Valuation Of Mining Low Coal Calories Using Real Option Analysis

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Abstract

The purpose of this research is to calculate the valuation of coal mining projects, especially low-calorie coal using the Real Option and Discounted Cash Flow methods for comparison. Research has been carried out in PT. Pesona Khatulistiwa Nusantara (PT.PKN), which one has low-calorie coal reserves in four mining areas, and currently has production in two mining areas. At the opening of the two previous sites, the feasibility calculation was carried out using the Discounted Cash Flow method, which this method did not describe the movement of coal prices that occurred in the future so that management was not flexible in setting strategies to dealing with fluctuating coal prices. Where in that period there was a continuous decline in coal prices from 2011 to 2016. Currently PT. PKN plans to open a new mining area, namely at the Ardimulyo Mine Operation (AMO) site, to get a more detailed analysis the valuation of this AMO project will be calculated using Real Option to accompany the calculation with discounted cash flow. The calculation using the real option method (without abandon) shows the NPV value below the discounted cash flow method, while the exit option/abandonment value increases as the selling price of coal decreases. So it is recommended to run an exit option/abandonment when the selling price of coal is not economical.

Keywords
Real Option, Mining Valuation, Exit Option, Feasibility.

1. Introduction

Indonesia has been a leading exporter of thermal coal since 2005. The portion of thermal coal exported consists of medium quality types (between 5100 and 6100 cal/gram) and low quality types (below 5100 cal/gram), most are export to China and India . Indonesia has 2.2% of the total global coal reserves, according to the BP Statistical Review of World Energy, around 60% of the total coal reserves in Indonesia consist of low quality coal (sub-bituminous).

PT. Pesona Khatulistiwa Nusantara (PT.PKN) is a coal mining company, specifications in low-calorie coal mining. PT. PKN has low calorie coal reserves (3,000 – 5,000 cal/gram, the majority of reserves are around 3000 cal/gram). PT.PKN has four mining site, started mining operations since 2009 at the KMO site, and started mining operations at the SMO site in early 2012, when the SMO site started operating the decline in coal commodity prices happen continuously until the end of 2016. And the operational still running during that periode and generate loss. There was an increase in coal prices after 2016 – 2019 but cannot cover losses incurred from previous years.

Investment feasibility studies or company financial projections use the Discounted Cash flow (DCF) method, where the reference coal price and projected costs will always escalate every year and a constant discount rate every year,

while the actual condition is not, the coal price increase is not constant as it increases the time period. From the description above, the problems in writing this thesis are:
1. Investment valuation using DCF will be over estimate.
2. The use of the DCF method makes the company inflexible with changes in world coal prices.

Due to the uncertainty faced by PT. PKN, especially as a producer of low calorie coal category with high sensitivity to falling commodity prices, it is deemed necessary to have an investment analysis using the Real Option method as a reference in making investment decisions, and this method will be used to calculate the economics of the AMO site, which is planned to be operational in 2022.

1.1 Objectives
The purpose of this research is:
1. To get the economic value of an investment project using the real option method on a low calorie mining project at the third site of PT PKN.
2. provide recommendations to companies for strategies to get maximum profit in the face of uncertainty that occurs in mining projects, especially low-calorie coal.

2. Literature Review
Investment appraisal is a process to comparing the expected financial benefits from a proposal or project with the estimated cost, the purpose of this investment appraisal is to see whether an investment is feasible or not. The three most commonly used methods for conducting investment appraisals are:

1. Payback or breakeven analysis(BEP).
2. Net Present Value (NPV).
3. Internal rate of return (IRR).
4.

As mentioned above, various investment valuation methods are used to determine whether a project is feasible to execute with a measurable level of risk or not to be carried out by considering various risks of losing investment value and also to choose among projects that are more profitable. The initial trend of the three methods is that Net Present Value (NPV) is the method that is considered the most reliable for evaluating investments that have potential gains. NPV is generally calculated using the discount cash flow method, but apart from that there is also a Real Option method that is used even though it is not widely used.

