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Investment Valuation of Crushing Station Upgrade to Support Coal Production in Pit Z using Discounted Cash Flow Method

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ABSTRACT:
Pit Z at the Binungan site contains substantial coal reserves, estimated at around 10.77 million metric tons based on Life of Mine (LOM) data. The current issue involves the breakdown of the crusher unit at the crushing station during the processing of Pit Z coal. Further investigation revealed that the damage was caused by the Hardgrove Grindability Index (HGI) of Pit Z coal (29-36), which is lower than the crusher unit's specification (HGI ≥ 40). The HGI measures coal's resistance to crushing; the lower the HGI value, the harder the coal is to crush. This study aims to evaluate the financial feasibility of constructing a New Crushing Station, utilizing the Discounted Cash Flow (DCF) method with incremental cost analysis. The construction of a new crushing station yields the following financial parameters: NPV of Rp. 60.236 billion, Profitability Index (PI) of 2.69, IRR of 61.65%, Payback Period of 1.63 years, and Discounted Payback Period of 1.81 years. Sensitivity analysis indicates that coal production is the most sensitive parameter affecting NPV, with a ±20% change in this parameter resulting in a ±33.69% fluctuation in NPV. Additionally, Scenario Analysis and Monte Carlo Simulations reveal that the worst-case scenario produces an NPV of Rp. 54.581 billion, the best-case scenario an NPV of Rp. 64.498 billion, with a 0% probability of NPV < 0, and a 47.28% probability of NPV exceeding the Base Case. This study suggests that constructing a new crushing station is financially viable with manageable risk.
Keywords: Pit Z, Discounted Cash Flow, Hardgrove Grindability Index, Crushing Station, Incremental Cost, NPV.

INTRODUCTION

Indonesia is one of the world's largest coal exporters. In 2019, Indonesia's coal export reached 454 MT with a value of US$21.5 billion. Coal exports increased for 4th consecutive year in 2019; China and India are Indonesia's two major coal export destination countries. Indonesia coal reserves accounted for 2.2% of total world reserves (BP, 2018). Indonesia's coal resources and reserves are dominated by low and medium-quality coal (Wehnert et al., 2019). In

September 2018, Kementerian announced an increase in resources and reserves to 166 and 37 billion tons (Oktaviani, 2018).

The proportion of coal revenue has been increasing along with the coal export (Clark & Zhang, 2022). For the last four years, coal revenue collected has averaged around IDR 41.4 trillion or close to 80% of total non-oil & gas revenue. However, coal revenue contribution to the state budget is relatively low, around 1.5 to 2 % of total revenue (Energy, n.d.-a). The government's reasoning for the exploitation of coal is to increase trade revenue and help counterbalance the deficit coming from the oil and gas trade (Energy, n.d.-b).

In 2023, PT. BC conducted coal mining operational activities in Pit Z, Site Binungan. Pit Z consists of Pit Z West and Pit Z East; in Pit Z, there are several coal seams, including ZU, ZL, Z and Z_1.

Table 1. LOM (Life of mine) Data of Pit Z, Site Binungan

Years		2023	2024	2025	2026	2027	2028	2029	Total
OB	kBcm	1.800	6.935	12.901	16.997	16.815	11.431	2.309	68.492
Coal	kton	210	400	1.320	2.470	2.700	2.820	850	10.770

Coal Seam	In - Situ Coal Quality										
	TM	IM	ASH	FC	TS	CV kkal/kg			HGI		NA2O
	arb%	adb%	adb%	adb%	adb%	adb	arb	daf	Min	Average	(%)
ZU	38.14	14.94	3.45	39.56	0.12	5188	3774	6361	36	39	0.21
Z	38.02	22.77	3.82	33.95	0.13	4711	3775	6491	34	35	0.18
ZL	38.14	15.09	3.32	39.48	0.13	5327	3880	6534	29	37	0.23
Z_1	33.98	14.12	3.22	34.37	0.18	5673	4362	6864	31	38	0.17

Based on Pit Z LOM data, it is known that the amount of coal to be mined in the range of 2023 - 2029 is around 10.77 Million Tons, and the total amount of overburden (OB) to be removed is 68.49 Million Bcm. In addition, based on this data, one of the coal characteristic parameters can be known, that is, HGI (Hardgrove Grindability Index); HGI is a measure of coal resistance to crushing activity; the smaller the HGI value, the harder the coal properties/characteristics to be crushed.

