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ECONOMIC VIABILITY OF SMALL–SCALE LNG PROJECTS WITHIN THE NIGERIAN MARKET

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Abstract

The issue of gas flaring in Nigeria's petroleum industry has posed a notable challenge when it comes to public relations. This problem has attracted substantial criticism from environmentalists and has gained increased attention from the media, regulators, and investors. Operators are striving to reduce flaring by adhering to discharge limits. This can mean delaying well development or investing in technologies that effectively make use of associated gas, all while still maintaining oil production. One potential solution is investing in small-scale facilities such as gas-to-liquids (GTL) units, compressed natural gas (CNG) in a box, and portable LNG units. These technologies allow for the transportation of modest amounts of relevant gas via truck. This study focuses on the economic feasibility of small-scale LNG solutions as potential alternatives to traditional large-scale plants. It evaluates economic metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), Cost-To-Profit (C/P) ratio, and Payback Period. To shed light on the factors that have the greatest impact on the economic indicators of small-scale LNG, namely CAPEX, plant capacity, LNG price, feed gas price, and transportation, a sensitivity *analysis is conducted. Additionally, a Monte Carlo simulation methodology is used to assess economic metrics under different scenarios. The findings indicate that a plant capacity exceeding 0.5 million metric tons per annum (MTPA) is crucial in ensuring the viability and appeal of the small-scale LNG project. According to the base-case scenario, the optimal conditions for the project involve a capacity that exceeds 0.5 MTPA, capital costs below US$3600 per ton of LNG produced (TPA), product prices that surpass US$14 per thousand cubic feet (Mcf), and feed gas prices below US$4 per Mcf.*

Keywords: Small-Scale LNG; Economic Viability; Economic Metrics; Sensitivity Analysis; Monte Carlo Simulation; SWOT Analysis; Energy Security

INTRODUCTION

Globally, natural gas has emerged as a significant feedstock and energy source, offering notable environmental benefits and economic advantages when compared to liquid fossil fuels. Entrepreneurs have taken a keen interest in addressing the issue of widespread gas flaring, recognizing the potential to combine environmental action with commercial success. However, many producers have been hesitant to collect associated gas due to low pricing and transportation limitations. In Nigeria, the petroleum industry's extensive operations have made associated gas flaring a prominent and contentious issue, attracting criticism from environmentalists and heightened scrutiny from the press, authorities, and investors.

Oil corporations often justify the environmentally unsound practice of flaring associated gas by pointing to a lack of infrastructure for its collection and utilization (Kanshio, Agogo, & Chior, 2017). Nigeria, being a developing nation, lacks a market for raw gas, which discourages oil companies from investing in the necessary infrastructure. As a result, associated gas is typically disposed of through flaring, leading to significant economic and environmental losses. Nigeria, for instance, has flared a substantial amount of gas, with 206.18BCF flared over a 12-month period (NNPC, 2021), representing a significant loss of electricity.

To reduce flaring, operators may resort to measures such as suspending or halting well development to avoid exceeding discharge limits. Another approach involves investing in technology that enables the profitable use of associated gas while ensuring uninterrupted oil production. Small-scale facilities, including gas-to-liquids (GTL), compressed natural gas (CNG) units, and portable LNG units, are being considered as viable options for utilizing small volumes of associated gas. It is worth noting that scientific literature has paid limited attention to the economic feasibility of small-scale LNG production. While Nigeria's LNG business has traditionally focused on exports, there is potential for small-scale LNG projects to cater to domestic consumption.

In Nigeria, there is a current emphasis on establishing small-scale LNG liquefaction facilities to maximize the economic value of the country's vast gas resources. Advancements in technology now allow for the monetization of small and stranded gas sources, providing new opportunities for natural gas production and commercialization. Micro and mini liquefaction facilities are emerging as attractive complements to larger-scale LNG plants.

Small-scale LNG projects offer several benefits, including efficient gas transportation to isolated locations, integrated power production, revitalization of gas-based enterprises, and the delivery of compressed natural gas for transportation purposes. These projects contribute significantly to the elimination of hazardous and costly fuel sources, the conservation of foreign exchange used for importing petrol, and the enhancement of Nigeria's oil and gas revenues. Moreover, the various economic pursuits associated with small-scale LNG projects are expected to directly benefit individuals involved in different aspects of these projects.

In light of the above, this study analyzes the commercial viability of small-scale LNG projects in Nigeria and conduct a SWOT analysis of recent developments in the small-scale LNG sector. The significance of this study lies in LNG's pivotal role in future energy policies, providing energy security, cost reduction, environmental improvement, and contributing to the global goal of reducing CO2 emissions. Additionally, the study aims to serve as an economic guide for prospective investors interested in small-scale LNG ventures in Nigeria.

MATERIALS AND METHODS

Research Design

The research methodology employed in this study involves a descriptive research design and a quantitative research approach. A descriptive research design is appropriate for this study as it focuses on observing and quantifying parameters without manipulating variables. This approach allows for a better understanding of the phenomenon of small-scale LNG investment within the context of volatile energy prices.

The data used in this study primarily consists of secondary data obtained from books and publications available through web sources. Due to the lack of primary data, reliance on secondary data is necessary. However, it is important to acknowledge that using secondary data has limitations, such as potential data lag or infrequent updates, which may not capture the most current developments or timeframes.

Methods of Data Collection

All data utilized in this study were obtained from secondary sources such as relevant case studies, literature, and valid web pages. Secondary data obtained are summarized below in the table 1.

