Implementation Monte Carlo Simulation in Investment Evaluation: Case Study - Gas Compressor Investment PLTG 4 x 25 MW Maleo-Gorontalo

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Keywords: Capital Budgeting, Investment Evaluation, Sensitivity Analysis, Monte Carlo Simulation, uncertainty.

Abstract: Investment evaluation is a crucial part before investment decision in order to measure will the project generate profit for the company. This study is investment evaluation Gas Compressor Investment PLTG 4 x25 MW Maleo Gorontalo. There are two investment evaluation method in this project Capital Budgeting and Monte Carlo Simulation. Capital Budgeting technique used to measure this investment evaluation in this project consist of Net Present Value (NPV), Internal Rate Return (IRR), Probability Index (PI) and Payback Period (PBP). From the evaluation, it was obtained that a positive NPV of 500,444, an IRR of 11.50% greater than the WACC of 9%, while the PI of 1.08 and PBP of 1.57 years was faster than the duration of the 2 (two) year contract. Monte Carlo simulation applied to predict the financial feasibility of a project by considering risks and uncertainties use to calculate Probability NPV<0 in this project, with use Capital Expenditure (CAPEX), Lifetime Project and Debt: Equity Portion as the input variables. Monte Carlo simulation result probability NPV <0 is 10,32 % mean while probability NPV >0 is 89,68%.

1 INTRODUCTION

1.1 Background

Electricity is a basic human need, which is an inseparable part from daily life. According to report second quarter of 2020 the data shows that the development of the national electrification ratio has reached 99.09%, as explained in the graph below:

Figure .1. Electrification Ratio

The electrification growth mentioned above resulted an increase in electricity production in GWh with an average annual growth of 5.62% while the average annual increase in electricity sales in GWh was 5.86% per year. The comparison between production and sales in GWh is presented in the graph below:

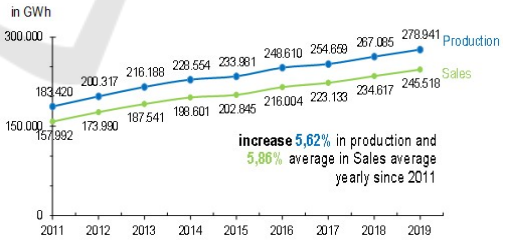

Figure .2. Production and Sales in GWh 2011-2019.

The transformation of PLN towards new and renewable energy (EBT) is still emphasizing the energy mix in coal and placing natural gas energy sources as a transition energy to EBT. The following is the energy mix target to generate electricity starting at the end of 2025.

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Siregar, A. and Wiryono, S.
Implementation Monte Carlo Simulation in Investment Evaluation: Case Study - Gas Compressor Investment PLTG 4 x 25 MW Maleo-Gorontalo.
DOI: 10.5220/0010935100003255
In *Proceedings of the 3rd International Conference on Applied Economics and Social Science (ICAESS 2021)*, pages 72-79
ISBN: 978-989-758-605-7

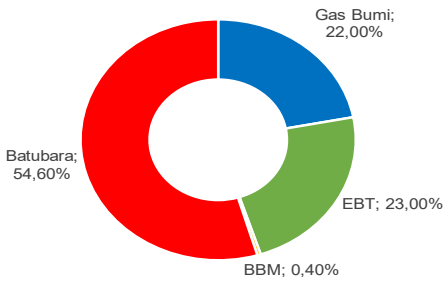

Figure 3: Target of energy mixing end of 2025.

PT XYZ as a subsidiary of PT Pelayanan Listrik Nasional Batam (PLNB) a state-owned company electricity provider in Batam island. PT XYZ has contributing to Optimizing Cost Efficiency in PT PLN (Persero) group especially for gas infrastructure and the first subsidiary specialize in gas pipeline in PT PLN (Persero).

PT XYZ has received an offering letter from PT PLN Gas Geothermal ("PLNGG") as the owner of the project to offer Investment in Gas Compressor for PLTG 4 x 25 MW Maleo-Gorontalo.

Management of PT XYZ need to ensure the investment decision according to offering letter will generate a profit margin to the Company.