Real Option introduced in 1977 by Stewart Myers, based on observations and using option pricing theory in making investment decisions. Real Option is a method used as a method to solve various problems in investment (Mauer-Triantis, 1994). Trigeoris (1996) conducted research on Real Option by analyzing the credit risk of financial institutions. This research is in line with subsequent research conducted in 2002 by introducing Real Option as a new insight in assessing investment opportunities, minimizing investment uncertainty which is different from conventional thinking (Trigeorgis, 2002). (Pusvitasari, ER: 2010) argues that in Real Option theory the risks that will be faced by an investment project are fixed and occur during the period of investment activity or the project is running and decision makers have flexibility because of the latest information so that current decisions interact with future decisions. According to Csapi (2019) Real Option is a more effective method to minimize uncertainty and minimize risk, thus this method is a very appropriate theory for managing uncertainty in investment.

2.1 Real Option Aspect
There are three aspects as the basis for the difference between the Real Options method and the traditional method with DCF (Michael J. Maubossin, 1999):

1. Flexibility : Flexibility can be defined as the ability to postpone, leave, carry out an expansion, or terminate a deal for a business. NPV estimation using the DCF method does not include the value of uncertainty in its calculation, so it is considered more fragile than the Real Options approach as far as adaptability.

2. Contingency : Is a situation where the future of an investment depends on the success of the current investment. Where decision makers can still decide to invest at this time. Even though it has a negative NPV value in order to get better opportunities in the future. By using the DCF method the results can experience deviations in the calculation of the value of this future option investment.

3. Volatility: The increase in volatility is directly proportional to the high value of the option to be given. Greater volatility will result in a larger value as well as a discount rate resulting in a smaller NPV value. This also means that industries that face higher volatility have more valuable option values.

2.2 Types of Real Options

According to Turvey (2001) there are eight types of real options:

1. Timing Options: Are options that occur when there is an opportunity to carry out business expansion. The existence of uncertainty that occurs in future cash flows causes managers or decision makers to delay the execution of the investment until the uncertainty is resolved first. In this condition, investors are given the right but are not obliged to carry out investments in the future. If the investment is executed immediately then the value of the options means that they are exercised below their true value, and managers face all the uncertainties of the project being carried out.

2. Flexibility Options: Flexibility can stem from the uncertainty of multiple markets, products, and even people. When faced with an undesirable situation, it is possible to allocate resources from one product to another, or from one market to another. So flexibility options can have a high value in this situation.

3. Growth options: Growth options are created by executing investments that provide a payoff in a market uncertainty that does not currently exist. Options arise from various policies, most of which result from the exercise of timing options.

4. Exit options/abandonments: Exit options/abandonment is a condition where the owner of the options has the right to cancel or temporarily close the project/business activity due to uncertainty in the future. This method is carried out with the aim of reducing losses that will occur if a loss occurs along the course of a project.

5. Learning options: Is an option caused by carrying out an investment whose value is not too large with the aim of testing for the value of the next investment that has a larger scale. The value of this option will be high if the new product is only the initial stage of innovation rather than a mature product. This is due to the lack of information about the new market. To deal with this condition, an option was formed through incremental stages of the development of the new product.

6. Rainbow options: Rainbow options are options that occur when an investment faces multiple sources of uncertainty and occurs simultaneously. This uncertainty can result in conflict with each other, so options are needed that can result in mutually exclusive results. The two policies are a combination of options to abandon (if the market doesn't accept the new product) and growth options (if the market turns out to be bigger and profitable).

7. Hybrid options: Hybrid options are options that have many types. The existence of Hybrid options is due to the fact that each project has its own characteristics in terms of the options used. If each project uses different options then the value of the project only has one type of option.

8. Compound options: Compound options are options that occur when the exercise of one option results in another option. for example in the many Research & Development.