Table 1: Summary of Data

Factor	Base	Unit	Sources
Design Capacity	0.7	MTPA	Jiang et al., 2018
CAPEX	2000	US$/TPA	Bertsch et al., 2017
OPEX	5.0%	% CAPEX	Mohd and Abdullah, 2018
Feed Gas Price	4	US$/MSCF	www.oilprice.com
Technology Efficiency	85%	%	Air Products and Chemicals Inc
Feed Gas @ technology efficiency	281369.55	Mcf/Year	Calculated
LNG Price	14	US$/Mcf	www.oilprice.com
Transportation	400	US$/Day	Assumed
Discount Rate	12%	%	Assumed
Tax Rate	30%	%	Assumed
Project Duration	20	Years	Assumed
Days in a Year	330	Days	Assumed

Capital Expenditure (CAPEX)

The demand for natural gas on a global scale has skyrocketed, resulting in the emergence of numerous projects within the liquefied natural gas (LNG) industry. These projects have been specifically designed to cater to countries that lack a gas pipeline infrastructure. As a consequence of intense competition in the market, technological advancements, and the implementation of major projects, there has been a significant decrease in the cost of constructing LNG liquefaction plants, commonly known as CAPEX. Determining the CAPEX for LNG involves taking into account several factors, such as the plant's location, the volume and quality of the feed gas, product specifications, market conditions, and stability of pricing. Nevertheless, after conducting extensive research, it becomes evident that there is a noticeable lack of detailed information regarding the CAPEX for small-scale LNG (SSLNG) plants. Recognizing this research gap, this particular thesis adopts a base case-scenario for SSLNG, utilizing a CAPEX value of US$2000 per ton per annum (TPA). This assumption acts as a groundwork for carrying out further analysis and exploration within the SSLNG sector.

Operating Expenditure (OPEX)

Operational cost, commonly known as OPEX, is a term frequently encountered by us, university students. It encompasses a wide range of components, including fuel gas consumption, operation personnel, maintenance, consumables, insurance, and more. In the context of this thesis, we specifically focus on the cost associated with fuel within the feed gas. By deducting the expenses related to fuel gas from the overall OPEX, we can estimate that the remaining operational expenses typically fall in the range of 2% to 3% of the capital expenditure (CAPEX). Consequently, for the purpose of further evaluation, the OPEX equivalent to 5% of CAPEX will serve as the base case scenario.

Plant Capacity

Small-scale LNG plants have a capacity range of 50 to 100 tons per day (TPd) and are defined as plants with a capacity less than 1 million tons per annum (MTPA) by the International Gas Union (IGU). Large-scale LNG plants, on the other hand, have a capacity higher than 1 MTPA. The Royal Dutch Shell categorizes LNG capacity into small-scale (less than 1 MTPA), medium-scale (2 to less than 4 MTPA), and large-scale (above 4 MTPA). Most existing LNG plants are medium to large-scale facilities, with capacities such as 4.5 MTPA for Australia Pacific LNG (APLNG) and 3.6 MTPA for Gorgon LNG. Qatar LNG's Ras Laffan and Qatargas LNG facilities have the largest capacity at 7.8 MTPA per train. However, there are proposals for small-scale LNG facilities aiming to reduce construction costs. For example, Elba Island LNG in Georgia, USA, is under construction with a capacity of 0.25 MTPA per train using the Moveable Modular Liquefaction System (MMLS) by Shell. Other small-scale LNG projects in North America plan to use IPSMR®, OSMR®, and Prico® technologies. The study uses a capacity of 0.7 MTPA as the base case scenario for evaluation.

SSLNG technologies offer a wide array of capabilities for mini-LNG plants, encompassing capacities that range from 50TPd to 100TPd. As defined by the International Gas Union (IGU), small-scale LNG plants refer to facilities with a capacity below 1 MTPA, while large-scale LNG plants entail capacities surpassing 1 MTPA. However, Royal Dutch Shell classifies LNG capacity into three distinct categories: small-scale (less than 1 MTPA), medium-scale (2 to less than 4 MTPA), and large-scale (above 4 MTPA). For the purpose of this thesis, the baseline scenario assumes a capacity of 0.7 MTPA.

Feedstock/Flared Gas Price

The processing of feed gas and fuel consumption place significant importance on the feed gas price. The determination of the required quantity of feed gas relies on both the plant's capacity and the efficiency of the liquefaction technology used in that specific facility. One must bear in mind that the cost of raw natural gas can vary depending on the region being considered. Examining the data from the past three years, we find that the lowest documented price for natural gas reaches a value of US$3 per thousand cubic feet (Mcf). In contrast, figure 3.1 reveals the highest industrial natural gas price, which amounts to US$7.7 per Mcf. Thus, in our evaluation of the SSLNG project, we will adopt a feed gas price of US$4 per Mcf as the base case scenario.

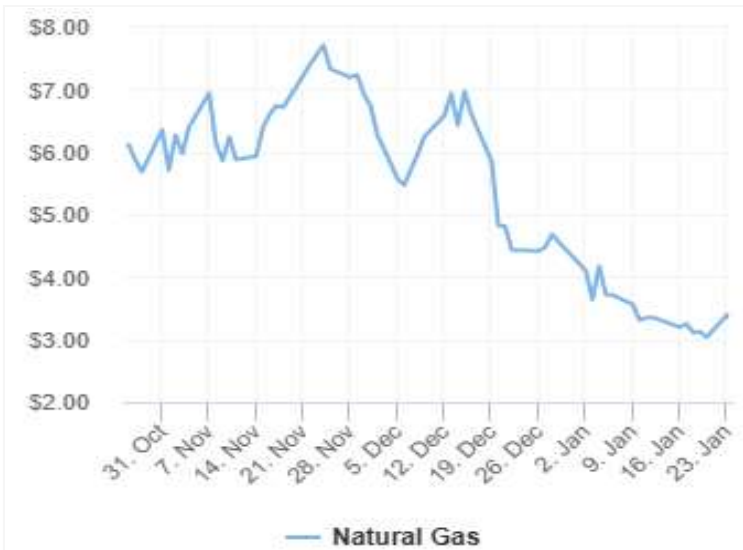

Figure 1: Natural gas price for the past 3 years (oilprice.com)

