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Investment Analysis of LNG Storage Facility Development in Indonesia

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ABSTRACT: The gas industry has had remarkable growth in recent years due to cleaner combustion, and LNG stands at the top of the gas industry as its flexibility and transportability made it an attractive option. Indonesia that has geographical advantage provides natural advantage to become a central player in the global LNG market. However, investment decisions related to new LNG storage facilities are faced with uncertainties and challenges including volatile energy markets, fluctuating LNG prices, geopolitical risks, evolving environmental regulations, and technological changes. This study assesses the feasibility of developing an LNG storage facility in Indonesia. Commercially, it is feasible due to growing LNG demand and Indonesia's strategic advantages. An LNG storage facility with 180.000 m³ capacity is feasible, showing an NPV of $33.7 million, an IRR of 10.96%, a payback period of 14.61 years, and a Profitability Index (PI) of 1.26. Increasing the tank capacity to 200.000 m³ improves feasibility with an NPV of $44.3 million, an IRR of 11.61%, a payback period of 13.67 years, and a PI of 1.32. Integrating with existing infrastructure further enhances feasibility, yielding an NPV of $77.7 million, an IRR of 14.10%, a payback period of 11.04 years, and a PI of 1.56.

KEYWORDS: Capital Budgeting, LNG, LNG Storage, Investment Analysis, Monte Carlo Simulation, Sensitivity Analysis.

INTRODUCTION

The gas industry has had remarkable growth in recent years, driven by increasing demand for cleaner energy sources that offer cleaner combustion compared to another fossil fuel as oil and coal and Liquefied Natural Gas (LNG) stands at the top of the gas industry as its versatility and transportability made it an attractive option for countries seeking to fulfill their gas demand.

Nationally, gas will serve as a transitional fuel in line with the commitment to energy transition, although its share will slightly be replaced by renewable energy. The largest demand for primary gas energy comes from industry and power generation. In the Ordinary State scenario, gas demand increases to 4.637 trillion British Thermal Unit (BTU) in 2060, with approximately 47% coming from power generation. Meanwhile, in the Appropriate Sustainability scenario, national gas demand growth is higher, reaching 5.786 trillion BTU in 2058 and slightly decreasing to 5.773 trillion BTU in 2060 [1]. Indonesia LNG domestic use is also increasing in the past decade.

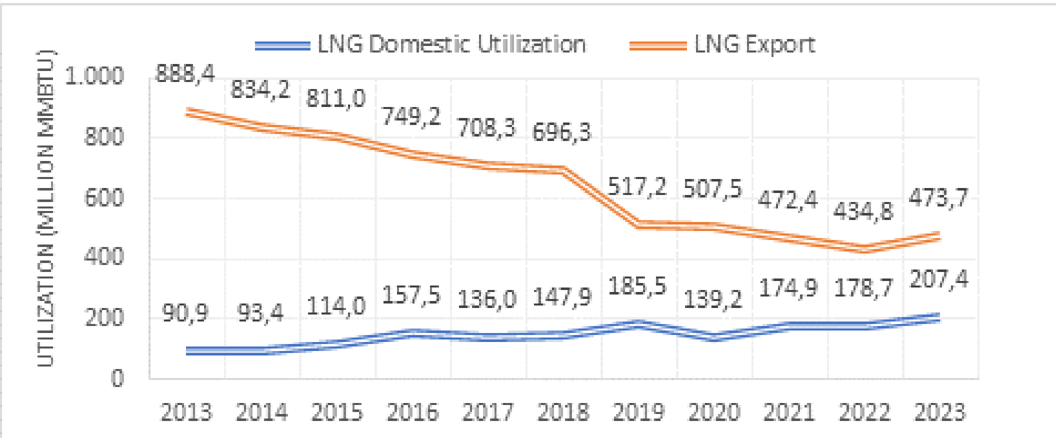

Figure 1. Indonesia LNG Utilization 2013 – 2023 [2]

Globally, Natural gas demand continues to grow with the largest demand come from electricity and industry sectors. The demand in Asia, Russia, Africa, and South America regions is set to peak after 2040. Industry and buildings are the key demand drivers in emerging Asia. LNG will play an important role in meeting global gas supply and drive the growth of global LNG market [3]. The outlook for Asia's natural gas demand remains positive as China, India and emerging LNG markets in Southeast and South Asia set ambitious plans to increase the gas's proportions of energy consumption mix.