2.3 Option Valuation Binomial Lattice Methode

This technique uses a tree diagram or known as a lattice to describe the uncertainty of a variable from the project. The price variable is one of the variables that is often studied in this Binomial Lattice because of its very significant influence on the mining economy. The level of volatility of commodity prices can be determined easily based on historical data. By using the formula below, commodity price movements will move up (up = u) and down (down=d) based on their volatility.

$$u = \exp\left(\sigma\sqrt{\Delta T}\right)$$

$$d = \frac{1}{u}$$

Description:

u	:	Upward move
d	:	Downward move
σ	:	Volatility
ΔT	:	Steping time

After getting the cash flow for each lattice, the NPV can be calculated using the Binomial Lattice Technique with the following formula:

$$PVCF_{t-1} = CF_{t-1} + \frac{\left| p * CF_{t,up} + (1-p)*CF_{t,down} \right|}{(1+r)^{\Delta T}}$$

Description:

PVCFt-1	: cash flow on year t-1
p	: risk neutral probability
CFt,up	: cash flow at year t for up condition
CFt,down	: cash flow at year t for down condition
r	: discount rate
ΔT	: time difference (1 year)

2.4 Real Option in Mining Industry

According to research by Peters (2016) and Yuliyanto (2016) Real Option is one method that can provide opportunities to take advantage of opportunities that arise during the course of the project, because this method considers all uncertain conditions that will occur during the project. Brennan and Schwartz (1985) state that fluctuations in commodity selling prices lead to high uncertainty in cash flows, so mining activities should also be valued in the same way as the stock market concept. This is in line with the opinion of Tua.et.al (2020) where the Real Option method allows management flexibility to be carried out by optimizing the value of project options by considering the NPV and premium options. The option premium is the additional return that shareholders are expected to receive for taking risk exceeding the no-risk level, Damodaran, A. (2002). With the DCF method, the NPV value is obtained from the discounted cash flow, while in the premium option the NPV is obtained by calculating the option value using a binomial tree. Research Tua.et.all (2020) compared the calculation of the feasibility of mining investments with the DCF and RO methods at the same mining striping ratio, where with DCF concluded the investment was not feasible but with the RO method it became feasible, because most of the downside risk (down value) could be avoided if exercising management flexibility, i.e. abandoning or canceling a mine design in the assessment process. The Real Option method is very suitable to be applied to mining investment (Konstandatos, 2008). This method is appropriate to be applied to the mining sector because of its flexibility, because in the mining sector there is a decision to close the site, open a new site, or develop other projects (Konstandatos & Kyng, 2012). Uncertainties in the mining sector include volatility in mineral prices, political conditions related to mining permits (Brennan and Schwartz, 1985, Costa Lima & Suslick, 2006; Tsekrekos et al. 2012; Tufano, 1998) and geological conditions and reserves. additives (SA Abdel Sabour, Dimitrakopoulos, & Kumral, 2008; Azimi, Osanloo, & Esfahanipour, 2013; Huang. et al, 2014; Wen. et al, 2014). Due to this uncertainty, mining projects can use simulations and dynamic system models that can be implemented in Real Option analysis (Savolainen, 2016).

2.5 Cost Structure in Mining & Coal Price

In the coal mining industry there are various mining methods that can be used depending on certain circumstances and conditions, the most commonly used is open pit mining. To support mining activities, the cost structure in mining activities can be described as follows:

1. Direct Production Costs:
   - Stripping & overburden removal costs
   - Coal digging & loading costs

- Coal hauling costs
- Coal haul road maintenance costs
- Processing costs & quality control
- Shipping cost

2. Indirect Costs:
   - Labor & general costs
   - Work safety costs
   - Environmental costs & restoration of ex-mining land
   - Corporate Social Responsibility Fee
3. Depreciation expense
4. Interest Expense
5. Coal royalty
6. Taxes

In practice the coal price agreement between the company and the buyer refers to contract (the buyer can be an end user or a trader), there are two types of contracts, namely:

1. Long-term contracts, this type of contract has a validity period with an agreed price, so it can reduce flexibility in dealing with uncertainties in the future. There are five types of long-term contracts that are adjusted to the sale and purchase price agreement:
   - Fixed price contracts
   - Contracts at market prices (market price contracts)
   - Contracts with prices that are regularly renegotiated at a certain time frame (evergreen contract)
   - Contracts based on mining production costs (cost plus contract)
   - Contracts linked to a specific index (base price escalation contract)
2. Spot Contract, which is a standard for buying or selling commodities, where the calculation of the contract price is carried out per day of agreement, generally referring to the ICI index (Indonesian Coal Index).