LNG Price

Throughout various regions and seasons, the pricing of LNG plant products undergoes considerable variation. Specifically, during the winter months in Europe and the Americas, the demand for natural gas, or more specifically liquefied natural gas (LNG), sees a substantial surge, leading to a subsequent increase in prices. Furthermore, it is important to note that the United Kingdom National Balancing Point (NBP), which serves as a key benchmark for gas prices, experiences significant fluctuations throughout the year, particularly within Europe. During the winter period, the NBP price tends to rise to approximately US$8 per million British thermal units (MMBtu), while in the summer months, it can plummet as low as US$4.50 per MMBtu (IGU, 2018). In the context of this thesis, the base case scenario assumes a product price of US$14 per thousand standard cubic feet (MMscf) for LNG.

Transportation (Trucking)

LNG can be transported via truck in the target market. It is assumed that the cost of the truck is included in the CAPEX. Based on this assumption, the trucking activities would cost a total of US$4,000000 per year for the purchase of spare parts, servicing, and fueling.

Plant Efficiency

The effectiveness of technology relies on the specific process used to liquefy natural gas in the plant, as well as the makeup of the gas being processed. When the gas contains a high concentration of valuable components, only around 80 percent of the natural gas can be successfully converted into liquefied natural gas (LNG). The remaining 20 percent undergoes various treatment procedures, including the removal of liquid slugs, stabilization of condensate, elimination of acid gas, extraction of water and fuel gas, separation of natural gas liquids (NGL), removal of nitrogen, and control of boil-off gas. This paper assumes that the efficiency of the SSLNG plant, in terms of both carbon and thermal efficiency, is determined by the composition of the feed gas. To put it simply, this study considers an efficiency percentage of 85 percent as the base case scenario, with a standard deviation of 10 percent for both the lower and higher case scenarios.

Methods of Data Analysis

The data analysis methods employed in this study involve several steps and techniques. The first step is the estimation of cash flows, followed by determining the required rate of return and applying investment decision rules. These decision rules, also known as capital budgeting techniques or investment criteria, are used to evaluate the economic worth of the small-scale LNG investment project.

The primary analytical tool employed in this study is the discounted cash flow (DCF) model. This model enables us to calculate present values and net present values by taking into account the time value of money through the discounting of cash flows. In order to compute the cash flows, we identify a variety of input parameters including capital requirements, project finance terms, operating expenses, product prices, tax and interest rates, among others. The cash flow calculation is based on an after-tax flow to equity approach. The DCF model allows for multiple valuation measurements, including net present value (NPV), internal rate of return (IRR), and payback period.

To address the inherent uncertainty in cash flow calculations, we employ the Monte Carlo Simulation technique. This technique generates random values for uncertain inputs, presenting a wide range of potential scenarios. It allows us to assess the risk and uncertainty associated with the investment project. In the case of the LNG project, the parameters selected for analysis include Capital Expenditure (CAPEX), Operational Expenditure (OPEX), plant capacity, feed gas price, technology efficiency, product price, and transportation. It is important to note that these project parameters can exhibit significant variations. Therefore, the utilization of the Monte Carlo simulation is essential to avoid time-consuming and redundant prediction processes. In this study, we generate 15,000 random scenarios to construct probability distributions. For a Summary of the parameters used in the Monte Carlo Simulations, please refer to Table 2.

In addition to the Monte Carlo Simulation, sensitivity analysis is also conducted in order to assess the impact of parameter variations on the outcomes of discounted cash flow. This evaluation enables us to gain a better understanding of the influential factors and driving parameters in the economic metrics assessment of the Monte Carlo Simulations. The base case scenario remains constant at 100 percent, while the low and high case scenarios involve a 50 percent increase or decrease in each parameter. By identifying the parameters that exert the greatest influence on outputs, such as NPV, we can gain valuable insights into the economic valuation process. Furthermore, a rank correlation tornado chart is utilized to analyze the level of uncertainty resulting from simultaneous variations in scenario inputs. This offers significant insight into the analysis.

Table 2: Summary of the parameters used for Monte Carlo Simulations

Parameter	Base	Standard Deviation	Unit
Design Capacity	0.7	0.35	MTPA
CAPEX	2000	1000	US$/TPA
OPEX	5.0%	3%	% CAPEX
Feed Gas Price	4	2	US$/MSCF
Technology Efficiency	85%	10%	%
LNG Price	14	7	US$/Mcf
Transportation	400	200	US$ million/year

The development of project scenarios involves numerous assumptions. For the small-scale LNG project, it is assumed to be a new venture without expanding an existing plant, located in the Niger Delta region of Nigeria with access to gas reserves. Pre-project costs like exploration and production, as well as planning and feasibility studies, are excluded from project costs as sunk costs. Cash flows are assumed to occur at the end of each year, with monetary values starting at a base value of 2021 U.S. dollars. A 30 percent corporate income tax is applied to cash flows, and straight-line depreciation over 20 years is used for physical capital. While these assumptions introduce uncertainty, they are held constant to focus on specific inputs relevant to the project economics.

By employing these data analysis methods, the study aims to provide a comprehensive evaluation of the small-scale LNG investment project's economic viability and profitability.