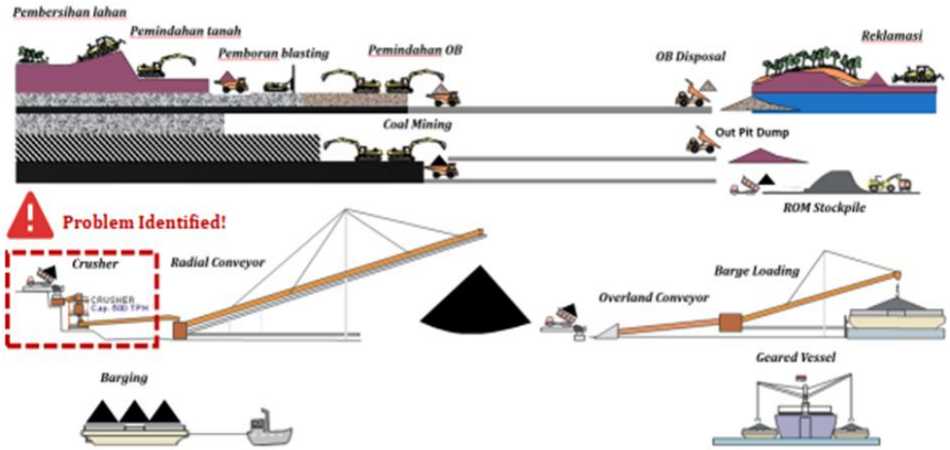


Figure 1. Coal Mining Business Process

The following is attached to the coal mining business process from upstream (coal mining activities in the pit) to downstream (coal barging activities by barge to the mother vessel) (Zonailo, 2023). In the business process, there is a coal crushing activity in the CPP (coal processing plant), the crushing activity aims to produce coal products with dimensions in accordance with market needs (Osborne et al., 2023).

Coal Processing Plant (CPP) in Binungan Site has 3 crushers, Location of each crusher can be seen in the figure below.

Figure 2. Coal Processing Plant (CPP) Binungan Layout

The problem occurred during the Pit Z coal crushing activity in CR 12, where during the crushing activity, it was found that the CR 12 primary crusher (single roller) was damaged with 12 missing crusher eyes (Singh & Choudhary, 2022). After further inspection and analysis, it can

be concluded that the cause of damage to the CR 12 primary crusher is the HGI value of Pit Z coal which is lower than 40, where the lowest value is 29 (seam ZL). The specification of the existing crusher unit at the Coal Processing Plant (CPP) Binungan Mine Operation is for coal with HGI values ≥ 40, so of course, with these specifications, it cannot accommodate Pit Z coal with HGI < 40.

Figure 3. Primary Crusher CR 12 (Breakdown)

The temporary alternative to solving this problem is the Pit Z coal crushing activity, which is carried out manually (using an excavator bucket) (Liu et al., 2024). However, this method is considered less effective and efficient because it can produce coal with a max size of 5 cm; a secondary crushing process is still needed (Taha, Benzaazoua, Hakkou, & Mansori, 2017). Coal-crushing activities using excavator buckets also have limitations in terms of productivity, where using this method, coal-crushing productivity is 180 TPH (12% of crusher capacity).

To respond to the existing issues related to the disrupted coal crushing process and temporary solutions that are considered less effective and efficient, improvements / best alternative solutions are needed to support Pit Z's coal crushing activity.

RESEARCH METHODS

The research methodology in this study will be carried out in several stages. The first is a preliminary analysis, which identifies the root causes of business issues and provides alternative solutions (Wright, Cairns, O'Brien, & Goodwin, 2019). The second is further analysis of the financial feasibility of the alternative solutions to determine whether the implementation of the alternatives is financially feasible.

Figure 4. The research framework of the research

Data Collection Method

In this research, the author will use both a qualitative and quantitative approach. The data used in this research is mainly from PT. BC Data collection is divided into two categories: primary and secondary data that support the research (Areco et al., 2021).