3. Methods

The research uses a quantitative approach. Empirical research where the data is in the form of something that can be calculated, research that uses a lot of data in the form of numbers (Sugiyono, 2003). In this study, we will use Real Option analysis, especially the Binomial Lattice, where the price variable is one of the variables that is often studied with this technique. The research framework can be seen in the image below (figure 1).

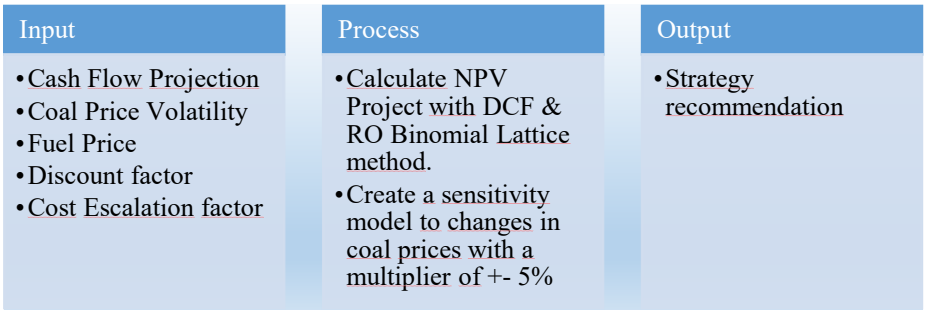

Figure 1. Research Framework

4. Data Collection

The data collection in this research consists of secondary data in the form of:

- PT.PKN internal reports, in the form of technical feasibility data and financial feasibility studies, operational costs, capital expenditures.
- Historical coal reference price according to HBA (Indonesian coal price reference).

5. Results and Discussion

To calculate the upward and downward move of coal prices, the first step must be to calculate the historical volatility of coal prices. In this study, volatility is calculated by referring to the Reference Coal Price (HBA) trend for the last

four years (January 2019 – December 2021), so that the HBA volatility value is 34.56%. According to this volatility the upward move value is 1.41, which means that each price increase is added 1.41 and the downward move is 0.71, which means that each price decrease is reduced by 0.71. After determining the upward move and downward move, the probability is upward probability of 41.44% and downward probability of 58.56%, this means that the probability of a decline in coal prices in the future is higher.

To calculate cash flow refers to the 2021 budget for the existing site, as follows (table 1, Table 2 and table 3):

Table 1. Production Cost

Cost Item	Cost / Ton (USD)
A. Direct Production Costs	**$ 39,00**
- Stripping & overburden removal costs	$ 29,68
- Coal digging & loading costs	$ 0,89
- Coal hauling costs	$ 0,60
- Coal haul road maintenance costs	$ 0,21
- Processing costs & quality control	$ 3,62
- Shipping cost	$ 4,00
B. Indirect Production Cost:	**$ 3,75**
- Labor & general costs	$ 3,50
- Work safety costs	$ 0,05
- Environmental & reclamation cost	$ 0,10
- Corporate Social Responsibility Fee	$ 0,10

Total coal reserves are 1,426,000 with a Stripping Ratio of 14 BCM/Ton

Table 2. Production Schedule

Production	2022	2023	2024
Coal	258.320	629.000	538.680
OB Removal	3.120.000	9.073.980	7.771.020

The amount of investment calculated in this feasibility study is the costs that have been incurred by the company during the exploration and licensing period as well as costs that will be incurred by PT PKN in the context of developing coal mines in the Ardimulyo Area.