Indonesia has a long history in the LNG industry when the first LNG Plant built in Bontang, East Kalimantan, which started operations in 1977. The discovery of massive natural gas in the early 1970s ignited the spark for construction of LNG Plant (Bontang LNG and Arun LNG). The first LNG shipment in 1977 was exported from LNG Badak to Japan and marked Indonesia's entry into the global LNG market. Subsequently, several significant LNG Plants were established, including Tangguh in West Papua and Donggi-Senoro in Central Sulawesi. Donggi-Senoro LNG commenced its first liquefied natural gas (LNG) delivery in 2015, while Tangguh began its LNG delivery operations in 2009 [4]. Currently, Indonesia prioritizes supplying domestic LNG needs in accordance with Ministry of Energy and Mineral Resources Regulation No. 06 of 2016. The domestic LNG demand is expected to continue to rise as PLN's (Indonesia's state-owned electricity company) 35 GW power plant projects come [5].

Tanks specifically designed for LNG play a critical role in LNG value chain to facilitating the storage, loading, and unloading of LNG. Indonesia as a player in LNG business has the potential to further develop its LNG infrastructure including storage facilities. However, there are many factors to consider before developing LNG storage facilities in Indonesia, including changes in the market, legal constraints, technological advancements, financial viability, and risk management techniques. The economic sustainability of the project, risk mitigation, and long-term success of the project thus depend on a thorough examination of investment decisions made regarding an LNG storage facility project.

A. Business Situation

LNG growing demand for both global and domestic use drives the need for development of LNG Infrastructure in Indonesia especially LNG storage facilities. Indonesia that has geographical advantage with its strategic location along major shipping routes provides natural advantage to become a central player in the global LNG market. LNG storage facilities enhance energy security by ensuring a reliable supply of natural gas and mitigating risks associated with fluctuating production levels and import dependency.

However, despite the promising prospects of LNG as transition energy to cleaner energy, investment decision related to new LNG storage facility are faced with uncertainties and challenges. These challenges include volatile energy markets, fluctuating LNG prices, geopolitical risks, evolving environmental regulations, and technological disruptions. There are some financial challenges to evaluate an LNG Storage Facility construction project such as significant upfront capital expenditure, uncertainty in input parameters, and long-term revenue projections. And add with some risk consideration such as market price volatility, construction and operational risks, and regulatory and environmental risks make the needed of careful evaluation and justification to ensure long-term profitability and sustainability.

B. Objective and Scope

This research focuses on investment analysis of the construction of a new LNG storage facility in Indonesia. The research objective of this study is as follow:

- To identify and analyze the economic feasibility of LNG storage facility construction project.
- To assess the sensitivity of financial performance metrics, such as NPV, IRR, and payback period, to variations in key input parameters using sensitivity analysis techniques and Monte Carlo simulations.
- To assess the scenarios that yield better economic results.

The research will primarily investigate key financial considerations and investment criteria associated with such projects. The scope of the research is primarily focused on business situation analysis and economic feasibility analysis. Other factors, such as LNG market structure, environmental impact, and social implications, are beyond the scope of this study.

LITERATURE REVIEW

A. LNG Supply Chain

LNG Supply Chain starts from Upstream processes to extract natural gas from inside earth using drilling process. The natural gas is then liquefied through the LNG production process. The processing train of LNG is divided into two sub-sections namely Hot Section and Cold Section. The hot section prepares and purifies the gas, while the cold section takes it to cryogenic temperatures for liquefaction. After liquefaction process, the gas will become LNG and will be stored at LNG Storage Tanks before it loaded into transport carriers by using terminal's LNG loading arms. The shipping process takes place to ship the LNG to the importing terminal

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to be regasified. Importing and regassification terminals basically consist of LNG storage tanks, supporting utilities and regasification plant [6].