Data Analysis Method

In this research, the author's data from the previous process will be analyzed with predictive and prescriptive analytics to predict what will happen in the future and what must be done to achieve ideal conditions (Lepenioti, Bousdekis, Apostolou, & Mentzas, 2020).

Capital Budgeting Analysis

Capital budgeting is the process of evaluating and selecting long-term investments consistent with the firm's goal of maximizing owners' wealth (Rahmadyanti & Damayanti, 2022). The process consists of five distinct but interrelated steps: proposal generation, Review and analysis, Decision making, Implementation and Follow-up (Gitman, Juchau, & Flanagan, 2015).

Weighted Average Cost of Capital

The weighted average cost of capital (WACC), ra, reflects the expected average future cost of capital over the long run (Dobrowolski, Drozdowski, Panait, & Apostu, 2022). It is found by weighting the cost of each specific type of capital by its proportion in the firm's capital structure.

$$r_a = (w_i \times r_i) + (w_p \times r_p) + (w_s \times r_{r \text{ or } n})$$

w_i = proportion of long-term debt in capital structure
w_p = proportion of preferred stock in capital structure
w_s = proportion of common stock equity in capital structure
$w_i + w_p + w_s = 1.0$

Payback Period

The payback period is when the firm recovers its initial investment in a project, as calculated from cash inflows (Gitman et al., 2015).

Net Present Value

The NPV method discounts the firm's cash flows at the firm's cost of capital. The net present value (NPV) is found by subtracting a project's initial investment (CF0) from the present value of its cash inflows (CFt) discounted at a rate equal to the firm's cost of capital (r):

$$\text{NPV} = \text{Present value of cash inflows} - \text{Initial investment}$$

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

Profitability Index

A variation of the NPV rule is called the profitability index (PI). For a project with an initial cash outflow followed by cash inflows, the profitability index (PI) equals the present value of cash inflows divided by the initial cash outflow (Gitman et al., 2015).

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

Internal Rate of Return

The internal rate of return (IRR) is the discount rate that equates the NPV of an investment opportunity with $0 (because the present value of cash inflows equals the initial investment). It is the rate of return that the firm will earn if it invests in the project and receives the given cash inflows (Gitman et al., 2015).

$$\$0 = \sum_{t=1}^{n} \frac{CF_t}{(1 + IRR)^t} - CF_0$$

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

RESULTS AND DISCUSSION

Capital Expenditure

The initial investment for Crushing Station 11 Upgrade is at around IDR 35.7 Billion, based on the final quotation from the infrastructure contractor that PT has approved. BC. The detail of the capital expenditure of this project is shown in the table below:

Table 2. Capital Expenditure for Crushing Station 11 Upgrade

NO	DESCRIPTION		PROJECT COST
1	Preparation	IDR	2.385.100.000,00
2	Earth Work	IDR	1.098.120.675,12
3	Civil Work	IDR	3.500.545.800,00
4	Mechanical	IDR	14.774.898.035,65
5	Structure	IDR	8.865.945.592,00
6	Electrical Work	IDR	4.874.998.281,98
7	Dust Suppression	IDR	205.304.400,00
	Grand Total	IDR	35.704.912.784,74
	Rounded	IDR	35.704.913.000,00

Operating Expenditure (OPEX)

In this research, operating expenditure is the cost for Pit Z coal crushing activity both in the ROM (run of mine) and CPP (coal processing plant). The detail of the operating expenditure of this project is shown in the table below:

Table 3. Operating Expenditure (Bucket Crusher & Crushing Station)

No	Operations Expenditure Details	Cost / Ton
A	**Coal Crushing with Bucket Crusher**	
1	Equipment Rent Cost	IDR 9.750
2	Maintenance Cost (Primary Crushing with Bucket Crusher)	
3	Fuel Cost	
4	Maintenance Cost (Secondary Crushing with Crushing Station)	
5	Electricity Cost	
B	**Coal Crushing with Crushing Station**	
1	Maintenance Cost (Primary & Secondary Crushing)	IDR 1.292
2	Electricity Cost	

Note: Operation Expenditure Cost adjusted to Pit Z Coal Mining Activity

Depreciation

Based on government regulation, Law Number 3 of 2020 and Government Regulation No. 77/2014 on the Implementation of Mineral and Coal Mining Business Activities, the asset owned by PKB2B's license holder will become state-owned property at the end of the mining operations. The depreciation calculation of this research is based on the assumption of the economic lifetime of infrastructure, so Pit Z Life of Mine does not adjust the calculation (Wellmer & Scholz, 2018). The Depreciation will use the straight-line method for a useful lifetime of 10 years. The depreciation is determined to be 0.83% monthly or 10% annually.