Table 3. Investment

Item	Total
Exploration	$ 250.000,00
Legal & Permit	$ 100.000,00
Land Compensation	$ 6.896.600,00
Infrastructure	$ 694.000,00
Hauling Road	$ 786.250,00
Equipment	$ 422.750,00
Total	**$ 9.149.600,00**

The coal price of coal refers to the average Coal Reference Price (HBA) in 2021, which is $120.69/Ton, and has converted to the quality of the AMO site using the HPB marker formula. Due to the formula price of coal AMO site is $71.31/Ton. The investment financing structure for mining operations is 70% bank loan and 30% own capital. The interest rate on the loan is 10% per annum (in US$) and is fixed, with a repayment period according to the mining period. The exchange rate of the dollar to rupiah is US$ 1.00 = Rp. 14,500, -, the price of diesel refers to the purchase price of PT. PKN on site for the period December 2021, cost escalation is 2.5% per year, discount rate is 10%, income tax rate is 25%. Coal Royalty ; 13.50% of the selling price less shipping costs.

The calculation of the feasibility of the investment is carried out according to the company's strategy is to run mining in 3 years. As a comparison of real options, the calculation of investment feasibility is also carried out by calculating the NPV using the DCF method (Table 4).

Table 4. NPV Project Using Real Option Binomial Lattice

Probability per Lattice	**Year**	**Y – 2021**	**Y - 2022**	**Y - 2023**	**Y – 2024**
	Y - 2021	100,00%	41,44%	17,18%	7,12%
	Y - 2022		58,56%	48,54%	30,17%
	Y - 2023			34,29%	42,63%
	Y - 2024				20,08%
Coal Price Per Lattice	**Year**	**Y – 2021**	**Y - 2022**	**Y - 2023**	**Y – 2024**
	Y - 2021	71,31	100,75	142,34	201,11
	Y - 2022		50,47	71,31	100,75
	Y - 2023			35,72	50,47
	Y - 2024				25,29
Cash Flow Per lattice	**Year**	**Y – 2021**	**Y - 2022**	**Y - 2023**	**Y – 2024**
	Y - 2021	- 350.000	2.985.111	35.868.360	50.697.005
	Y - 2022	-	- 5.716.573	6.882.546	15.625.219
	Y - 2023	-	-	- 11.225.104	- 3.440.256
	Y - 2024	-	-	-	- 15.176.467
NPV Without Abandon	**Year**	**Y – 2021**	**Y - 2022**	**Y - 2023**	**Y – 2024**
	Y - 2021	5.266.160	32.652.692	63.287.191	50.697.005
	Y - 2022		- 12.561.051	10.938.388	15.625.219
	Y - 2023			- 20.600.010	- 3.440.256
	Y - 2024				- 15.176.467
NPV With Abandon	**Year**	**Y – 2021**	**Y - 2022**	**Y - 2023**	**Y – 2024**
	Y - 2021	12.319.932	33.627.533	63.287.191	50.697.005
	Y - 2022	-	-	12.769.699	15.625.219
	Y - 2023	-	-	-	-
	Y - 2024	-	-	-	-

By using the Real Option method, the NPV without abandon is: $ 5,266,160, which means that production and sales are still carried out when the price is not economical. Meanwhile, if the company run the exit/abandon option (production and sales are not carried out when the price is not economical) then the NPV become $12,319,932. So the exit/abandonment option is worth $7,053,771 (table 5).

Table 5. NPV Project Using Discounted Cash Flow

Year	**0**	1	2	3
	2021	**2022**	**2023**	**2024**
Revenue				
Sales Volume	$ -	258.320	629.000	538.680
Coal Price	$ 71,31	71,31	71,31	71,31
Gross revenue	$ -	$ 18.420.799	$ 44.853.990	$ 38.413.271
Coal Royalty	$ -	$ 2.347.315	$ 5.707.137	$ 4.880.178
Net Revenue	**$ -**	**$ 16.073.484**	**$ 39.146.853**	**$ 33.533.093**
Profit & Loss				
Direct Cost	$ -	$ 9.621.205	$ 27.494.746	$ 24.135.360
Indirect Cost	$ -	$ 968.700	$ 2.417.719	$ 2.122.315
Loan Interest	$ -	$ 274.488	$ 182.992	$ 91.496
Depreciation & Amortization	$ -	$ 1.657.451	$ 4.035.833	$ 3.456.316
Net Income / (loss) Before Tax	**$ -**	**$ 3.551.640**	**$ 5.015.563**	**$ 3.727.606**
Tax	$ -	$ 887.910	$ 1.253.891	$ 931.901
Net Income / (loss) After Tax	**$ -**	**$ 2.663.730**	**$ 3.761.672**	**$ 2.795.704**
Cash Flow				
Add Back Depreciation & Amortization	$ -	$ 1.657.451	$ 4.035.833	$ 3.456.316