B. LNG Storage Technology

LNG Storage systems maintain the gas in a liquid state for storage. In LNG Storage Systems, auto-refrigeration is employed to maintain constant pressure and temperature in the tank. There are 3 common types of LNG Storage based on European Standard EN1473 by containment type namely "single containment", "double containment" and "full containment". A single containment tank is designed and constructed with only the inner tank capable of handling the low temperature requirements for LNG storing. A double containment tank is designed and constructed so that both inner and outer tanks can contain the refrigerated liquid. Full containment tank can be described as a double containment tank with the difference between them is that the outer tank of a full containment tank is intended to be capable of both containing the refrigerated liquid and of controlling venting of vapor from LNG leakage [7].

Normally, the larger the size of storage tank, the total price will increase. However, in figure 4.2 shows that unit price per m3 decreases as the total capacity increases [8]

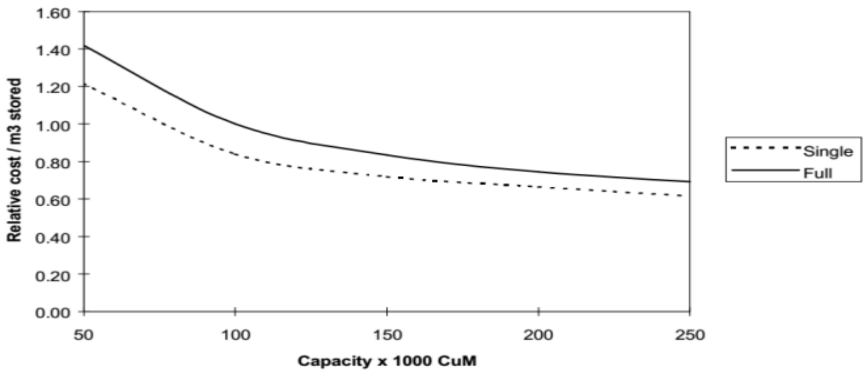

Figure 2. Unit Cost Ratio vs Tank Capacity (Usable) [8]

C. BOG Losses

Evaporation of LNG occurs at LNG supply chain process. Boil of Gas (BOG) losses in the supply chain is one of the key factors for LNG technical economic assessment [9]. LNG, a cryogenic liquid is transported and stored in tanks and due to heat leakage into LNG and its cryogenic nature during storage, LNG continuously evaporates. LNG exists in an equilibrium between thermodynamic liquid and vapor, depending on the pressure and temperature inside the tanks. To keep the temperature constant and appropriate for tank pressure, LNG will cool itself or auto-refrigeration by evaporating a small portion of the LNG and generated BOG [10].

In storage mode, Boil-off of LNG happens during holding mode. LNG is stored in tanks at standard pressure ranging from 0 to 0.15 bar above atmospheric pressure. There are 2 main sources of boil-off gas during holding mode which were heat ingress into storage and pipes from surroundings and changes in the ambient pressure. Storage tanks are typically designed to reduce the ingress of heat from the surroundings and solar heating so that vaporization is less than 0.05 % of the total tank content per day, although this can vary from 0.02 to 0.1% [11].

The amount of BOG generated must be minimized and managed to optimize the supply chain of LNG during storage and transportation. During transportation, BOG can be utilized as fuel for the LNG carrier's engine. In storage phase, BOG can be re-liquefied again and returned to storage tank, or it can be used for Terminal Fuel Own Use or export to gas transmission / distribution system.

D. Capital Budgeting Techniques

To evaluate investment opportunities, the firms must first determine relevant cash flows associated with the investments. The cash flows of any investment projects may include three components namely Initial Investment, Operating Cash Flows, and Terminal Cash Flow[12]. There are 4 capital budgeting technique that used in this research is Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), and Payback Period that written as follows:

- $NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - CF_0$

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- $\$0 = \sum_{t=0}^{n} \frac{CFt}{(1+IRR)^t} - CF_0$
- $PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{CF_0}$
- The Payback Period used in this research is using Discounted Payback Period which calculate using discounted cash flow.

E. Sensitivity Analysis

Sensitivity analysis determines how different values of an independent variable affect a particular dependent variable under a given set of assumptions. It is a way to predict the outcome of a decision given a certain range of variables. By creating a given set of variables, an analyst can determine how changes in one variable affect the outcome [13]. In this study, sensitivity analysis is conducted for input variables that have high uncertainty.