Efficiency Cost Projection

Efficiency cost projection in this research is the operation & maintenance cost difference for coal crushing activity between the Bucket Crusher and the New Crushing Station (Crushing Station 11 Upgrade). The cost projection is shown as follows:

Table 4. Efficiency Cost Projection

A. Production Profile		**2025**	**2026**	**2027**	**2028**	**2029**
Coal Production	MT	**1.442.000**	**2.592.000**	**2.822.000**	**2.942.000**	**972.000**
B. Bucket Crusher						
B.1 Primary Crushing (Operation & Maintenance Cost)						
- Excavator PC 400	$/hour	**$54,20**	**$54,20**	**$54,20**	**$54,20**	**$54,20**
- Bucket Crusher Teeth	$/hour	**$9,29**	**$9,29**	**$9,29**	**$9,29**	**$9,29**
- Fuel	$/hour	**$40,00**	**$40,00**	**$40,00**	**$40,00**	**$40,00**
Total Cost (Primary Cruhing)	$/ton	**$0,57**	**$0,57**	**$0,57**	**$0,57**	**$0,57**
B.2 Secondary Crushing (Operation & Maintenance Cost)						
- Chain Conveyor	$/ton	**$0,02**	**$0,02**	**$0,02**	**$0,02**	**$0,02**
- Belt Conveyor (TC & SC)	$/ton	**$0,00**	**$0,00**	**$0,00**	**$0,00**	**$0,00**
- Secondary Crusher	$/ton	**$0,01**	**$0,01**	**$0,01**	**$0,01**	**$0,01**
- Electicity	$/ton	**$0,05**	**$0,05**	**$0,05**	**$0,05**	**$0,05**

Total Cost (Secondary Cruhing)	$/ton	**$0,08**	**$0,08**	**$0,08**	**$0,08**	**$0,08**
Total Cost (Bucket Crusher)	$/ton	**$0,65**	**$0,65**	**$0,65**	**$0,65**	**$0,65**
	$/year	**$937.295,30**	**$1.684.791,56**	**$1.834.290,81**	**$1.912.290,42**	**$631.796,84**
C. New Crushing Station						
C.1 Primary & Secondary Crushing (Operations & Maintenance Cost)						
- Chain Conveyor	$/ton	**$0,02**	**$0,02**	**$0,02**	**$0,02**	**$0,02**
- Belt Conveyor (TC & SC)	$/ton	**$0,01**	**$0,01**	**$0,01**	**$0,01**	**$0,01**
- Primary Crusher	$/ton	**$0,01**	**$0,01**	**$0,01**	**$0,01**	**$0,01**
- Secondary Crusher	$/ton	**$0,01**	**$0,01**	**$0,01**	**$0,01**	**$0,01**
- Electicity	$/ton	**$0,05**	**$0,05**	**$0,05**	**$0,05**	**$0,05**
Total Cost (New Crushing Station)	$/ton	**$0,09**	**$0,09**	**$0,09**	**$0,09**	**$0,09**
	$/year	**$124.213,88**	**$223.274,88**	**$243.087,08**	**$253.423,88**	**$83.728,08**
Incremental (Cost Difference)	$/year	**$813.081,42**	**$1.461.516,68**	**$1.591.203,73**	**$1.658.866,54**	**$548.068,76**

Cash Flow Analysis

The calculation of cash flow analysis in this research does not start from the revenue stream but directly on the profit and loss stream (Cook, 2021). This is because the revenue value is obtained from the amount of coal sold. So, there is no difference in revenue value between the use of a bucket crusher and a new crushing station in coal crushing activity; the difference only occurs in the operation and maintenance cost (Purhamadani, Bagherpour, & Tudeshki, 2021).

