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Financial Feasibility Study of Methanol Refinery from Natural Gas Plant Project using Monte Carlo Simulation

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ABSTRACT

Indonesia has abundant natural resources, one of which is natural gas. Utilization of the large demand for natural gas in Eastern Indonesia through the construction project of a methanol refinery is a solution to substitute methanol imports in Indonesia. One of the biggest challenges in building a methanol refinery in Indonesia is a project that meets the economic feasibility indicator. In the methanol refinery project, it is also possible to accommodate the uncertainty variable that raises the possibility of facing the actual risk under the expected return such as investment costs, natural gas prices, and the selling price of methanol. Therefore, an economic method is needed that is not able to accommodate the possibility of the occurrence of these uncertain variables, one of which is the deterministic method and the probabilistic Monte Carlo. This research will focus on the economic feasibility of the methanol project using the deterministic method and the probabilistic Monte Carlo calculation through the Free Cashflow calculation in accordance with the principles of project finance. The feasibility of deterministic and probabilistic economic in this study uses Microsoft Excel 2016 and Crystal Ball 11.1.2.4 applications. The indicators used by the deterministic method in this study are NPV>0, IRR>10%, PBP<10 years, PI>1, and probabilistic feasibility test indicators, Average Cumulative Probability of Feasibility Test Parameters >70%. The results showed that the deterministic and probabilistic project economic methods met the specified criteria. The three uncertainty variables that most influence the economic model using the Monte Carlo probabilistic method are methanol prices, gas prices, and CAPEX.

Key words: Project Financial Feasibility Study, Methanol from Natural Gas, Monte Carlo Simulation

INTRODUCTION

Indonesia has abundant natural resources, one of which is natural gas. Natural gas can be used as a fuel to provide thermal energy for power generation or as raw material and converted into other products that can be sold such as methanol [1].

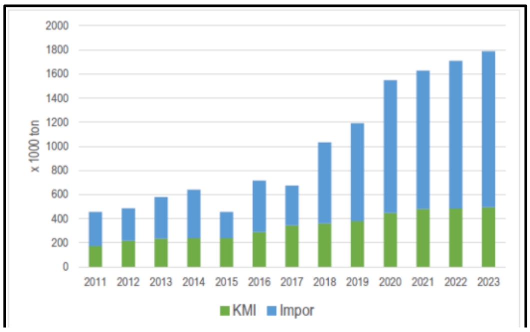

Fig. 1 Methanol Supply and Demand Existing and Future in Indonesia

Utilization of the large demand for natural gas in eastern Indonesia through the construction of a methanol refinery project is a solution to substitute methanol imports in Indonesia [2]. Methanol production for domestic use in Indonesia currently reaches 200.000 tons/year. This is not sufficient to meet Indonesia's projected needs of up to 1.800.000 tons per year with Methanol imports increasing to 1.300.000 tons per year [2]. The results of the Literature Review on Determining the Capacity and Location of Methanol Refinery in Indonesia, this study will examine the economic of a methanol refinery with a capacity of 997.920 tons per year located in Bintuni, West Papua.

Methanol, also known as methyl alcohol, is a chemical compound with the chemical formula CH_3OH that can be produced from natural gas. Methanol is a raw material for the chemical industry and engine fuel & additives whose final products are useful for everyday life [2]. The process of producing methanol from natural gas generally has process stages consisting of synthesis gas, synthesis of methanol, and purification of methanol which can be simply seen in Figure 2. Basic steps of methanol production [3].

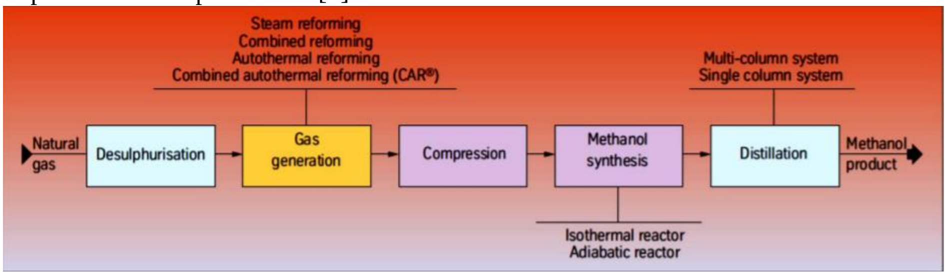

Fig. 2 Basic steps of methanol production [3]