F. Monte Carlo Simulation

Monte Carlo (MC) simulation is used to model possible outcomes to predict uncertainty in the decision-making process. It generates random set of values for uncertain variables repeatedly to simulate a model [12]. MC methods involve probabilistic simulation techniques that can be used to address a wide range of optimization and inference problems in science. MC methods proceed by generating a large number of possible values of the desired parameters and substituting the integrations by sample averages. Practically, these parameter values can be acquired either by physically duplicating the desired experiment or by probabilistically defining it and generating a set of random realizations [14].

METHODOLOGY

Research design are types for inquiry within qualitative, quantitative, and mixed method approaches that provide specific direction for procedures in a research study [15]. The author uses both qualitative and quantitative research combination or mixed method approach. Qualitative research will be used to gather and analyze internal and external condition in LNG market to determine the opportunity and threats related to development of LNG Storage Facility in Indonesia. Quantitative research will be used to calculate the economic viability of the project by using numerical data to build a Financial Model then determine whether the project is profitable or not. Sensitivity analysis and Monte Carlo simulation will be done to understand the variables that influence the feasibility of the project and the risk related to them.

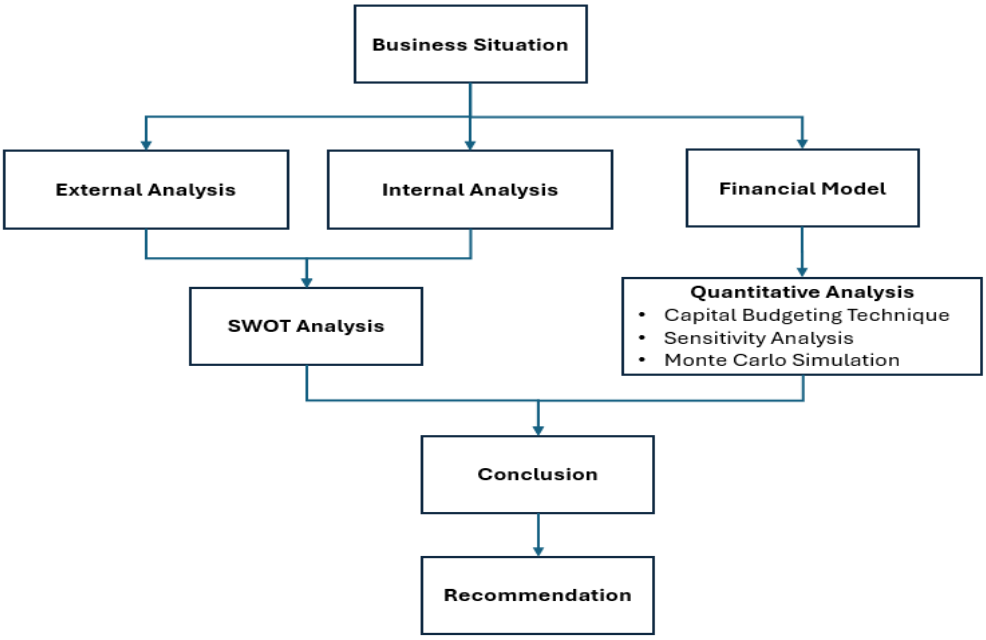

Figure 3. Research Flow Diagram

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Primary data is collected through semi-structured interviews and discussion with respondents that have experience in the LNG field. Secondary data was obtained from various sources including published reports, journals, papers, and books. The data was used to gain an understanding of the LNG Storage Project and help in developing a financial model to determine economic viability.

RESULTS AND DISCUSSION

A. Business Situation Analysis

This research uses external analysis to describe the current business situation related to LNG and internal analysis to identify resources and capabilities that can be used as the source of competitive advantage.