RESULTS AND DISCUSSION

Economic Metrics

The low, base, and high case scenario returned an ***NPV (Million)*** of $120.10, $2,500.70, $6,982.10; ***IRR*** of 5%, 23%, 28%; C/P of 0.3, 1.8, 2.2; ***Payback Period*** of 5.6, 2.7, 2.3; ***Modified IRR*** of 10%, 14%, 15% respectively (Appendix 1 – 3).

Sensitivity Analysis

The variables in Table 2 and assumptions are used to determine the economic metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), Cost-to-Profit ratio (C/P), and Payback Period for all three case scenarios. The NPV, IRR, C/P, and payback period results are compared to conduct a sensitivity analysis for each of the variables. The outcome of the NPV, IRR, C/P, and payback period estimation is presented in Figures 2 to 5 respectively in the form of tornado charts.

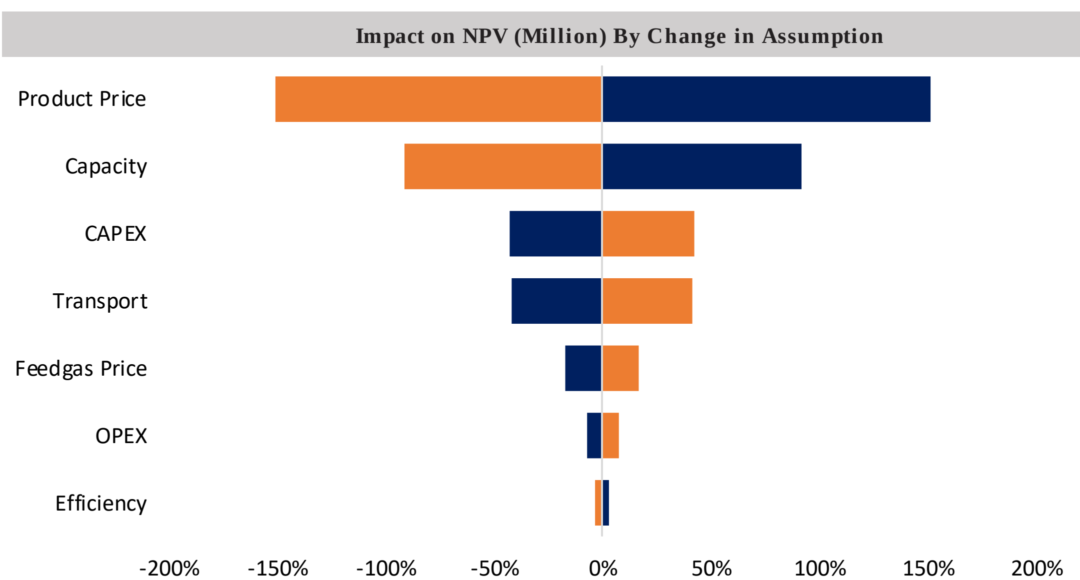

Figure 2: NPV Tornado chart (Base case scenario)

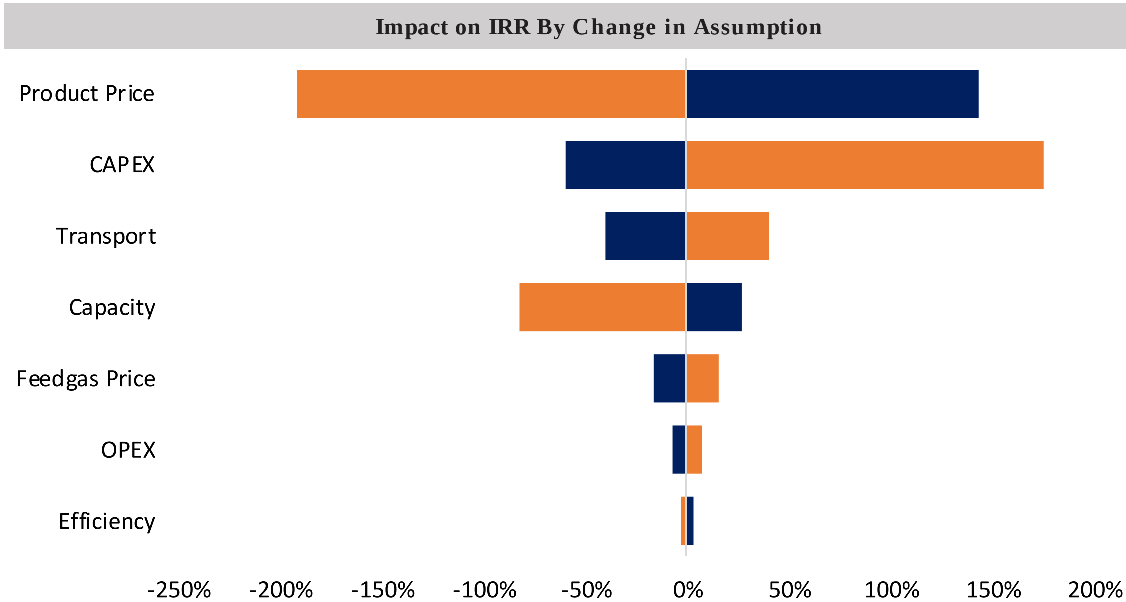

Figure 3: IRR Tornado chart (Base case scenario)