Table 5. Project Cash Flow

STREAM	YEARS	2024	2025	2026
PROFIT & LOSS	**INCREMENTAL (EBITDA)**	Rp -	Rp 12.196.221.375	Rp 21.922.750.210
	(-) Depreciation	Rp -	-Rp 2.082.786.592	-Rp 3.570.491.300

	Taxable Income	Rp -	Rp 10.113.434.783	Rp 18.352.258.910
	Tax Expense	Rp -	Rp 4.551.045.652	Rp 8.258.516.509
	Net Income	Rp -	Rp 14.664.480.435	Rp 26.610.775.419
CASH FLOW	**(+) Depreciation**	Rp -	Rp 2.082.786.592	Rp 3.570.491.300
	CF Operation	Rp -	Rp 16.747.267.027	Rp 30.181.266.719
	CF Investment (CAPEX)	-Rp 35.704.913.000	-Rp 35.704.913.000	Rp -
	Net Cash Flow (EAT)	-Rp 35.704.913.000	-Rp 18.957.645.973	Rp 30.181.266.719
	Cumulative Cash Flow	-Rp 35.704.913.000	-Rp 18.957.645.973	Rp 11.223.620.746
DEPRECIATION SCHEDULE	**Beginning remaining asset value**	Rp -	Rp 35.704.913.000	Rp 33.622.126.408
	CAPEX	Rp 35.704.913.000	Rp 35.704.913.000	Rp -
	Depreciation	Rp -	-Rp 2.082.786.592	-Rp 3.570.491.300
	End remaining asset value	Rp 35.704.913.000	Rp 33.622.126.408	Rp 30.051.635.108
	% Depreciation	0,00%	5,83%	10,00%

STREAM	**YEARS**	**2027**	**2028**	**2029**
PROFIT & LOSS	**INCREMENTAL (EBITDA)**	Rp 23.868.055.977	Rp 24.882.998.116	Rp 8.221.031.329
	(-) Depreciation	-Rp 3.570.491.300	-Rp 3.570.491.300	-Rp 3.570.491.300
	Taxable Income	Rp 20.297.564.677	Rp 21.312.506.816	Rp 4.650.540.029
	Tax Expense	Rp 9.133.904.105	Rp 9.590.628.067	Rp 2.092.743.013
	Net Income	Rp 29.431.468.782	Rp 30.903.134.884	Rp 6.743.283.042
CASH FLOW	**(+) Depreciation**	Rp 3.570.491.300	Rp 3.570.491.300	Rp 3.570.491.300
	CF Operation	Rp 33.001.960.082	Rp 34.473.626.184	Rp 10.313.774.342
	CF Investment (CAPEX)	Rp -	Rp -	Rp -
	Net Cash Flow (EAT)	Rp 33.001.960.082	Rp 34.473.626.184	Rp 10.313.774.342

	Cumulative Cash Flow	Rp 44.225.580.828	Rp 78.699.207.012	Rp 89.012.981.353
DEPRECIATION SCHEDULE	**Beginning remaining asset value**	Rp 30.051.635.108	Rp 26.481.143.808	Rp 22.910.652.508
	CAPEX	Rp -	Rp -	Rp -
	Depreciation	-Rp 3.570.491.300	-Rp 3.570.491.300	-Rp 3.570.491.300
	End remaining asset value	Rp 26.481.143.808	Rp 22.910.652.508	Rp 19.340.161.208
	% Depreciation	10,00%	10,00%	10,00%

Weighted Average Cost of Capital

PT. BC funds its operational activities from its own equity and does not use debt, so the calculation of WACC will be the same as the result of the Cost of Equity. The Component used for calculating the cost of equity are as follows:

Table 6. Cost of Equity

Parameters	Reference	Time Range	Value
Risk free rate (Rf)	IGYSC - 10 Years Government Bond Yield	Last 10 Years	6,90%
Risk Premium (Rm - Rf)	Damodaran (Indonesia - Equity Risk Premium)	As of June 2024,	7,38%
Beta	Yahoo Finance (Average Similar Company)	As of June 2024,	0,362