Table 1. External Analysis using PESTEL Analysis

Aspect	Description
Political	The domestic and global political landscape can affect LNG infrastructure development in Indonesia. Global uncertainties like the Russia-Ukraine war have disrupted gas supply, increasing LNG's importance. In Indonesia, presidential elections every five years often lead to policy shifts. Despite this, LNG storage development aligns with the National Energy General Plan to enhance infrastructure and energy security, with a projected investment need of USD 24.8 billion over 15 years, as forecasted by the Directorate General of Oil and Gas in April 2026.
Economy	The development of LNG storage facilities is influenced by microeconomic and macroeconomic factors such as inflation, interest rates, and economic growth. The economic feasibility depends on construction, operation, and maintenance costs, as well as financing options. The government encourages LNG development in eastern Indonesia for equal economic distribution. As energy demand grows, LNG facilities are critical for energy transition towards the 2060 Net Zero Emission target.
Social-Cultural	Social-cultural conditions, including local cultures and customs, are crucial in developing LNG facilities across Indonesia's multi-island geography. Positive relationships with local communities, job creation, and skill development are key benefits. However, environmental protection values and fair compensation for land use are essential to gain community support and ensure project acceptance.
Technology	Technological advancements enhance operational efficiency and safety in the LNG storage business. Improved LNG tank technology can reduce construction costs by 12% and land needed by 33%, as well as lower the boil-off rate by 15% [7]. Despite the current reliance on natural gas, future advancements in renewable energy technology could disrupt the LNG business.
Environment	While natural gas is cleaner than other fossil fuels, LNG still contributes to greenhouse gas emissions and other environmental impacts. Compliance with environmental regulations and standards is crucial. The construction and operation of LNG facilities must assess and mitigate impacts on ecosystems, emissions, habitat disruption, and potential accidents to align with Indonesia's goal of net zero emissions by 2060.
Legal	Indonesia's legal framework for LNG business activities includes regulations on safety, environmental standards, and operational practices. A business entity must have an LNG Storage Business License to operate. Compliance with Government Regulation No. 36/2004 and guidelines from relevant authorities is required for LNG storage business operations.

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Table 2. Internal Analysis using Resource-Based View Analysis and VRIO Framework

Resources	Description	VRIO Analysis
Natural Gas Reserves (Tangible Resource)	In 2023, Indonesia has proven gas reserve of 35.30 TSCF. Additionally, probable and possible gas reserves account for 19.46 TSCF make the total of gas reserves in Indonesia become 54.67 TSCF [2]. There is potential for oil and gas basins that have not yet been explored in Indonesia [16] and can increase Indonesia's gas reserve in the future. This resource can support the long-term economic viability of LNG projects.	Sustainable Competitive Advantage (SCA)
Strategic Location (Tangible Resource)	Indonesia's geographic position is situated along important maritime trade routes and near with key LNG import markets in Asia (Japan, South Korea, and China). This can provide logistical advantages for LNG market trading.	Sustainable Competitive Advantage (SCA)
Existing LNG Infrastructure (Tangible Resource)	Indonesia has operating LNG Plants, LNG Tankers and several LNG Regassification Terminals. There are also new LNG Plants projects that are expected to increase LNG Supply and development of mini-LNG terminals for remote areas. Those facilities provide a full LNG supply chain. Combine with gas infrastructure that already exist, reduce the need for building supporting facilities for the development of LNG storage facility project.	Sustainable Competitive Advantage (SCA)
Human Resource (Intangible Resource)	Indonesia workforces have many experiences in operating and maintaining LNG related infrastructure since the first LNG Plant development in Indonesia. This workforce can contribute to operational efficiency by maintaining equipment, optimizing processes, and troubleshooting issues effectively.	Temporary Competitive Advantage (TCA)
Reputation (Intangible Resource)	Indonesia has good reputation as a reliable LNG supplier and was known as a major LNG exporter. This reputation can be a competitive advantage to attract domestic and international customers.	Sustainable Competitive Advantage (SCA)

Using external and internal analysis above, the SWOT Analysis of LNG Storage Facility analyze and is shown in Table 3.

Table 3. SWOT Analysis

Strengths	Weaknesses	Opportunity	Threats
• Indonesia is rich in natural gas resources, support the needs for extensive LNG storage. • Existing LNG Plants and Terminals can be the foundation for further storage development. • Indonesia has skilled workforce in with decades of experience in the LNG sector. • Government support and strategic initiatives that drive the development of LNG infrastructure. • Indonesia has good reputation as a reliable LNG supplier	• Complex licensing from multiple government authorities poses significant challenges. • Technology to build storage facilities heavily depends on foreign companies. • Potential opposition from communities due to environmental concerns and land acquisition issues.	• Growing LNG demand both domestic and global presents opportunities to develop LNG storage facilities. • Indonesia strategic location offer potential to become regional hub for LNG. • Support from government to promote LNG infrastructure and align with the nation target of NZE by 2060	• Fluctuation in global economic conditions can impact the viability of the project. • Advancement in technology related to renewable energy can shift energy demand and disrupt the LNG business. • Potential environmental impact during construction and operation can hinder the project.