1.2 Problem Statement

As described above, will investment in Compressor for PLTG 4 x 25 MW generate profit to PT XYZ. And questions related to this statement are:

a. What return are expected and how can management maximize the return?
b. How are investment performing evaluated by Capital Budgeting?
c. Which scenarios greatest financial risk or benefit?
d. Percentage of probability Net Present Value > 0, as indicate of project success?

1.3 Objective

The main objectives of this paper are as follow:

a. To analyze investment evaluation of the project with to the Capital Budgeting technique.
b. To identify the most sensitives variable key changes input to capital budgeting indicator.
c. To perform assessment on sensitivity of uncertainties factors in the investment decision with Monte Carlo simulation to get profitability of success of project.

2 LITERATURE REVIEW

2.1 Capital Budgeting

Capital budgeting is the process of evaluating and selecting long term investment. This process intended to achieve the firm's goal of maximizing shareholder's wealth (Gitman, Lawrence, J_Zutter, Chad J :2014).

2.1.1 Discounted Cash Flow

According to the Chan S. Park (2007: p.216) Discounted Cash Flow (DCF) is a method of evaluating an investment by estimating future cash flow and taking into consideration of money. The discounted cash flow (DCF) formula is as below:

$$\boldsymbol{DCFt} = \frac{\boldsymbol{NCF_t}}{(\boldsymbol{1}+\boldsymbol{r})^{\boldsymbol{t}}}$$

Where:
DCFt = Net cash flow at the year of year t
r = Discount rate
t = Number of the year t = 0,1,2,3….t

2.1.2 Weight Average Cost of Capital (WACC)

A method to calculating MARR is WACC approach with assuming source of investment capital from debt and equity. The expected return for equity investor name cost of equity, the expected that lenders hope to make on their investment named cost of debt. All financing that the company takes on, the composition of cost of financing will be a weighted average of the cost of equity and debt, this weight cost name Weight Average Cost of Capital (Damoradan 2011). WACC formula as below:

$$\boldsymbol{WACC} = [\boldsymbol{rd} * (\boldsymbol{1}-\boldsymbol{tax}) * \boldsymbol{D}/(\boldsymbol{D}+\boldsymbol{E})] + [\boldsymbol{re} * \boldsymbol{E}/(\boldsymbol{D}+\boldsymbol{E})]$$

Where:
rd = cost of debt
re = cost of equity
D = Debt
E = Equity

2.2 Capital Budgeting Technique

2.2.1 Net Present Value (NPV)

NPV determines whether project is an acceptable investment, NPV is the difference between the present value of cash inflow and the present value of

cash outflow (Chan S. Park 2007: p.216). NPV formula as below:

$$NPV = \sum_{t=1}^{t=N} \frac{NCFt}{(1+r)^t} - Initial\ Investment$$

Where:
NCFt = Net Cash flow in t period
r = discount rate
N = life of the project

Decision criteria for NPV as follows:
If NPV ≥ 0, accept the project
If NPV ≤ 0, reject the project

2.2.2 Internal Rate of Return (IRR)

According to Gitman (2018: p.454) Internal rate of return (IRR) is the discount rate that equates the NPV of an investment opportunity with 0 (because present value of cash inflow equals the initial investment).

IRR formula show as below:

$$0 = \sum_{t=1}^{n} \frac{CFt}{(1+r)^t} - CFo$$

Where:
CFt = Cash flow in period t
r = Discount rate
N = lifetime of the project
IRR = Internal rate of return of the project

When IRR is used to make accept – reject decision, the decision are as follows:
If the IRR > Discount Rate, accept the project.
If the IRR < Discount Rate, reject the project.