Calculation of Cost of Equity: $Ke = Rf + \beta\ (Rm - Rf)$ = 6.90% + 0.362 (7.38%) = 9.57%

The result for the cost of equity that is used to discount the cash flow from the project (WACC) is 9.57%

Capital Budgeting Analysis (Discounted Cash Flow Method)

In this research, some criteria will be used to evaluate the project's feasibility. The 5 criteria are Payback Period, Discounted Payback Period, Net Present Value (NPV), Profitability Index and Interest Rate of Return (IRR). By discounting the cash flow using WACC as a discount rate, the result of the project feasibility is shown in the table below:

Table 7. Cost of Equity

Stream	2024	2025	2026
FREE CASH FLOW TO THE FIRM			
Cash Outflow	-Rp 35.704.913.000	Rp -	Rp -
Cash Inflow	Rp -	Rp 16.747.267.027	Rp 30.181.266.719
Total Cash flow	-Rp 35.704.913.000	Rp 16.747.267.027	Rp 30.181.266.719
Accumulated Cash Flow	-Rp 35.704.913.000	-Rp 18.957.645.973	Rp 11.223.620.746

Cash Flow (in Billion)	-Rp 35,705	-Rp 18,958	Rp 11,224
WACC	9,57%		
PV of Cash Flow	-Rp 35.704.913.000	Rp 15.285.016.730	Rp 25.140.934.131
Accumulated PV of Cash Flow	-Rp 35.704.913.000	-Rp 20.419.896.270	Rp 4.721.037.862

Stream	2027	2028	2029
FREE CASH FLOW TO THE FIRM			
Cash Outflow	Rp -	Rp -	Rp -
Cash Inflow	Rp 33.001.960.082	Rp 34.473.626.184	Rp 10.313.774.342
Total Cash flow	Rp 33.001.960.082	Rp 34.473.626.184	Rp 10.313.774.342
Accumulated Cash Flow	Rp 44.225.580.828	Rp 78.699.207.012	Rp 89.012.981.353
Cash Flow (in Billion)	Rp 44,226	Rp 78,699	Rp 89,013
WACC			
PV of Cash Flow	Rp 25.090.288.494	Rp 23.920.753.833	Rp 6.531.718.993
Accumulated PV of Cash Flow	Rp 29.811.326.356	Rp 53.732.080.188	Rp 60.263.799.181

Payback Period	1,63	Years
Discounted Payback Period	1,81	Years
Net Present Value	Rp 60.263.799.181,15	
Profitability Index	2,69	
IRR	61,65%	

Based on the capital budgeting analysis, it was found that the NPV value is IDR 60.263.799.181, IRR of 61.65% which is greater than the WACC 9.57%, Payback Period 1.63 years, Discounted Payback Period 1.81 years which is shorter than Pit Z mining operations plan and lifetime use of asset and Profitability Index 2.69 which is greater than 1.

Sensitivity Analysis

In this research, sensitivity analysis is conducted to identify how significant certain variables influence the financial feasibility parameters of the project, some of the variables that used in this research are Coal Production, Equipment Rent Price, Capex, Fuel Price, WACC, Maintenance Cost and Power Price. Sensitivity analysis is carried out by increasing and decreasing the base value of each variable by ± 20%, which is then continued by looking at these changes to

the volatility of the NPV project value. The following table and chart summarize the result of the sensitivity analysis:

Table 9. Sensitivity Analysis

Sensitivity Analysis	-20% Swing	Current Assumption	+20% Swing
Power Price	Rp 1.016	Rp 1.270	Rp 1.524
Maintenance Cost	80,00%	100,00%	120,00%
WACC	7,65%	9,57%	11,48%
Fuel Price	Rp 12.000	Rp 15.000	Rp 18.000
Capex	Rp 28.563.930.400	Rp 35.704.913.000	Rp 42.845.895.600
Equipment Rent Price	Rp 650.400	Rp 813.000	Rp 975.600
Coal Production	8.616.000	10.770.000	12.924.000