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Based on the Business Situation Analysis, the development of LNG storage facility in Indonesia encounters several challenges and uncertainties that pose significant risks for the viability of the investment. However, the strategic competitive advantages, government support, economic growth potential can help to mitigate these challenges. This development is also aligned with the country's long-term energy goal and makes it a prudent decision to continue the investment.

B. Feasibility Analysis

A Project Feasibility Analysis will be conducted for 2 scenarios. The 1st scenario is to build an LNG Tank with capacity of 180.000 m3. The 2nd scenario is to build an LNG Tank with capacity of 200.000 m3. Cost components and data used in this analysis are Capex, O&M cost, Losses cost from Boil-off Gas, and 20 years depreciation. The revenue will be generated from Storage Fee and the project lifetime is 20 years after the commissioning. The investment should generate returns that are above Weighted Average Cost of Capital (WACC). WACC used in this research is 7.95%.

1) Capital Budgeting Technique

Table 4. Economic Viability Results

Economic Parameter	**180.000 m3**	**200.000 m3**	**Acceptance Criteria**
Net Present Value (million US$)	33.7	44.3	> 0
IRR	10.96%	11.61%	> Hurdle Rate
Discounted Payback Period	14.61	13.67	< Project Lifetime
PI	1.26	1.32	>1
Conclusion	**Feasible**	**Feasible**	

Based on those 2 scenarios, under normal conditions with full capacity committed, both of scenarios are feasible to continue with LNG Storage Facility with 200.000 m3 capacity give more return for investor. The reason for this is the investment costs per cubic meter are lower for tanks with larger capacity as mentioned in Literature Review, even though operating costs increase for larger capacity. However, the LNG market is volatile, and it can affect the economic viability of LNG Storage Facility projects. It will be further analyzed.

2) Sensitivity Analysis

The sensitivity analysis is carried out by using NPV as output variables that will be affected by the change in input variables. Sensitivity analysis conducted on this research, considering variations in key parameters that have high uncertainty level such as Storage Fee Tariff, Capital Expenditure (Capex), Operational Expenditure (Opex), and LNG Price. LNG Price will affect the cost of Losses which makes it more beneficial for the investment if the price is lower.

Table 5. Sensitivity Analysis of LNG Tank Capacity 180.000 m3 (in million US$)

Input Parameter	**-20%**	**-10%**	**0%**	**+10%**	**+20%**
Tariff	- 9.1	12.2	33.7	55.1	76.5
Capex	58.3	46.0	33.7	21.4	9.2
Operation & Maintenance Cost	39.2	36.5	33.7	30.9	28.2
LNG Price	39.7	36.7	33.7	30.7	27.7

The results show that the changes of Storage Fee for 20% reduction make the NPV negative while other changes in input parameters not giving a negative NPV in 20% changes range.

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Table 6. Sensitivity Analysis of LNG Tank Capacity 200.000 m3 (in million US$)

Input Parameter	-20%	-10%	0%	+10%	+20%
Tariff	- 3.3	20.5	44.3	68.1	91.9
Capex	70.5	57.4	44.3	31.2	18.1
Operation & Maintenance Cost	50.2	47.2	44.3	41.4	38.4
LNG Price	51.0	47.6	44.3	41.0	37.6

Using tornado chart for sensitivity analysis shown in Figure 6 indicates that tariff or storage fee is the most sensitive parameter to NPV. Capex can be considered a high-risk factor that can have significant impact to NPV while the change in Opex and LNG Price have less impact to NPV.