2.2.3 Profitability Index (Pi)

According to Ross, et. AI, (2010) profitability index is ratio accumulation net present value, net cash flow after initial investment divided by initial investment.

$$DPI = \frac{\sum_{t=1}^{t=N} \frac{NCFt}{(1+r)^t}}{IO}$$

Where:
NCFt = Net Cash flow in period t
r = Discount Rate
IO = Initial Investment
N = project lifetime

DPI criteria for independent project as follow:
If DPI ≥ 0, then project can be accepted
If DPI ≤ 0, then reject the project

2.2.4 Payback Period Analysis (PBP)

Payback period analysis is when the period of time over which cash flow from investment are expected to recover the initial outlay (Erich A. Helfert: 2001 p.444), with formula as follow:

$$PBB = \sum_{t=1}^{t=N} NCFt \geq 0$$

Where:
PBP = Payback period (PBP)
NCFt = Net Cash flow in t period
N = life of the project

Criteria in PBP indicator:
If the PBP < cut off time the project, accept the project
If the PBP > cut off time the project, reject the project

2.3 Sensitivity Analysis

Sensitivity analysis is the process of tweaking one key input or driver in a financial model and seeing how sensitive model is to the change in that variable (Danielle Stein Fairhurst: 2017: p.160). In this sensitivity analysis used to identify how significant each variable impact to investment analysis parameter of the project. The main uncertainty factors in this project are:

1. Capital cost
2. Inflation
3. Interest
4. Capital expenditure (CAPEX)
5. Operational expenditure (OPEX)
6. Lifetime project (month)

3 RESEARCH MODEL

3.1 Conceptual Framework

Proper decision in investment will generate benefit to company. The future is certainly not exact, however capital budgeting technique will be making better decision in investment evaluation as economic decision. This paper project output will be used as an input to company management in order to investment evaluation.

The framework of this final project shown as below:

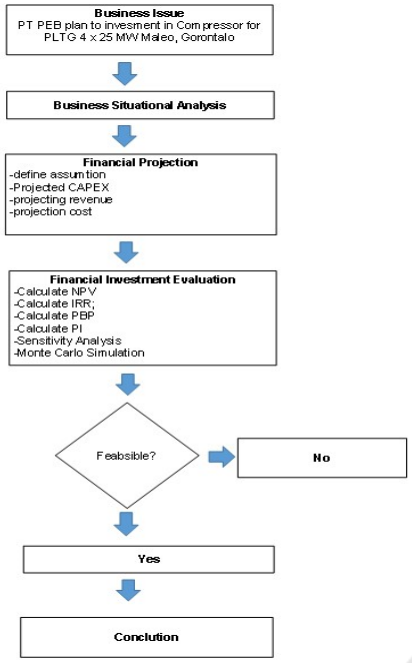

Figure 4: Conceptual Framework.

4 ANALYSES

4.1 Defining Assumption

Project cooperation concept use in this final project is Build, Operate, Own (BOO), with project lifetime 2 (two) years according to the Letter of Intent (LOI) from user with an option will be extended until 5 (five) years.

4.2 Project Investment Cost

Total investment cost of for this project USD 7.118.174, -, according to bill of quantity and engineering team calculation consist of:

Table 1: Investment Cost.

NO	ITEM DESCRIPTION	QTY	UNIT	PRICE (USD)
1	PROJECT MANAGEMENT	1	LS	115.468
2	ENGINEERING	1	LS	156.970
3	MAIN EQUIPMENT	1	LS	4.255.619
4	PIPING & VALVES	1	LS	547.430
5	C. INSTRUMENT CONTROL, SAFETY DEVICE & ELECTRICAL	1	LS	465.038
6	CIVIL WORKS	1	LS	575.596
7	SITE CONSTRUCTION	1	LS	277.978
8	PRE COMMISSIONING & COMMISIONING	1	LS	34.302
9	INSURANCE	1	LS	42.667
			SUB TOTAL	**6.471.067**
			PPN 10%	**647.107**
			TOTAL	**7.118.174**

4.3 WACC

WACC calculation for this project using Regulation of Badan Pengatur Migas No. 8 tahun 2013, article 14. Calculation and Reference and show as below:

Table .2. WACC.

Parameters	Value	Time Range	References
Cost of Equity :			
Risk Free Rate	0,15%		Bloomberg.com
β (Beta)	2,46	March 2015-Dec2020	Yahoo finance (JKSE and PGAS)
Base premium for mature equity Market (BPMEM)	6,56%	Jan 2021	Damodaran (http://pages.stern.nyu.edu/)
Indonesia Country Risk Premium (ICRP)	1,84%	Jan 2021	Damodaran (http://pages.stern.nyu.edu/)
Cost of Debt :			
Weighted average cost of debt	5,24%	Dec 2020	www.bi.go.id
Effective tax rate	25%		Government Regulation

Authors use PT Perusahaan Gas Negara (PGN) with listed code in Jakarta Stock Exchange PGAS as data to calculated β(beta) detail provided in Appendix 3-1, assume Gas Compressor use for PLTG 4 x 25 MW in Maleo is part of Gas Infrastructure. Then WACC output calculation below:

Table .3. WACC Calculation.