Sensitivity Analysis	-20% Swing NPV	Current NPV	+20% Swing NPV
Power Price	Rp 60.263.799.181	Rp 60.263.799.181	Rp 60.263.799.181
Maintenance Cost	Rp 61.722.962.038	Rp 60.263.799.181	Rp 58.804.636.324
WACC	Rp 65.146.637.309	Rp 60.263.799.181	Rp 55.734.073.817
Fuel Price	Rp 68.265.554.380	Rp 60.263.799.181	Rp 52.262.043.983
Capex	Rp 68.514.335.694	Rp 60.263.799.181	Rp 52.013.262.668
Equipment Rent Price	Rp 71.106.177.475	Rp 60.263.799.181	Rp 49.421.420.887
Coal Production	Rp 39.960.502.832	Rp 60.263.799.181	Rp 80.567.095.530

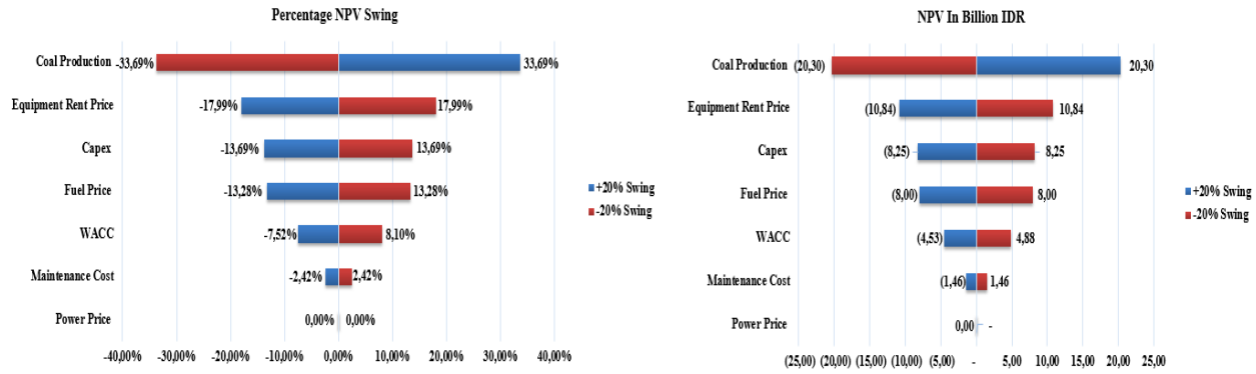


Figure 5. Primary Crusher CR 12 (Breakdown)

Based on sensitivity analysis, it is found that coal production is the most sensitive parameter that affects the increase and decrease of NPV, followed by Equipment Rent Price and CAPEX, while parameters that are not very sensitive to changes in NPV are Maintenance Cost and Power Price.

Scenario Analysis

Scenario analysis is carried out by looking at the effect of several variables simultaneously according to historical data on the volatility of the NPV value. The following table summarize the result of the scenario analysis:

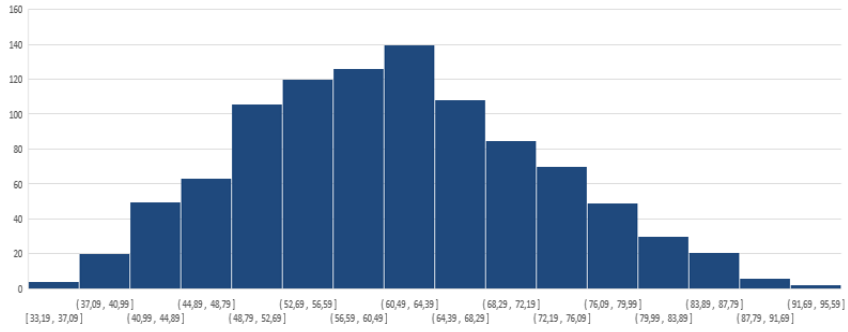
Table 10. Scenario Analysis

Details	Worst Case	Base Case	Best Case
Capex	Rp. 39.818.429.081	Rp. 35.704.913.000	Rp. 31.750.119.593
Coal Production	Rp. 9.296.724	Rp. 10.770.000	Rp. 12.560.069
Fuel Price	Rp. 18.087	Rp. 15.000	Rp. 11.651
Equipment Rental Price	Rp. 914.624	Rp. 813.000	Rp. 725.683
Payback Period	1,79	1,63	1,49
Discounted Payback Period	2,00	1,81	1,65
NPV	Rp. 54.581.136.905	Rp. 60.263.799.181	Rp. 64.498.972.347
Profitability Index	2,37	2,69	3,03
IRR	53,17%	61,65%	70,47%