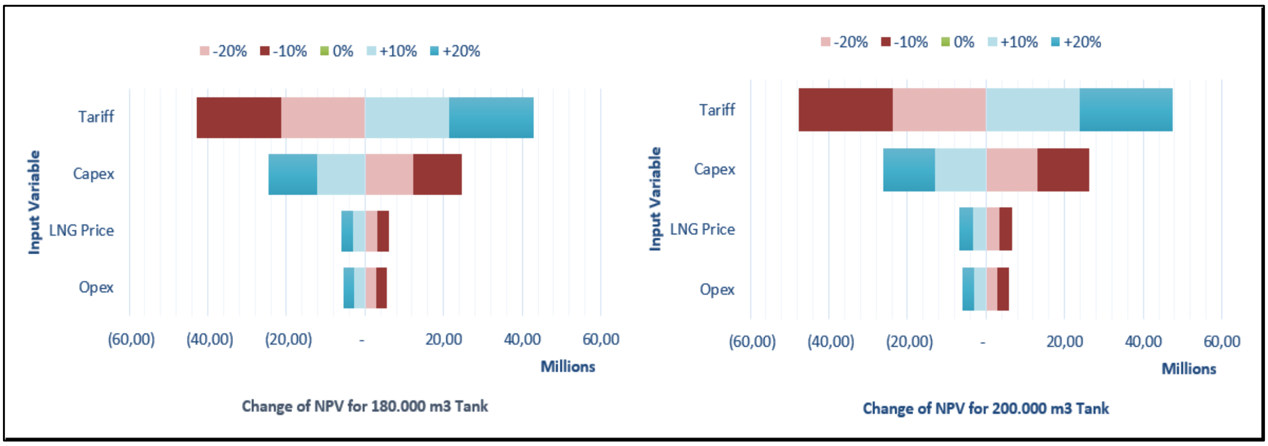

Figure 4. Tornado Chart of Sensitivity Analysis

3) Monte Carlo Simulation

Monte Carlo Simulation is then used to model the probability of different outcomes when there is potential of uncertainties with the input parameters. The simulation assumes that all components can be higher and lower using normal distribution in the range standard deviation of 10% from the base assumption except for LNG Price which use Standard Deviation from LNG Price data from 1 June 2023 – 31 May 2024. Monte Carlo simulation is performed for 10.000 iterations and will generate NPV. The results for the simulations are shown in Table 7.

Table 7. Monte Carlo Simulation Results

Input Parameter	Capacity of 180.000 m3	Capacity of 200.000 m3
Mean (Million US$)	33.9	44.6
Median (Million US$)	34.1	44.7
Standard Deviation (Million US$)	24.4	27.2
Min (Million US$)	- 55.6	- 56.5
Max (Million US$)	130.7	147.0
Negative NPV Frequency	857 times out of 10.000	523 times out of 10.000

Based on simulation, the probability of project NPV higher than 0 is 91.4% for investment with tank capacity of 180.000 m3 and 94.7% for investment with tank capacity of 200.000 m3. Both mean and median are positive and suggest that the projects are likely to be profitable under many scenarios. The standard deviation is quite high and implies that there is considerable variability in the NPVs but not extreme given higher mean of the NPVs than its standard deviation. There is less than 10% probability that the projects will result in a loss. It indicates a relatively low risk. However, risk mitigation should be done to develop contingency plans or insurance to handle the risk of negative NPV.

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Investment with tank capacity of 200.000 m3 shows higher mean and median NPV and IRR compared to the other scenario. This scenario appears to offer higher potential returns with slightly worse worst-case outcomes but has higher. It indicates that larger capacity gives greater overall profitability. Both scenarios exhibit downside risk with potential losses of NPV lower than 0.