Principal Payment	$ -	$ 914.960	$ 914.960	$ 914.960
Capex	$ 350.000	$ 8.099.600	$ -	$ -
Borrowed	$ -	$ 2.744.880	$ -	$ -
Undiscounted Cash Flow	**$ -350.000**	**$ -1.948.499**	**$ 6.882.546**	**$ 5.337.060**
Disccounted Cash Flow	**$ -350.000**	**$ -1.771.363**	**$ 5.688.054**	**$ 4.009.812**
NPV	**$ 7.576.503**			

Using the DCF method is projected to get an NPV of $7,576,503. From the description of the calculation above, it is obtained an overview of the two NPV calculations, both DCF and RO, as follows in table 6:

Tabel 6. Resume NPV

	Net Present value			
	DCF	*RO With* Abandon	*RO Without Abandon*	*Exit Option/ Abandonment*
NPV	$7.576.503.	$ 12.319.932.	$ 5.266.160	$ 7.053.771

The NPV results used the Discounted Cash flow method tends to be higher than the Real Option method with the without abandon option. The assumption of the operational process in calculating the NPV of the DCF and RO without abandon methods is the same, where production and sales will continue to be carried out every year (without any delays), including when the selling price of coal is not economical. Meanwhile, the with abandon option will result in a higher NPV, where production and sales activities are stopped / postponed when the selling price of coal is not economical. A sensitivity model of NPV is made to see the limits of the economical coal price and the effect on the NPV. Coal price refer to the base price (average in 2021) with a multiplier of +- 5% . The picture can be seen in the graph below (Figure 2):