Based on the scenario analysis conducted, it was found that in the best-case condition, the implementation of the project generated an NPV of Rp. 64,498,972,347, an increase of about 7.02% from the base case value, while in the worst ca-case condition, the implementation of the project generated an4,581,136,905, a decrease of about 10.4% from the base case value. In addition to the NPV parameter, increases and decreases also occur in other parameters in the best and worst-case scenarios. These results indicate that the project implementation will provide benefits for the company (financially feasible) because, during the worst possible outcome, the project can still generate profits.

Monte Carlo Simulations

In this research, besides sensitivity and scenario analysis, risk analysis was also conducted using Monte Carlo Simulation. The Monte Carlo simulation method is used to see all possible investment decision outcomes and assess the consequences of ongoing risks to make the right decisions under uncertainty. Monte Carlo simulation computes the model thousands of times, each time using a different randomly selected number. The results are used to describe the probability of achieving variation in results in a model. The simulation outputs are presented in the table below:



Decriptive Statistics	
Min	Rp 32.449.273.989
Max	Rp 92.142.001.941
Mean	Rp 61.007.783.556
Standard Deviation	Rp 10.884.067.718
Median	Rp 61.144.608.817
Kurtosis	- 0,58
Skewness	0,11
Prob NPV<0	0,00%
Prob NPV>0	100,00%
Prob NPV>Average	50,00%
Prob NPV>base	47,28%

Figure 6. Monte Carlo Simulations

Based on the results of the analysis using Monte Carlo Simulations, the NPV value obtained on average is IDR 61,007,783,556. The NPV value in Capital Budgeting Analysis (DCF Method) shows a slightly smaller value than this value, with a difference of around 1.23%. This very small difference shows that the parameter values used in this research are conservative because there is no significant difference in NPV value.

In addition, the possibility that this project is not feasible can be seen in the Prob NPV < 0 statement, where, based on the analysis results, the value is 0%. This strengthens the argument explained before in the scenario analysis that the project still generates profit even though the worst possible outcome happens.

Business Solutions

The option to invest in a New Crushing Station (CR 11 Upgrade) to support Pit Z coal production (coal crushing activity) is recommended to the company compared to existing methods & alternatives (Pit Z coal crushing with Excavator Bucket & Bucket Crusher), this is because the implementation of the project generates positive NPV, which is IDR 60,263,799,181, IRR of 61.65% which is greater than the WACC 9.57%, Payback Period 1.63 years, Discounted Payback Period 1.81 years which is shorter than Pit Z mining operations plan and lifetime use of asset and Profitability Index 2.69 which is greater than 1.

In addition, based on the Scenario analysis and Monte Carlo simulation, it was found that the project implementation does not have a chance of negative NPV; the project still generates profit even though the worst possible outcome occurs.

CONCLUSION

Based on the Capital Budgeting Analysis, the project implementation yielded several financial parameters that indicate financial feasibility, including a positive NPV of IDR 60.236 billion, a Profitability Index (PI) of 2.69, an IRR of 61.65%—higher than the cost of capital at 9.57%—and a payback period of 1.63 years with a discounted payback period of 1.81 years, both shorter than the planned operations and asset lifetime of Pit Z. The sensitivity analysis revealed that coal production is the most sensitive parameter affecting NPV, with a ±20% change in coal production leading to a ±33.69% change in NPV. Scenario analysis shows that the project remains financially feasible, with an NPV of IDR 54.581 billion in the worst-case scenario and IDR 64.498 billion in the best-case scenario. Additionally, Monte Carlo simulations estimate an average NPV of IDR 61.007 billion, a difference of approximately 1.23% from the base case NPV, with a 0% probability of NPV < 0 and a 47.28% probability of NPV > base case.

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