Detail	Value
Cost of equity	
Risk free rate (Rf)	0,15%
Beta	2,46
Base premium for mature equity Market (BPMEM)	6,56%
Indonesia Country Risk Premium (ICRP)	1,84%
	20,84%
Cost of debt	
Weighted average cost of debt	5,24%
Effective tax rate	25,00%
Effective cost of debt	3,93%
WACC Calculation	
Komposisi:	
Ekuitas	30%
Hutang	70%
WACC	**9,00%**

4.4 Revenue

Projected revenue of this project divided in 2 (two) streams:

- Cost Capital Recovery (CCR)
- Operation Maintenance Recovery (OMR)

Total CCR and OMR during lifetime project show as table below:

Table .4. revenue projection.

No.	Years	CCR (USD)	OMR (USD)	Total Revenue (USD)
1	2021	1.829.001	438.973	2.267.974
2	2022	5.472.010	1.314.336	6.786.346
3	2023	3.643.009	876.368	4.519.377
Total		**10.944.020**	**2.629.676**	**13.573.697**

4.5 Operating Expenditure (OPEX)

To operating a gas compressor facility, required operating cost that consist of fixed cost and variable cost:

Table .5. fixed and variable cost/annum

NO	ITEM DESCRIPTION	QTY	UNIT	PRICE (USD)	Note
A	**Operation & Maintenance**				
1	Man Power	1	LS	599.825	per annum
2	Supporting	1	LS	160.089	per annum
3	Spare Parts & Consumable	1	LS	546.010	per annum
4	O&M all risk Insurance	1	LS	7.397	per annum
	Total			**1.313.322**	

4.6 Capital Budgeting Analysis

Analysis result according to the investment evaluation analysis rule show as table below:

Table .6. Investment Analysis Result.

No.	Parameters	Criteria Indicator	Value/Result
1	**Pay Back Period (PBP)**	If the PBP < cut off time the project, accept the project	1,57
		If the PBP > cut off time the project, reject the project	Accept
2	**Net Present Value (NPV)**	If NPV ≥ 0, accept the project	USD 500.444
		If NPV ≤ 0, reject the project	Accept
3	**Profitability Index (PI)**	If PI ≥ 0 , then project can be accepted	1,08
		If PI ≤ 0, then reject the project	Accept
4	**Internal Rate Return (IRR)**	If the IRR > Discount Rate, accept the project	11,50%
		If the IRR < Discount Rate, reject the project	Accept

From table 5 above, it shown that Investment in Compressor for PLTG 4 x 25 MW Maleo, Gorontalo has positive value of NPV USD 500.444 with IRR 11,50% greater than WACC 9% and Payback Period 1,57 years. This parameter described that investing in Gas Compressor for PLTG 4 x 25 MW feasible and will generated profit for PT XYZ.

4.7 Sensitivity Analysis

According to Stein Fairhurst, Danielle (2017:140) Sensitivity analysis is the process of tweaking one key input variable which lead to the greatest decrease or increase of the output variables when changes. In this project sensitivity analysis used to identify how significant each variable changes impact to investment analysis parameter of the project NPV, IRR, PI and PBP. The main uncertainty factors in this project shown in this table below and output will be presented in bar chart comparison to evaluate sensitivity level

Table .7. Sensitivity Parameter.