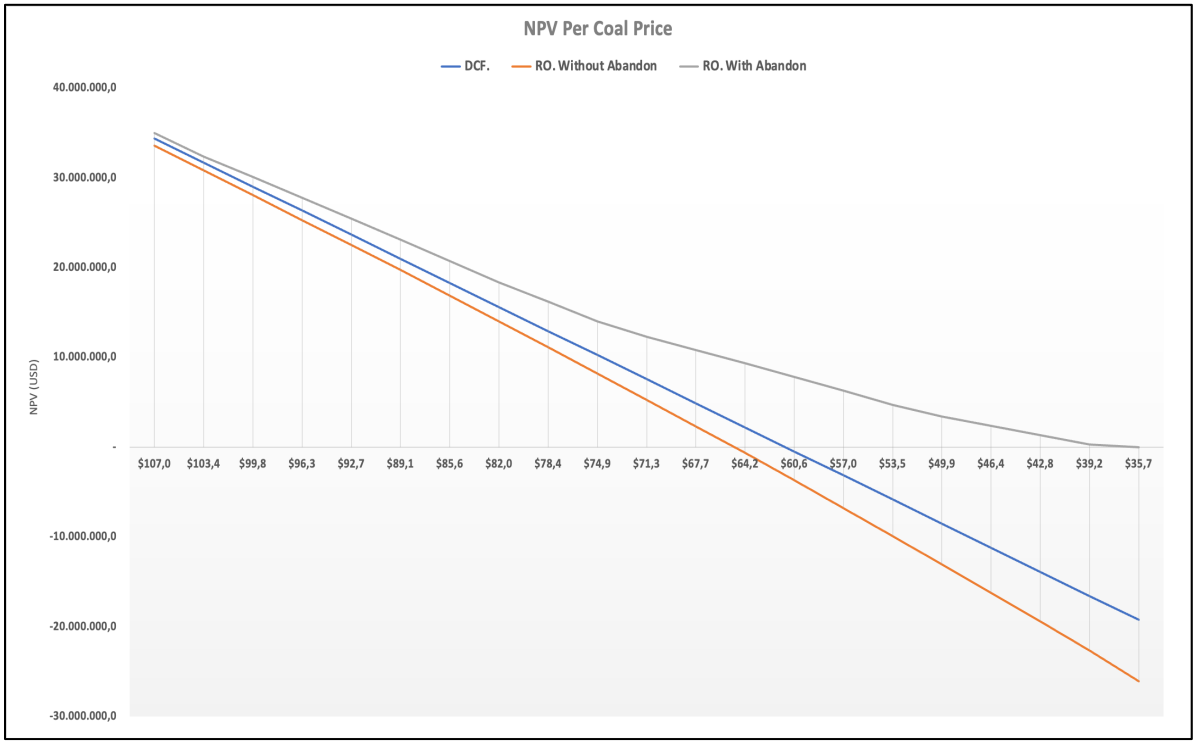

Figure 2. Graphic Sensitivity Analyis NPV to Coal Price Change

The graph above shows the NPV with the Discounted Cash Flow calculation is always higher than the NPV with the Real Option without abandon method. With the DCF method, the economic price is above $60.6/Ton, with the RO without abandon method, the economic price is above $64.2/Ton.

In the calculation of real options above, the difference in NPV between options with abandon and without abandon is the value of Exit Option/Abandonment, which is the potential for additional profit if there is a delay in production and sales. From this study, it was found that the Exit Option/Abandonment value at coal price $71.31/Ton is $7,053,771. The value of the option is not a small value if we look at the overall NPV of the project, a large profit will be obtained by the investment owner. To get the option value, practically all production and sales activities must be stopped when the price is not economical. The Exit Option/Abandonment value for each coal price change can be seen in the chart below in figure 3:

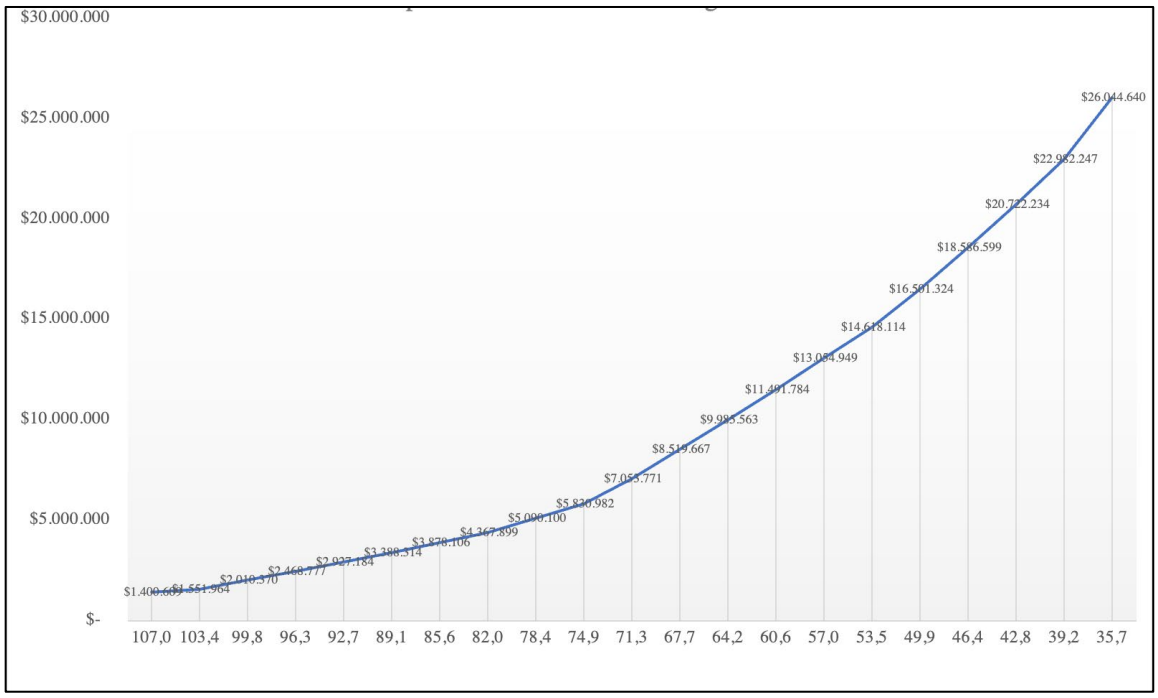

Figure 3. Graphic Exit Option Value due to Coal Price Changing

From the graphic above, we concluded that the higher coal price, the lower the Exit Option/Abandonment value of the mining project, but the lower the coal price, the higher the Exit Option/Abandonment of the project.