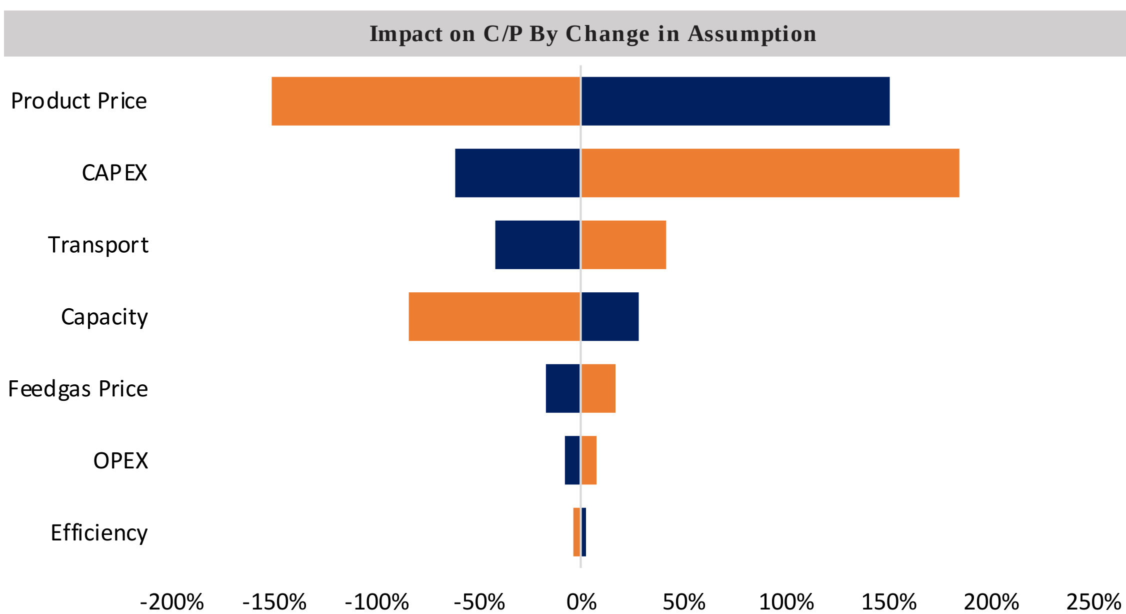

Figure 4: C/P Tornado chart (Base case scenario)

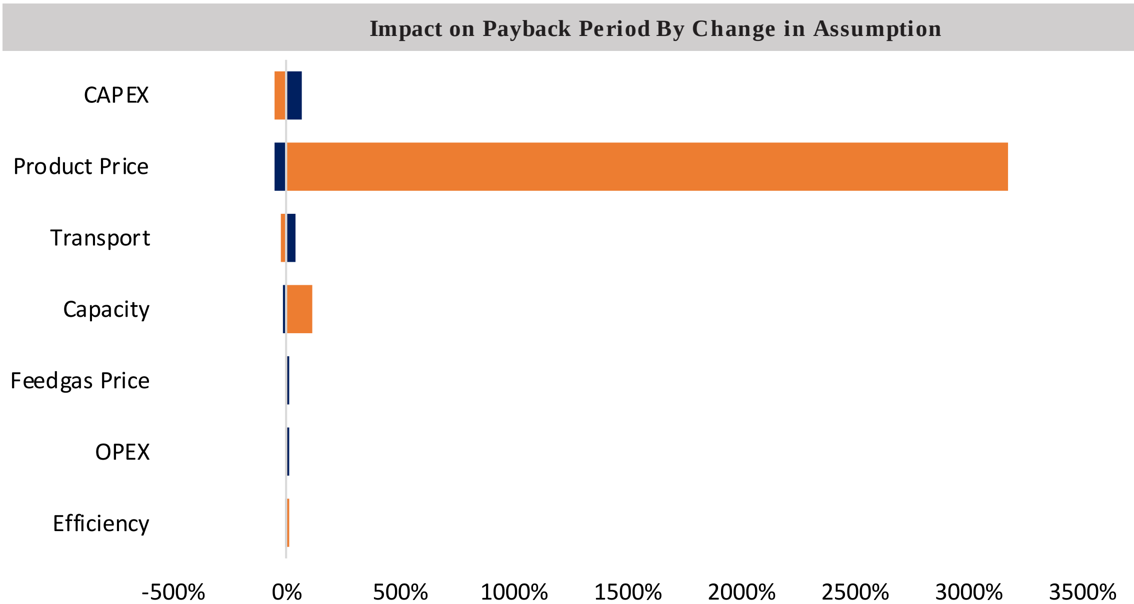

Figure 5: Payback Period Tornado chart (Base case scenario)

Upon careful examination of the aforementioned data in figures 2 – 5 above, it becomes apparent that each economic measure is affected in distinct ways by various factors. It is important to note that the parameters with the most significant impact on economic indicators are the pricing of products, capacity, CAPEX, feed gas pricing, and transportation. Conversely, the influence exerted by OPEX and efficiency is minimal. Grasping the significance of these crucial parameters in relation to economic analysis enables us to apply the insights gained from this sensitivity analysis when selecting and assessing other SSLNG projects. Given that efficiency and OPEX have little effect on economic metrics, they will remain consistent throughout the evaluation process for the SSLNG project.

The sensitivity analysis clearly reveals that incorporating this range of parameters in the economic assessment introduces a notable degree of uncertainty. Accordingly, a Monte Carlo approach, involving 15,000 iterations, has been employed to evaluate NPV, IRR, C/P, and Payback Period, as elaborated in the subsequent section.

Monte Carlo Simulation

A distribution curve was produced by the iterations for each economy measure. The histogram distribution of the 15,000 iterations from the Monte Carlo simulations is shown in Figures 6 - 9.