No.	Sensitivity Focus	Low	Base	High
1	Capital Expenditure (CAPEX)	-10%	Base	+10%
2	Operating Expenditures (OPEX	-10%	Base	+10%
3	Interest Rate	4,53%	5,24%	5,92%
4	Inflation Rate	1,32%	2,77%	3,61%
5	Life Time Project (month)	18	24	30
6	Debt : Equity Portion	80% : 20%	70% : 30%	60% : 40%

4.7.1 NPV Sensitivity Analysis

Changes in variable CAPEX, LIFETIME PROJECT and DEBT: EQUITY PORTION are the most sensitive parameter to NPV indicator show in the NPV Sensitivity analysis chart below:

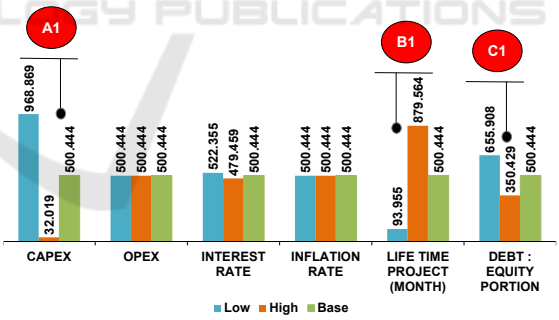

Figure .5. NPV Sensitivity analysis

From figure 5 shows above explain that:
A1). If CAPEX low under budget -10% in this project will impact to increase NPV USD 968.869, meanwhile if CAPEX high over budget +10% NPV value will decrease to USD 32.019,20 or -93,60% from BASE assumption.

B1). If LIFETIME PROJECT (MONTH) high with extended 6 (six) month from 24 (twenty-four) month become 30 (thirty) month NPV will increase to USD 879.563 or increase 75,76% from BASE assumption,

meanwhile if with shortened 6 (six) month NPV will drop to USD 93.995,36 (-81,23%) from BASE assumption.

C1). DEBT: EQUITY PORTION, with low assumption 80% Debt: 20% Equity will impact to NPV project USD 655.907,88 or increase 31,07% from NPV BASE assumption as impact of changes in WACC from 9% become 7,31%, meanwhile with high assumption 60% Debt: 40% Equity NPV become USD 350.428,60 or decrease 29,98% as impact changes in WACC from 9% become 10,70%. Other's parameter has less sensitive to NPV calculation

4.7.2 IRR Sensitivity analysis

Changes in variable CAPEX and LIFETIME PROJECT are the most sensitive parameter to IRR indicator as show in the IRR Sensitivity analysis chart below:

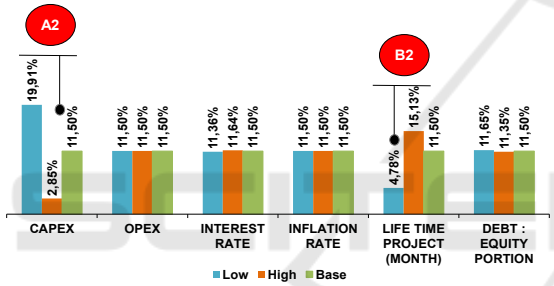

Figure .6. IRR Sensitivity analysis

From figure 6 above explain that:
A2). If CAPEX low under budget -10% will impact to IRR 19,91%, meanwhile if CAPEX high over budget +10% will impact to decrease IRR 2,85% lower than WACC 9% or decrease -75,24% from BASE assumption with IRR 11,50%.

B2). Additional LIFETIME PROJECT (MONTH) 6 (six) month from BASE assumption 24 month become 30 months will increase IRR to 15,13%, meanwhile with decrease LIFETIME PROJECT (MONTH) 6 (six) from 24 month to 18 month will decrease IRR to 4,78%.

Other's parameter has less sensitive to IRR calculation.

4.7.3 Profitability Index (PI) Sensitivity Analysis

Changes in variable CAPEX and LIFETIME PROJECT are the most sensitive parameter to PI indicator as show in the PI Sensitivity analysis chart below:

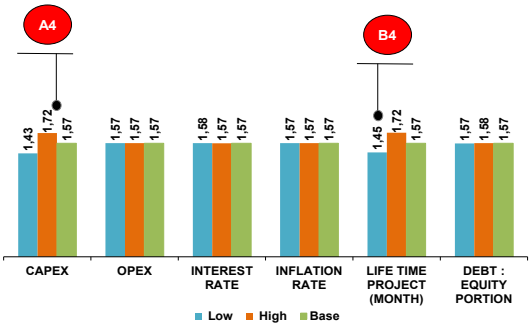

Figure .7. PI sensitivity analysis

From figure 7 above explanation that:
A3). If CAPEX low under budget -10%, this project show PI 1,17 meanwhile if CAPEX high over budget +10% PI will be decrease to 1,00.