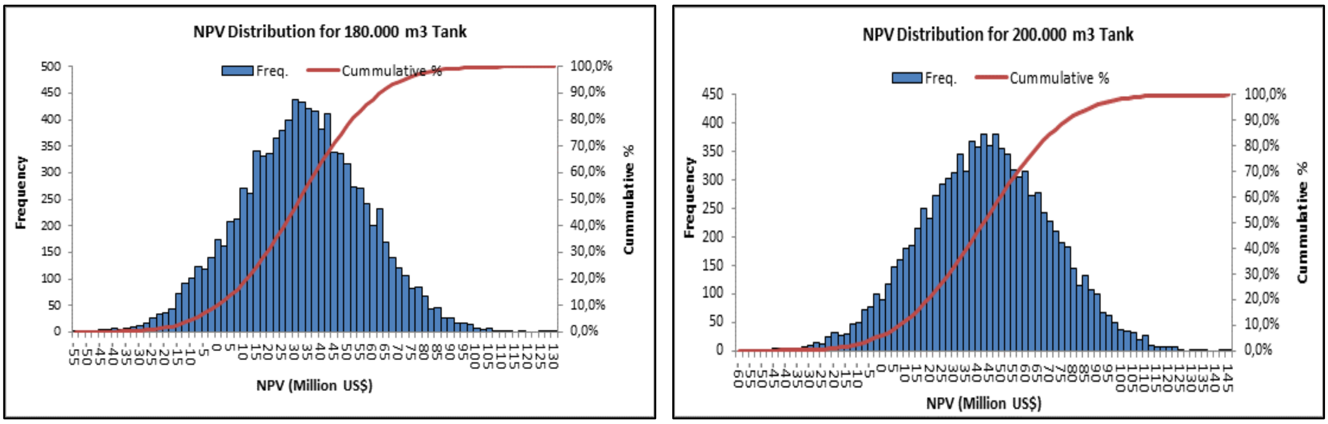

Figure 5. Generated Project NPV

4) Improved Scenario

The viability of LNG Storage Facility construction can be further improved by integrating it with existing LNG infrastructure such as Regassification or Liquefaction facility. By this scenario, LNG that evaporated and become Boil-off losses can be re-liquefied again and returned to storage tank, or it can be exported to gas transmission / distribution system as part of regassification gas. Using LNG tank with capacity of 200.000 m3 and eliminated Boil-off losses, the project yields better result as shown in Table 8.

Table 8. Economic Viability of Improved Scenario

Economic Parameter	Improved Scenario	Acceptance Criteria
Net Present Value (million US$)	77.7	> 0
IRR	14.10%	> Hurdle Rate
Discounted Payback Period	11.04	< Project Lifetime
PI	1.56	>1
Conclusion	**Feasible**	

CONCLUSION AND RECOMMENDATION

The construction of an LNG storage facility in Indonesia is commercially feasible, supported by the opportunity driven by the growth of LNG Demand and Indonesia strategic advantages. Using capital budgeting technique, the LNG storage facility project using storage capacity of 180.000 m3 is a feasible project which resulted in NPV of $33.7 million, an IRR of 10.96%, and Profitability Index of 1.26 with payback period of 14.61 years. However, if storage capacity increases to 200.000 m3, the feasibility of the project is better which resulted in NPV of $44.3 million, an IRR of 11.61%, and Profitability Index of 1.32 with payback period of 13.67 years. Integration with existing LNG Infrastructure can further increase the feasibility of the project using 200.000 m3 which resulted in NPV of $77.7 million and IRR 14.10% with payback period of 11.04 years and Profitability Index of 1.56.

Various input parameters, including Storage Fee, Investment and Operation Costs, LNG Price, and Volume Committed can influence the financial performance metrics (NPV and IRR) of LNG storage facility construction projects. Sensitivity analysis reveals the sensitivity of NPV and IRR to changes in these parameters. Storage Fee is the most sensitive parameter to NPV. Capex and WACC can be considered high-risk factors that have significant impact to NPV while the change in Opex and LNG Price have less impact to NPV. Storage volume demand also influences the financial viability of the project and should be carefully considered in determining the capacity of LNG tanks to be built. Monte Carlo simulation shows a 91.4% probability of positive NPV for a 180.000 m³ tank capacity and 94.7% for a 200.000 m³ capacity. Both scenarios have positive mean and median NPVs, indicating likely profitability despite considerable variability. The risk of loss is under 10%, suggesting low risk, though contingency plans or insurance are recommended. The 200.000 m³ capacity scenario offers higher potential returns with slightly increased risks, indicating greater overall profitability.

The development of an LNG storage facility in Indonesia presents significant opportunities driven by the growth of LNG Demand and strategic advantages that have been discussed. To make it successfully implemented in Indonesia, it requires a holistic approach that integrates economic considerations, LNG market forecasts, cost management strategies, and risk mitigation measures. By addressing these aspects, the project can maximize its economic returns, mitigate risks effectively, and contribute to the growth of LNG industry in Indonesia.

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