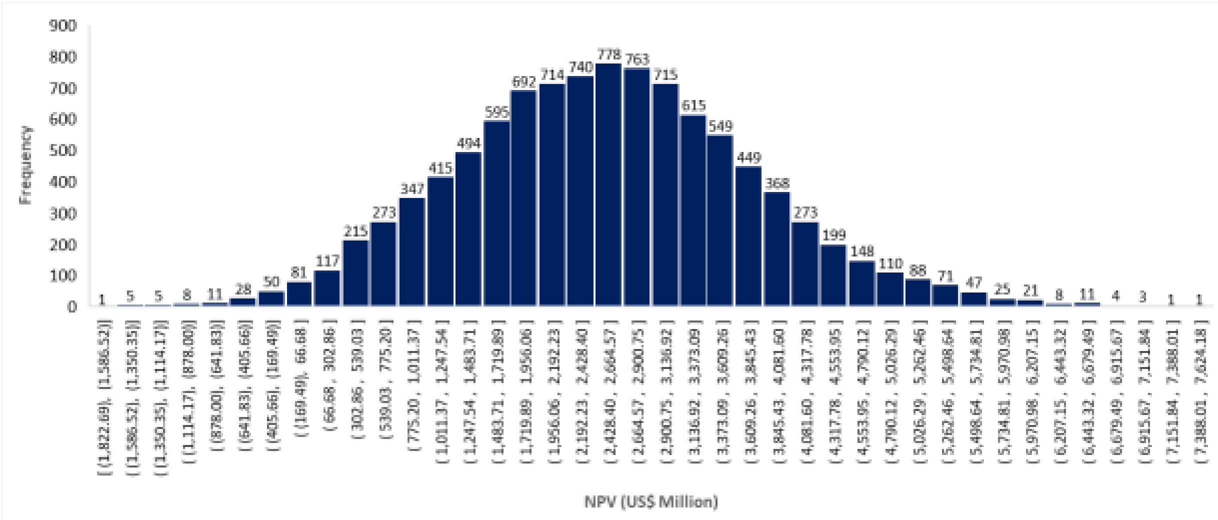

Figure 6: NPV Distribution Curve from Monte Carlo Simulation

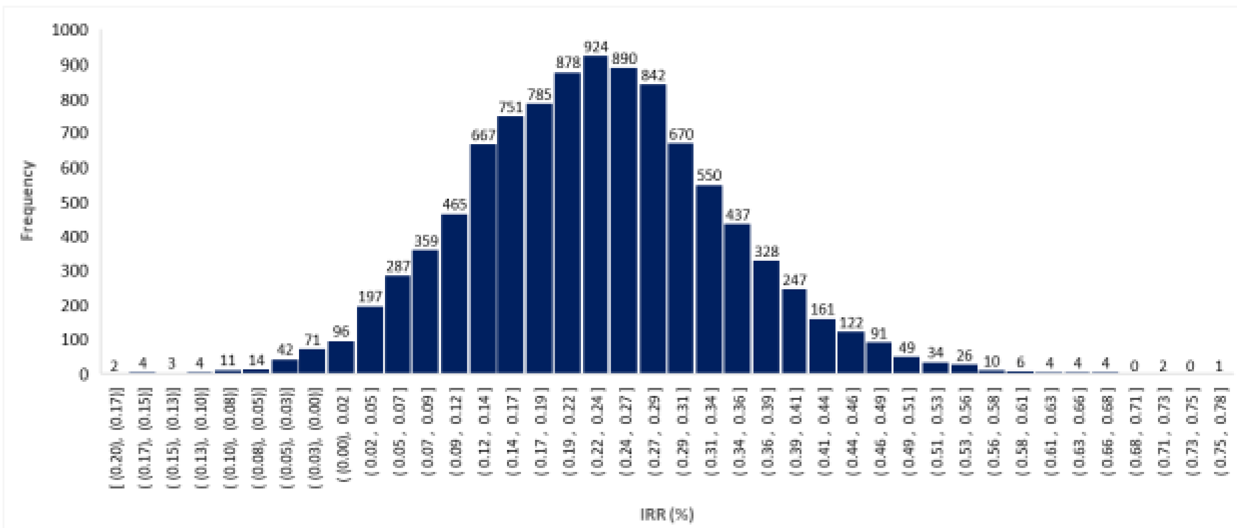

Figure 7: IRR Distribution Curve from Monte Carlo Simulation

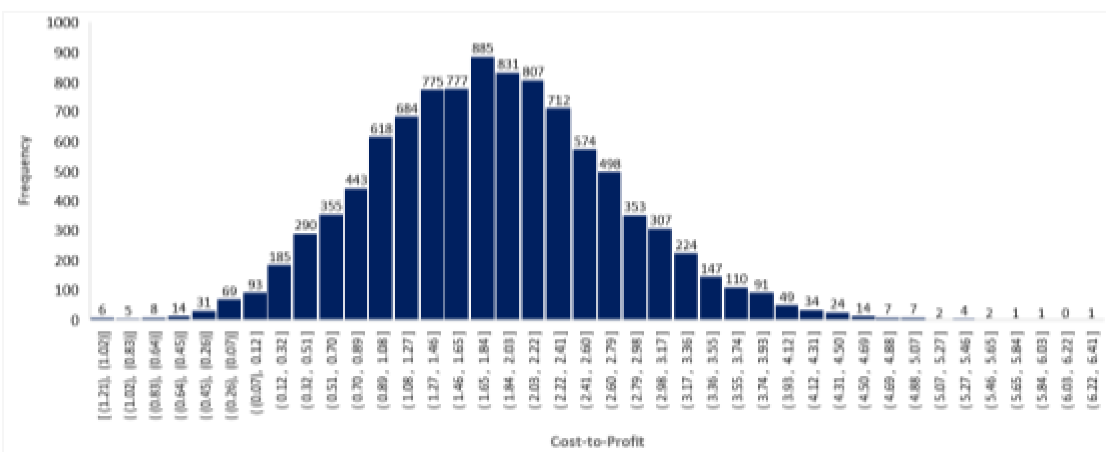

Figure 8: C/P Distribution Curve from Monte Carlo Simulation

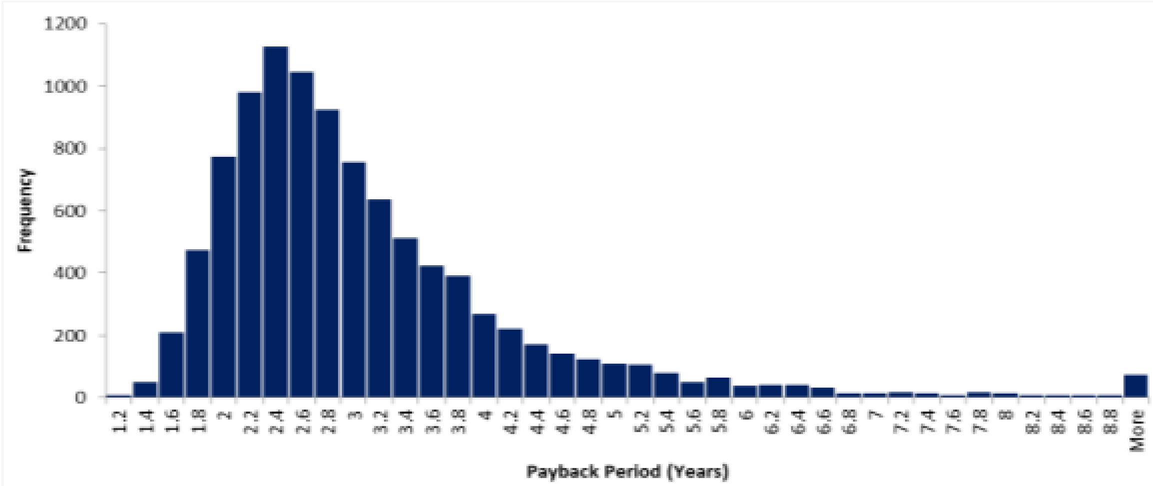

Figure 9: Payback Period Distribution Curve from Monte Carlo Simulation

The combined 15,000 iterations from the Monte Carlo simulation for NPV, IRR, C/P, and Payback Period assessment are shown in Figures 4.5–4.8 as a normal distribution or bell curve. Each statistic has a 50% probability of being higher or lower than the mean by definition since the distributions are normal distributions. Table 3 below provides a summary of the 15,000 Monte Carlo simulation runs.

Table 3: Summary of 15000 iterations of Monte Carlo Simulation

		NPV	*IRR*	*C/P*	*Payback*
Mean	$	2,513.05	22.8%	1.82	3.2
Median	$	2,493.18	22.6%	1.79	2.7
Standard Deviation	$	1,239.59	11.0%	0.91	25.0
Kurtosis	$	0.10	33.5%	0.28	9706.2
Skewness	$	0.17	18.5%	0.25	97.6
Minimum	$	(1,822.69)	-19.9%	-1.21	-184.6
Maximum	$	7,624.18	77.8%	6.41	2485.7

The average NPV is positive, as seen above, with an IRR greater than the estimated discount rate and a C/P more than 1. It is evident from the Monte Carlo simulations and the base case scenario that the SSLNG plant project is lucrative.

According to the sensitivity analysis and Monte Carlo simulations, the SSLNG project would be successful (assuming the base case circumstances) if the following requirements were met: capacity over 0.5 MTPA, capex below US$3600/TPA, product price above US$14/Mcf, and feed gas price below US$4/Mcf. This case scenario results in an IRR that is more than the discounted rate of 12%, a C/P that is greater than 1, and a payback period that is under 4 years.

SWOT Analysis

Strengths

i. Growing demand for natural gas as a clean energy source presents opportunities for investors in the small-scale LNG sector.