B3). Additional LIFETIME PROJECT (MONTH) 6 (six) month from BASE assumption 24 month become 30 months will impact to PI from 1,08 to 1,14 meanwhile decrease LIFETIME PROJECT (MONTH) 6 (six) month become 18 months will be decrease PI to 1,02.

Other's parameter has less sensitive to PI calculation.

4.7.4 Payback Period (PBP) Sensitivity Analysis

Changes in variable CAPEX and LIFETIME PROJECT are the most sensitive parameter to PBP indicator as show in the PBP Sensitivity analysis chart below:

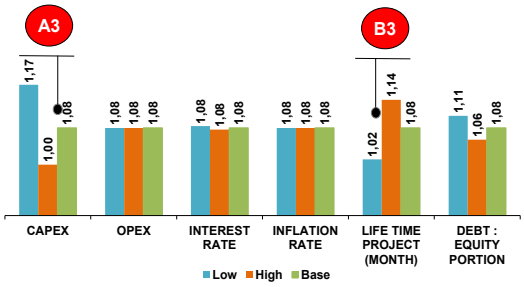

Figure .8. PBP sensitivity analysis

From figure 8 above explain that:
A4). if CAPEX lower under budget -10%, this project show PBP 1,43 years (equal to 1 year 6 month) but when the CAPEX high over budget +10% PBP will be decrease to 1,72 year (equal to 1 year 9 month).

B4). High assumption with additional LIFETIME PROJECT (MONTH) 6 (six) month from BASE assumption 24 month become 30 months will impact to PBP from 1,45 years (equal to 1 year 7 month) to 1,72 years (equal to 1 year 9 month) as impact of extended period which impact to second higher NPV USD 879.563,73 meanwhile decrease LIFETIME PROJECT (MONTH) 6 (six) month become 18-month impact to PBP 1,45 years (equal to 1 years 6 month), with negative impact to NPV USD 93.955,36.

Other's parameter has less sensitive to PBP calculation.

According to the sensitivity analysis Capital Expenditure (CAPEX), Lifetime Project and Debt: Equity Portion are the most sensitive variable key input.

4.8 Scenario Analysis

According to the result of sensitives analysis calculation above, author provide Scenario analysis as below:

Table .8. Scenario Analysis.

Criteria	Worst Case Scenario	Base Case Scenario	Best Case Scenario
Payback Period (PBP) - Years	1,62	1,57	1,68
Net Present Value (NPV)	199.076,29	500.444,15	1.239.436,89
Profitability Index (PI)	1,03	1,08	1,20
Internal Rate Return (IRR)	9,1%	11,50%	19,91%

4.9 Monte Carlo Simulation

After getting the results of investment decisions using the deterministic method as described in table 7 above, there are still weaknesses in predicting future conditions, because cash flows are built based on input from certain estimated values, when in fact there are uncertainties that may differ in future values. R. Flage et al (2013) and J. Li et al (2017) explained that to mitigate uncertainty, it can be done by making uncertainty values in certain probability distributions.

S. Grey at all (1995) explained that the simulation method is a method that can accommodate quantitative risk and uncertainty assessments in determining project investment. Monte Carlo simulation is one of the most applicable methods.

According to M. Marseguerra and E. Zio (2009: 180-186) Monte Carlo simulation method is based on iteration of repetition of random numbers and is usually used to obtain forecasts of certain probability models in solving a problem. Referring to the explanation above, the Monte Carlo simulation can be applied to predict the financial feasibility of a project by considering risks and uncertainties.

4.9.1 Monte Carlo Simulation Steps

The risk analysis simulation steps in the project's financial feasibility based on the Monte Carlo simulation technique are as follows:

1. Identification of input variables key changes with the greatest impact to the NPV. According to the sensitivity analysis Capital Expenditure (CAPEX), Lifetime Project and Debt: Equity Portion are the most sensitive variable key input.
2. Identify the NPV output calculation.
3. Define related assumptions to assign probability distribution to the input variables. Authors use probability distribution for the input variables:

Table .9. Probability distribution.