The economic theory used in project development uses a profitability approach because it involves profits that can be directly received financially [4]. The indicators used to determine the economic feasibility of the project in this study are Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Profitability Index (PI). The formula of the NPV equation is according to Formula 1 below:

$$\text{NPV} = \sum_{t=0}^{n} \frac{NCF_t}{(1+k)^t} - NCF_0 \quad (1)$$

Where: NPV = Net Present Value, NCF_0= initial cash outlay on a project, NCF_t= net cash flow generated by project at time t, n = life of the project, k = required rate of return.The formula of the IRR equation is according to Formula 2 below:

$$IRR = \sum_{t-1}^{t} \frac{C_t}{(1+r)^t} - C_0 \quad (2)$$

Where: IRR = Internal rate of return, C_t = Net cash inflow during the period t, r = discount rate, t = number of time periods, C_0 = Total Initial Investment Cost. The formula of the Payback Period (PBP) equation is according to Formula 3 below:

$$\sum_{t=0}^{t=PP} x_t = 0 \quad (3)$$

Where x_t = Cash Flow in year t; PP = project payback period; t = current financial year.The formula of the NPV equation is according to Formula 4 below:

$$PI = \frac{NPV}{I_0} \quad (4)$$

Where: NPV =Net Present Value; I_0 = initial investment.

In previous studies, it was explained that sensitivity analysis was carried out to see the magnitude of changes in project economic parameters such as NPV and IRR by changing one variable while the other variables did not change. The changes that occur are not only from one variable but from several variables that change simultaneously. To make changes to several variables simultaneously requires a simulation known as Monte Carlo simulation [4]. The concept of the Monte Carlo simulation can be seen in Figure 3.

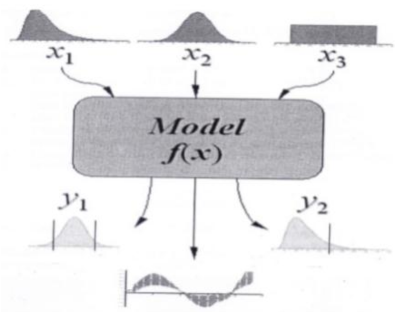

Fig. 3 Monte Carlo Simulation

DESIGN, MATERIAL, PROCEDURE, TECHNIQUE, OR METHODS

Research Procedure Scheme

The research procedure scheme can be seen in Fig.4.

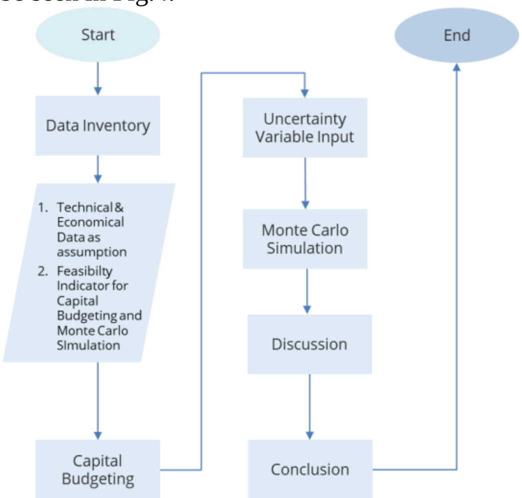

Fig. 4 Research Procedure Scheme

Fig. 4 shows the research steps. The start of this research is data inventory which reading, evaluating and assimilating data from previous research works and related literature into the current research to obtain assumptions for the next stage. This research will calculate the Free Cashflow in accordance with the principles of project finance to determine NPV, IRR, PP, and PI through the Microsoft Excel 2016 application. Next, Monte Carlo Simulation through Crystal Ball 11.1.2.4 application was carried out and cumulative probabilistic were obtained for NPV, IRR, PP, and PI. Finally, there are discussion and conclusion to finish the research.

Assumption and Justification

The Methanol Refinery Minimum Production Capacity and Location [5] can be seen in Table -1.

Table -1 Methanol Refinery Minimum Production Capacity and Location

No.	Parameter	Data Inventory
1	Demand Methanol Projection after 2024	1.800.000 Ton MeOH / Years
2	Supply Domestic Methanol Projection after 2024	500.000 Ton MeOH / Years
3	Potential Methanol Import Substitution	1.300.000 Ton MeOH / Years
4	Captive Market Demand Methanol after 2024	76,8%
5	Minimum Production Capacity	997.920Ton MeOH / Years
6	Potential Source Gas	Bintuni, West Papua
7	Gas Allocation Estimation for Methanol Refinery	109 MMSCFD / 20 Years
8	Methanol Refinery Location	Bintuni, West Papua

Technical and Economical Data [6] that will be used for Capital Budgeting can be seen in Table -2.