ii. Advancements in technology and infrastructure for small-scale LNG production, lowering production costs.
iii. Natural gas is a suitable substitute for high-polluting fossil fuels, driving the demand for natural gas in Nigeria.
iv. Favorable government policies, which includes incentives and support for investments in the small-scale LNG sector.

Weaknesses

i. Limited access to financing for small-scale LNG projects.
ii. Shortage of skilled labor in Nigeria's small-scale LNG industry.
iii. Uncertainties in natural gas pricing and supply chain management for investors.
iv. Inadequate government support and enabling business environment for investments.

Opportunities

i. The increasing demand for natural gas in sectors such as transportation, power generation, and industrial applications presents significant opportunities for investors.
ii. Increased awareness and commitment towards reducing greenhouse gas emissions in Nigeria, driving demand for clean energy sources such as natural gas.
iii. Potential for international partnerships and collaborations with investors, providing leverage with expertise and access to technology.
iv. Establishment of gas infrastructure and international gas markets presents significant opportunities for investors.

Threats

i. Competition from other clean energy sources such as solar and wind power, which could attract demand away from natural gas.
ii. Fluctuations in global gas prices and availability of supply, which could affect investor returns.
iii. Risks associated with investing in the Nigerian economy, including regulatory and security challenges.
iv. Technical constraints and operational risks in small-scale LNG production and distribution.

This analysis has brought to light that potential investors in Nigeria should prioritize the development of natural gas infrastructure that supports small-scale LNG production and distribution. Such a move will be advantageous for investors as they can benefit from government incentives and support for the sector, wherever available.