No.	Input Variables	Probability Distribution	Explanation
1	CAPEX	Uniform distribution	With the minimum and maximum value
2	Lifetime Project	Uniform distribution	With the minimum and maximum value
3	Debt: Equity Portion	Triangular distribution	With the minimum, most likely and maximum value

4.9.2 Monte Carlo Simulation Result

Monte Carlo simulation result with 1.000 iteration as follows:

Table .10. Statistic data from NPV Simulation Result.

Statistic	Value
Mean	474.346,30
Median	481.496,58
Standar Deviation	375.428,74
Skewness	(0,03)
Kurtosis	(0,56)
Minimum	(449.661,21)
Maximum	1.434.177,00
Probability NPV <0	10,32%

According to the table 10 above, Probability NPV<0 in this project is 10,32% meanwhile NPV>0 is 89,68%, NPV Monte Carlo Normal Distribution shown as below:

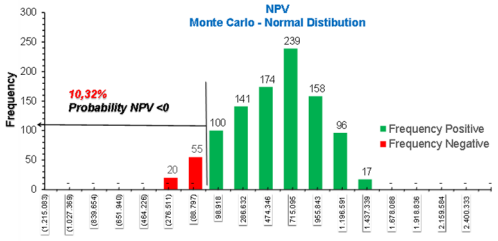

Figure .9. NPV Monte Carlo Normal distribution Simulation.

5 CONCLUSIONS

5.1 Capital Budgeting

Based on Investment Analysis calculation use Capital budgeting technique in table 5 above, it shown that Investment in Compressor for PLTG 4 x 25 MW Maleo, Gorontalo has positive value of NPV USD 500.444 with IRR 11,50% greater than WACC 9% and Payback Period 1,57 years. These parameters described that investing in Gas Compressor for PLTG 4 x 25 MW recommended to executed assume project will generate profit for PT XYZ.

5.2 Sensitivity Analysis

Sensitivity analysis shown that Capital Expenditure (CAPEX), Lifetime Project and Debt: Equity Portion are the most sensitive variable key input changes with the greatest impact to the NPV.

5.3 Monte Carlo Simulation

In this paper, for performing Monte Carlo simulation author use Capital Expenditure (CAPEX), Lifetime Project and Debt: Equity Portion as the input variables. The result shown that Probability **NPV<0 is 10,32%** and project success is **NPV>0 is 89,68%** as explain in figure 9.

This paper is still limited in getting the right variable input data. Expert opinion and historical data review methods should be applied, not just based on theoretical calculations

REFERENCES

Park, Chan S., 2007. Contemporary Engineering Economics. Pearson Education, Inc, New Jersey: 14th Edition.p.216.

Gitman, Lawrence J. Zutter, Chad J., 2018. Principles of Managerial Finance. Pearson Education. Global edition: 14th edition: p.454

Ross, S.A., Westerfilemd, R.W. and Jaffe, J.F .2010 Corporate Finance. McGraw – Hill. New York 10th edition.

Helfert, Erich A., 2001. Financial Analysis Tools and Technique. McGraw-Hill. USA p.444.

Stein Fairhurst, Danielle., 2017, Financial Modelling in Excel. Jhon Wiley & Son, Inch. New Jersey: p.160.

R. Flage, P. Baraldi, Z. Enrico and T. Aven 2013. Probability and Possibility Based Representation of Uncertainty in Fault Tree Analysis. Risk Analysis 33 (1), P:121-133

J. Liu, F. Jin, Q. Xie and M. Skitmore, .2017 Improving Risk Assessment in Financial Feasibility of International Engineering Project: A Risk Driver Perspective, International Journal of Project Management. p:204-211

S. Grey. 1995. Practical Risk Assessment for project Management. Jhon Wiley & Sons Ltd.

M. Marseguerra and E. Zio. 2009, Monte Carlo Simulation for Model Based Fault Diagnosis in Dynamic System, Reliab. Eng. Syst. Sf 94 (2). p:180-186

Peraturan BPH MIGAS Nomor 8 tahun 2013, pasal 14 Appendix