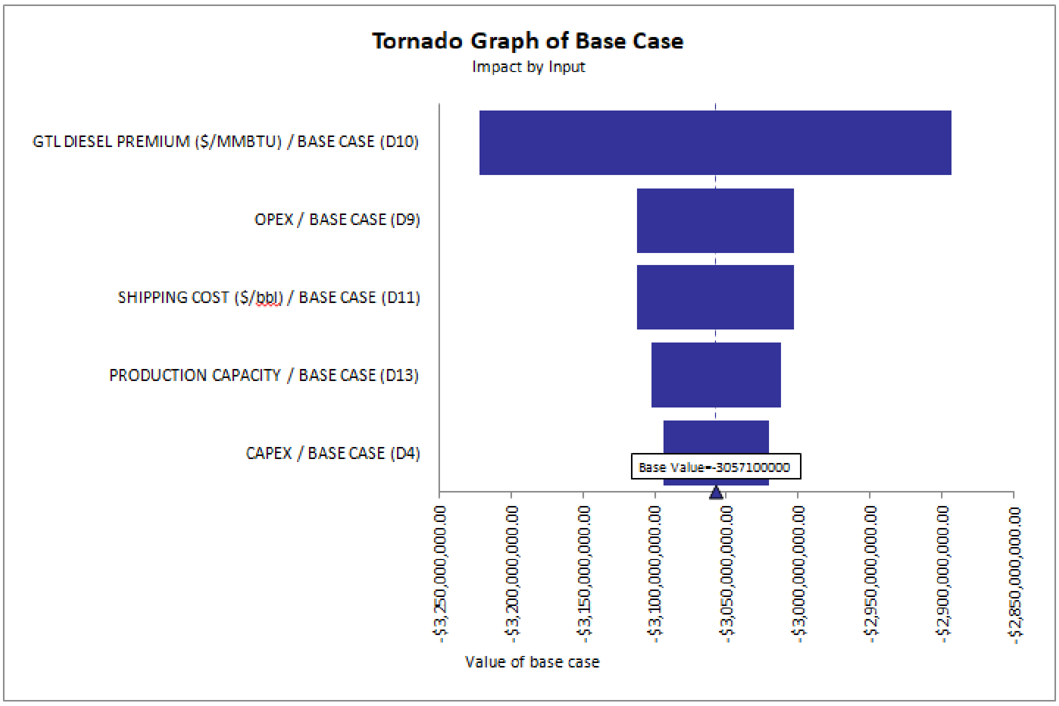

Figure 18. Tornado Plot of Sensitivity of the Factors on NPV for Base Case

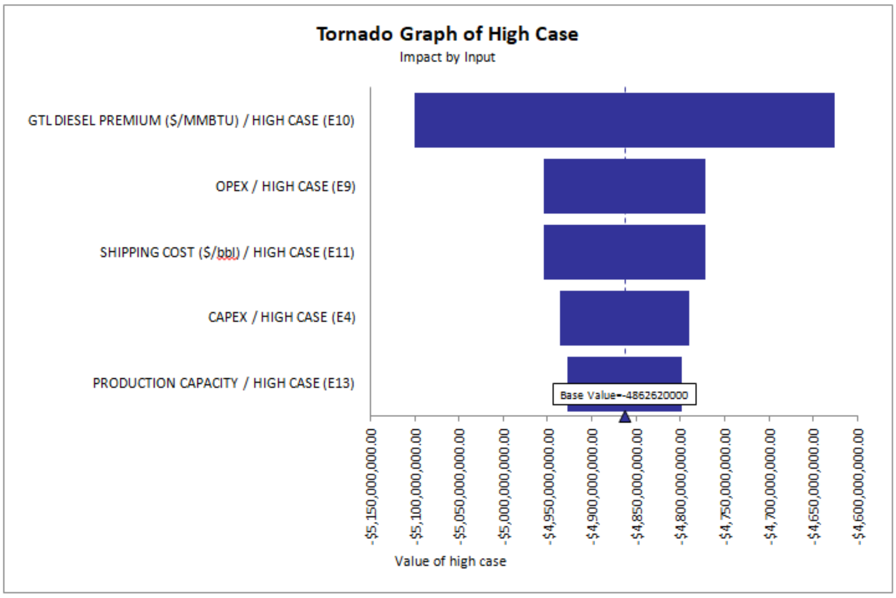

Figure 19. Tornado Plot of Sensitivity of the Factors on NPV for High Case

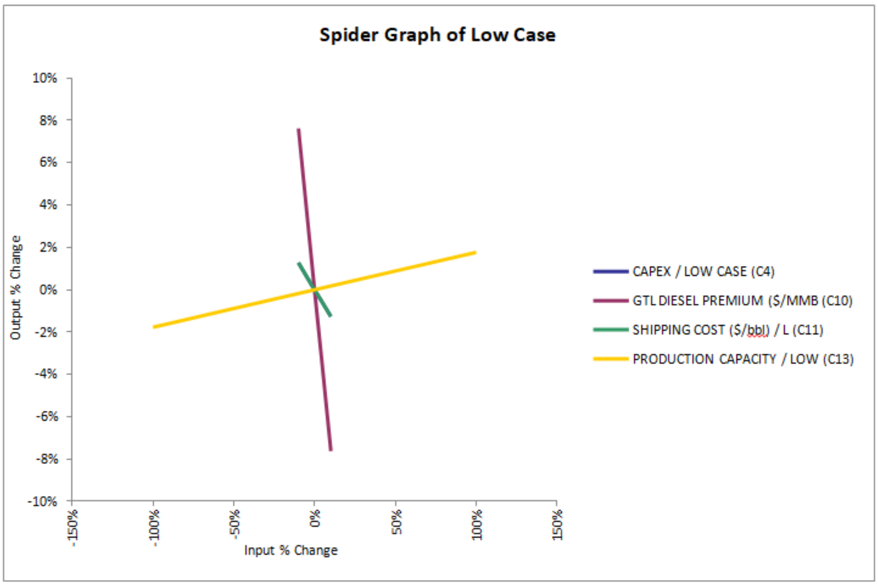

Figure 20. Spider Plot of Impact of some factors on the NPV for Low Case

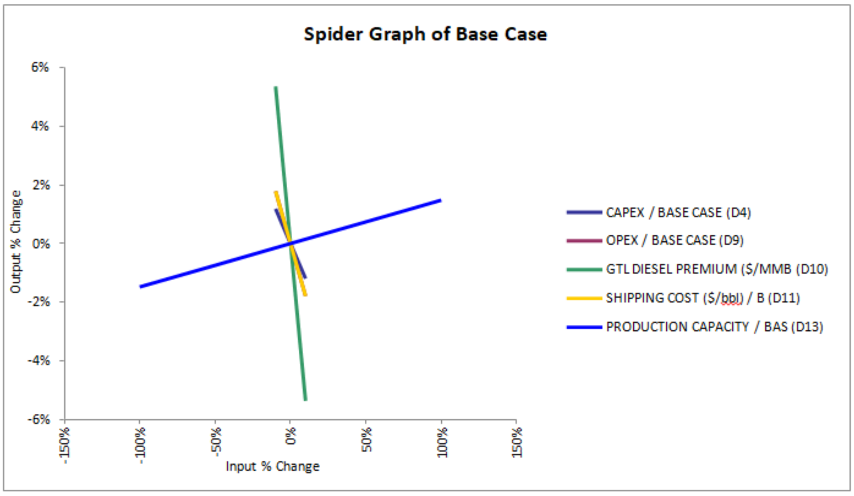

Figure 21. Spider Plot of Impact of some factors on the NPV for Base Case

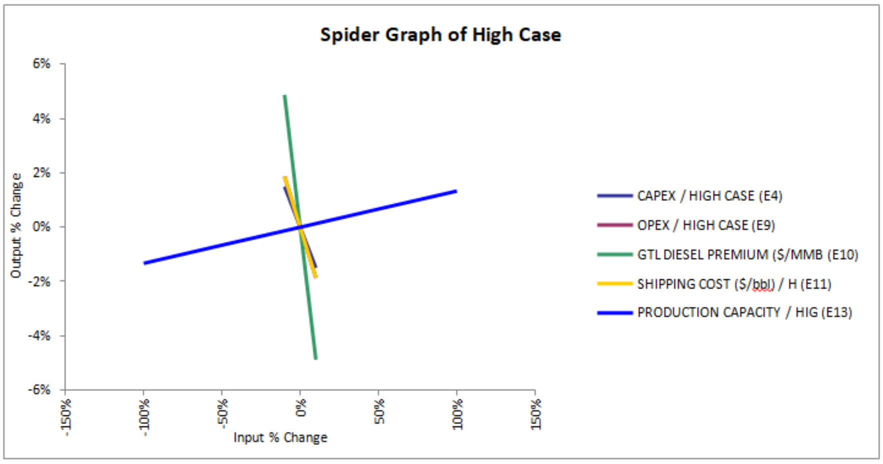

Figure 22. Spider Plot of Impact of some factors on the NPV for High Case

The spider plots were used to further show the sensitivity of some factors to NPV for the three case scenarios considered and are presented in figures 20 to 22. The point of overlapping is indicating that the factors have similar values, and the GTL diesel premium dominate in all three cases. A closer look at figures 17 through 22, the sensitivity of the factors differs and this is because the conditions are changing due to the different fiscal policies for the cases. That is to conclude that for profitability to be ensured, the prices of crude oil should be increased while other factors are kept constant.

Conclusion

The economic analysis of the implementation of the FT-GTL plant in Niger Delta, Nigeria showed a positive trend. DCF of the proposed project analysis produced performance criteria such as net present value (NPV) and internal rate of return (IRR) which were obtained