Table -2 Technical and Economical Data

No.	Data Teknis & Ekonomi	Unit	Nilai
1	Year Started Construction	Year of	Q1 2022
2	Year Started Production	Year of	Q1 2025
3	Total Refinery Operation Duration	Years	20,0
4	Refinery Operation Duration per Day	Days / Year	330,0
5	Natural Gas Prices at Plant Gate	USD / MMBtu	4,5
6	Minimum Projection of Methanol Selling Price	Ton MeOH / Year	350,0
7	Discount Rate and MARR	%	10,0%
8	Debt to Equity Ratio	%	70% : 30%
9	Corporate Tax Rate	%	20,0%
10	Interest	% / Year	7,0%
11	Grace Period	Year	1,0
12	Repayment Period	Year	13,0
13	Capacity Factor 1st Year	%	50%
14	Capacity Factor 2nd until 20th Year	%	100%
15	Inflation Rate	% / Year	1,5%
16	Methanol Production Capacity	Ton MeoH / Year	997.920,0
17	Gas Bumi Feed Capacity	MMSCFD	109,0

Economic Model Input

Economic Model Inputin this research can be seen in Table -3.

Table -3 Economic Model Input

No.	Parameter Input	Unit	Nilai
1	Revenue	Million USD / 20y	340,5
2	Direct Variable Cost (Feed Cost)	Million USD / 20y	148,7
3	Gross Margin	Million USD / 20y	191,9
4	Direct Fixed Cost (Exc. Feed Cost)	Million USD / 20y	49,3
5	IndirectFixed Cost	Million USD / 20y	1,8
6	Indirect Variable Cost	Million USD / 20y	3,3
7	Operating Margin	Million USD / 20y	137,4
8	Depreciation & Amortization	Million USD / 20y	26,2
9	Interest Expense	Million USD / 20y	12,0
10	Income After Tax	Million USD / 20y	79,3
11	Total Investment / CAPEX	Million USD	619,1

Monte Carlo Probabilistic Simulation Result [7] that will be the indicator to determine the feasibility of Probalistic Simulation can be seen in Table -4.

Table -4 Monte Carlo Probabilistic Simulation Result Feasibility Indicator

No.	Monte Carlo Probabilistic Simulation Result Feasibility Indicator	Unit	Cut Off
1	Cumulative Probability NPV > 0 USD	%	> 70%
2	Cumulative Probability IRR > MARR (10%)	%	> 70%
3	Cummulative Probability PP < 10 years	%	> 70%
4	Cummulative Probability PI > 0	%	> 70%
	Cumulative Probability Average	%	>70%

Monte Carlo Uncertainty Variables that will be used for Monte Carlo Simulation can be seen in Table -5.

Table -5 Basic Monte Carlo Uncertainty Variables

No.	Uncertainty Variables	Triangular Distribution Value	Information
1	CAPEX	minimum = 100%; most likely = 110%; maksimum = 120%	Distribution Fitting of Historical Data
2	Direct Fixed Cost (Maintenance, Operating Labor)	minimum = 100%; most likely = 105%; maksimum = 110%	Distribution Fitting of Historical Data
3	Indirect Fixed Cost (Adm., Spv & Clerical Labor, Ins.)	minimum = 100%; most likely = 105%; maksimum = 110%	Distribution Fitting of Historical Data
4	Indirect Variable Cost (Plant Overhead)	minimum = 100%; most likely = 105%; maksimum = 110%	Distribution Fitting of Historical Data
5	Gas Price at Plant Gate (USD/MMBtu)	minimum = 4.5; most likely = 5.5; maksimum = 6.0	Distribution Fitting of Projection Data
6	Methanol Price (USD / Ton MeOH)	minimum = 290,0; most likely = 327,4; maximum = 350,0	Distribution Fitting of Projection Data

RESULTS AND DISCUSSION

Capital Budgeting

Capital Budgeting Result in this research can be seen in Table -6.

Table -6 Capital Budgeting Result

Capital Budgeting Result	Two-Stage	Feasibility Indicator
NPV, Mln. USD	170,7	NPV>0
IRR Project, percentage	11,6%	IRR>10%
Payback Period, years	9,4	PP<10 years
PI, ratio	1,12	PI>1

Table -10 shows that through the Deterministic Model of Capital Budgeting the result of NPV, IRR, Payback Period, Profitability Index exceeds the predetermined indicators thereforethe economical of this project is declared feasible.

Basic Monte Carlo Simulation

Basic Monte Carlo Simulation Cumulative Probability in this research can be seen in Fig. 5.

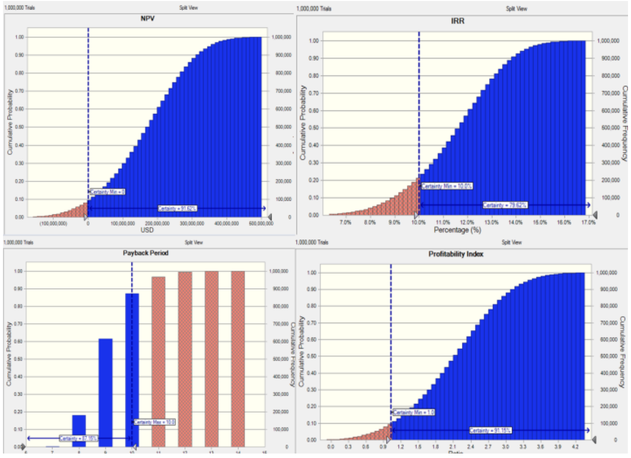

Fig. 5 Basic Monte Carlo Simulation CumulativeProbability

Basic Monte Carlo Simulation Cumulative Probability Result in this research can be seen in Table -7.