5.1 Proposed Improvements

Exit Option/Abandonment is not an easy condition to do but it is not impossible to do either for mining operation that is already running, especially with a large production scale. To run Exit Option/Abandonment the following costs will be incurred:

1. Stand-by costs for heavy equipment owned by contractors where there has been a long-term contract with the mining contractor.
2. Penalty fee for contract termination.
3. Employee costs (employees are laid off, layoffs, new recruitment when mining restarts).
4. The cost of maintaining and securing the company's assets.

Based on internal data and contract that is already running on a site that is already operating, the calculation of the assumption of operational costs to run Exit Option/Abandonment is as follows in table 7:

Tabel 7. Estimate Cost to Run Exit Option/Abandonment

Description	Annual Cost
1. Stand-by costs contractor units	$ 2.221.523
2. Penalty fee for termination of cooperation contract	$ 253.680
3. Employee costs	$ 42.419
4. The cost of maintaining and securing the company's assets	$ 30.952

Total	$ 2.548.573

The stand-by cost of contractor units is the largest portion of the exit option/abandonment fee. In this study, the cost refers to the mining contract on the existing site, assuming the terms of the AMO mining contract will be the same as the contract. Assuming how to run the options as follows:

1. Observation of the movement of the selling price of coal for a maximum of 6 months, after the price is confirmed not to improve, the company run terminates.
2. The cost of terminating the contractor's employee contract will be covered by the company, as well as the cost of re-recruitment if the company is still using the same contractor when running its production again.
3. Employee costs only accommodate the needs of contractors, for PT. PKN employees it is assumed that if there is a site closure, employees can be allocated to another sites, so there are no costs for PT. PKN employees.

Another scheme for the stand-by costs of this contractor's equipment is the company can bear the cost of leasing contractor equipment along with the basic salary of employees who are laid off on a monthly basis. Where these costs must be agreed at the beginning of the contract. Seeing that the production scale of the AMO site is relatively small and currently in preparation for production and sales, it is very possible to prepared this Exit Option/Abandonment if faces the coal price reduction. In order to carry out this strategy, it can be prepared at the beginning of the project setup. Relating to the costs that will arise if carrying out the Exit Option/Abandonment must be considered more carefully, especially those related to mining contractor contracts. The strategy for carrying out Exit Option/Abandonment at the AMO site can be arranged at the stage of drafting a contract with the contractor (related to costs for stand-by equipment while still paying attention to a win-win solution between the Company and the Contractor). And the fulfillment of Human Resources can maximize several positions filled by workers from the labor supply.

6. Conclusion

From the results of the research on the production scenario set by PT.PKN, it produces NPV (DCF) : $7,576,503, NPV (RO without abandon) : $5,266,160, NPV (RO with abandon) : $12,319,932, and the value of Option exit/Abandonment : $7,053,771. The difference in NPV between the option with abandon and without abandon is the value of the Exit Option/Abandonment, where there is potential for additional NPV if there is a delay in production and sales when the selling price of coal is not economical. However, there are limitations in carrying out this Exit Option/Abandonment practice, where companies that have run production are not flexible in exercising this option because there are costs that will arise when running it. These costs must be considered when choosing to exercise this option.

This research is limited to the calculation of feasibility using real options methode and estimated costs to exercise the exit/abandonment option when the selling price of coal is not economical, which this study discusses only the planning stage. The execution stage of running the exit option/abandonment has not been discussed in this study, it is hoped that further research can detail the stages of execution and evaluation.

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