from the cash flow of the projects under consideration, suggesting that the project is viable. The results of the economic analysis obtained at the different case scenarios using the most likely values of the economic input parameters indicate that FT-GTL profitability is highly dependent on the crude oil price, Capital Expenditure (CAPEX), Operating Expenditure (OPEX) and discounting factor and hence they should each be given proper considerations and review before embarking on future GTL projects. The following conclusions were arrived at as regards the best way Nigeria can monetize its stranded natural resources using the GTL technology.

1. Higher crude oil prices lead to increased NPV and IRR, indicating greater profitability, while lower prices have the opposite effect.
2. The payback period tends to be shorter when crude oil prices are high, as cash flows are more favorable.
3. Higher capital expenditures result in lower NPV and IRR, potentially making the project less economically attractive and elevated CAPEX lead to a longer payback period, which increases project risk.
4. Increased operating expenditures from the FT-GTL technology reduced the NPV and IRR thereby affecting project profitability and extend the payback period, increasing the time to recoup initial investments.
5. A higher discount rate factor decreases the present value of future cash flows, resulting in a lower NPV and potentially lower IRR. While a lower discount rate has the opposite effect, increasing the attractiveness of the FT-GTL plant project in terms of NPV and IRR.

Recommendation

Given the economic potential of GTL technology projects in Nigeria, as demonstrated in this research, it is recommended that project stakeholders implement a comprehensive risk management strategy for the FT-GTL plant project in Nigeria. This approach should include hedging, flexible pricing arrangements, cost-effective capital expenditures, and operational efficiency measures to mitigate risks and optimize project economics. By adopting this strategy, project stakeholders can refine their financial modeling to ensure alignment with industry's best practices and make informed decisions to drive long-term profitability. Continuous monitoring of market conditions, cost trends, and operational performance will also be crucial in identifying areas for improvement and adjusting the project's financial model accordingly. This proactive approach will ultimately enhance the project's chances of success and provide a solid foundation for sustainable growth in Nigeria's energy sector.

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***Change of Authorship**: The authors have read, understood, and complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the Instructions for Authors and is aware that with minor exceptions, no changes can be made to authorship once the paper is submitted.*

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