CONCLUSION & RECOMMENDATIONS

This paper presents an initial investigation using unpublished data, with a note that the information may not be entirely accurate as it is owned by the company that developed the technologies. Monte Carlo simulations and sensitivity analysis were conducted, focusing on economic metrics such as NPV, IRR, PI, and Payback Period. The results of the sensitivity analysis identified CAPEX, feed gas price, plant capacity, transport, and LNG pricing as the key factors influencing the viability and profitability of small-scale LNG (SSLNG) projects. Other factors also had an impact, although less significant. The economic study indicated that despite significant transportation costs, the SSLNG project remained viable.

The SWOT analysis highlighted important recommendations for prospective investors, including the development of natural gas infrastructure, leveraging government incentives and support, establishing partnerships with international companies, conducting thorough market research and feasibility studies, implementing comprehensive risk management strategies, and promoting technology transfer to local stakeholders in the SSLNG sector.

Based on the findings from this study, investors are recommended to:

- Conduct further research before proceeding with any project.
- Compare small-scale GTL and CNG plants to determine the most feasible option.
- Inquire about specific aspects to enhance the analysis of the project economy, including itemized CAPEX and OPEX costs, potential cost savings, consumer market research, product prices, transportation costs, natural gas field location, and project integration considerations.
- Establish partnerships and collaborations with international companies to access their expertise and technology, gaining a better understanding of the Nigerian market and expanding investment opportunities.
- Conduct thorough market research and feasibility studies to identify areas with favorable economic and financial returns for potential investments, ensuring all necessary information is available prior to decision-making.
- Implement comprehensive risk management strategies covering operational, financial, and regulatory risks to effectively manage investments and minimize potential losses.
- Promote technology transfer programs to contribute to the local economy, create job opportunities, and share knowledge with stakeholders in the small-scale LNG sector.

These recommendations aim to assist investors in making informed decisions, maximizing returns, managing risks, and fostering sustainable growth in the small-scale LNG industry while benefiting the local community.

WAY FORWARD

To further harness the opportunities while curbing the threats that this paper has highlighted, future studies should strive for a comprehensive and integrative approach, addressing technological advancements, market dynamics, regulatory frameworks, financial modeling, and socio-environmental impacts. Such research will be instrumental in guiding the SSLNG sector towards sustainable growth and resilience in the ever-evolving global energy landscape.

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APPENDICES

Appendix 1: Metrics Calculation for Low case scenario

Low												
Capacity	Year	CAPEX	OPEX	Depreciation	Feedgas		Transportation	Revenue	Profit Before Tax	Profit After Tax	Present Value
(MMcf/d)		(Million)	(Million)	(Million)	(MMscf/y)	$/y	(Million)	(Million)			(Million)
51.66	0	$350									($350)
	1		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$56
	2		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$50
	3		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$45
	4		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$40
	5		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$36
	6		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$32
	7		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$28
	8		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$25
	9		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$23
	10		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$20
	11		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$18
	12		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$16
	13		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$14
	14		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$13
	15		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$11
	16		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$10
	17		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$9
	18		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$8
	19		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$7
	20		$8.75	$18	22730.40	$45.46	$200	$362	$90	$63	$7
NB: All figures are stated in million								NPV (Million)			$120.10
								IRR			5%
								C/P			0.3
								Payback Period			5.6
								Modified IRR			10%

Appendix 2: Metrics Calculation for Base case scenario

Base											
Capacity	**Year**	**CAPEX**	**OPEX**	**Depreciation**	**Feedgas**		**Transportation**	**Revenue**	**Profit Before Tax**	**Profit After Tax**	**Present Value**
(MMcf/d)		**(Million)**	**(Million)**	**(Million)**	**(MMscf/y)**	**$/y**	**(Million)**	**(Million)**			**(Million)**
103.32	0	$1,400									($1,400)
	1		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$466
	2		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$416
	3		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$372
	4		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$332
	5		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$296
	6		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$265
	7		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$236
	8		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$211
	9		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$188
	10		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$168
	11		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$150
	12		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$134
	13		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$120
	14		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$107
	15		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$95
	16		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$85
	17		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$76
	18		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$68
	19		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$61
	20		$70.00	$70	40112.47	$160.45	$400	$1,446	$746	$522	$54
NB: All figures are stated in million								**NPV (Million)**			**$2,500.7**
								IRR			**23%**
								C/P			**1.8**
								Payback Period			**2.7**
								Modified IRR			**14%**

Appendix 3: Economic Metrics Calculation for High case scenario

High											
Capacity	**Year**	**CAPEX**	**OPEX**	**Depreciation**	**Feedgas**		**Transportation**	**Revenue**	**Profit Before Tax**	**Profit After Tax**	**Present Value**
(MMcf/d)		**(Million)**	**(Million)**	**(Million)**	**(MMscf/y)**	**$/y**	**(Million)**	**(Million)**			**(Million)**
154.98	0	$3,150									($3,150)
	1		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$1,211
	2		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$1,081
	3		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$966
	4		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$862
	5		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$770
	6		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$687
	7		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$614
	8		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$548
	9		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$489
	10		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$437
	11		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$390
	12		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$348
	13		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$311
	14		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$278
	15		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$248
	16		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$221
	17		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$198
	18		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$176
	19		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$157
	20		$236.25	$158	53835.16	$323.01	$600	$3,255	$1,938	$1,356	$141
								NPV (Million)			**$6,982.1**
NB: All figures are stated in million								**IRR**			**28%**
								C/P			**2.2**
								Payback Period			**2.3**
								Modified IRR			**15%**