Table -7 Basic Monte Carlo Simulation Probability Cumulative Result

Cumulative Probability	Basic Monte Carlo	Feasibility Indicator
NPV	91,6%	>70%
IRR Project	79,6%	>70%
Payback Period	87,2%	>70%
PI	91,2%	>70%
Average	87,4%	>70%

Table -7 shows that through Cumulative Probability of NPV, IRR, Payback Period, Profitability Index exceeds the predetermined indicators thereforethe probability economical of this project is declared feasible. The average cumulative probability is 87,4%, which means that there is a probability of 12,6% of this project is not feasible to run.

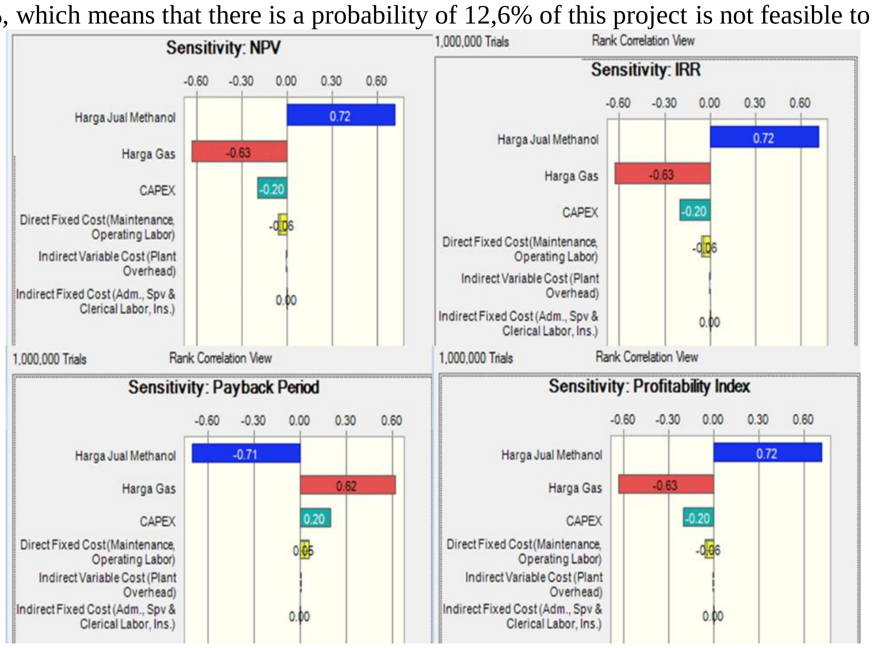

Fig. 6 Sensitivity Probabilistic Ranck Correlation Risk Correlation Monte Carlo Simulation

Table -8 Sensitivity Probabilistic Rank Correlation Risk Correlation Monte Carlo Simulation

Cumulative Probability	Harga Jual Methanol	Harga Gas	CAPEX	Indirect Variable Cost	Indirect Variable Cost	Indirect Fixed Cost
NPV	0,72	-0,63	-0,20	-0,06	0,00	0,00
IRR Project	0,72	-0,63	-0,20	-0,06	0,00	0,00
Payback Period	-0,71	0,62	0,20	0,05	0,00	0,00
PI	0,72	-0,63	-0,20	-0,06	0,00	0,00

By sensitivity probabilistic analysis In Figures 6 and Table -7, it is known that the three main variables that affect the project's NPV, IRR, Payback, PI are: methanol price, gas price, CAPEX. Therefore, these three variables are crucial to monitor toincrease the probability of feasibility of the Methanol project.

CONCLUSION

The result shows thatthe result of the Capital Budgeting deterministic model, NPV, IRR, Payback Period, Profitability Index exceeds the predetermined indicators (NPV>0, IRR>10%, PP < 10 years, and PI>0) therefore the economical of this project is statedfeasible. The result shows that the probability Cumulative Probability of NPV, IRR, Payback Period, Profitability Index exceeds the predetermined indicators (NPV>70%, IRR>70%, PP>70%, and PI>70%) therefore the probability economical model of this project is statedfeasible. By sensitivity probabilistic rank correlation it is known that the three main variables that affect the project's Profitability results are: methanol price, gas price, CAPEX. Recommendations for the next research are to include further analysis of the methanol forward price model and tax holiday scheme.

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