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Decision Making Acquisition Corridor Area to Get Additional Reserve to Extend the Mining Life at PT Borneo Indobara

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ABSTRACT

PT Borneo Indobara (*PT BIB*) is a coal mining company facing a critical challenge: its current coal reserves of 641 million tons will be depleted by 2035, while its operational permit extends until 2036. To address this, *PT BIB* aims to acquire an unclaimed corridor area adjacent to its *Kusan Girimulya Bawah* pit, which could provide additional reserves. This study evaluates three acquisition alternatives using the Simple Multi-Attribute Rating Technique (SMART) to determine the optimal option based on cost, reserve volume, operational feasibility, and regulatory compliance. The research employs qualitative methods, including interviews, focus group discussions, and field observations, to gather data on technical and economic factors. Findings reveal that Option 1–acquiring the corridor area without joint operations–offers the lowest cost ($31.29/t), operational simplicity, and sufficient reserves (3.63 million tons) to extend mining operations until 2036. Despite yielding fewer reserves than other options, it minimizes regulatory hurdles and operational disruptions. The study concludes that Option 1 is the most viable solution, balancing reserve acquisition with cost efficiency and operational flexibility. Implications include recommendations for revising feasibility studies, ensuring equipment capacity, and securing forestry permits to facilitate implementation.

Keyword : Mining, Coal, Mine planning, SMART

INTRIDUCTION

The Directorate General of Mineral and Coal (*Minerba*) of the Ministry of Energy and Mineral Resources (*Energi Sumber Daya Mineral*, *ESDM*) has projected coal production in Indonesia for the years 2024 to 2026 based on the Work Plan and Budget (*Rencana Kerja dan Anggaran Biaya*, *RKAB*) submissions by mining companies, which are made for a three-year period. In 2024, the total production from approved *RKABs* is projected to reach 922.14 million tons, which is 19.6% higher than the coal production realized in 2023, which was 770.97 million tons (Anggraini & Ardan, 2024; Maskur, 2023; Pesiwarissa et al., 2022; Sumantri et al., 2022; Tahan, 2021). However, starting next year, the coal production target will decrease. In 2025, total coal tonnage is expected to decrease to 917.16 million tons, and it will further decrease to 902.97 million tons in 2026. This aligns with the International Energy Agency's announcement in 2023 of a 2.3% decline in global coal demand by 2026. Indonesia's coal production projections for 2024–2026 could still increase with the return of *RKABs* from several companies for revaluation and resubmission.

Indonesian coal continues to play a significant role in the global market amid the energy transition trend. Stable demand keeps coal as one of Indonesia's key export commodities. Moreover, a large portion of the coal supply for power plants in the Asia-Pacific region comes from Indonesia, where approximately 70% of the world's operating power plants are located (Arrahman & Mahardika, 2023; Khoyyimah & ,Martha Suhardiyah, 2021; Miliyani et al., 2023; Ndasa et al., 2021; Pusaka & Takarini, 2023). Currently, Indonesia still relies on coal as the primary energy source for the next 10–20 years. The advantages of coal include its lower cost compared to other energy sources and its

abundant supply. Indonesia has national coal reserves of 35 billion tons, with resources amounting to 134 billion tons.

The year 2017 marked the resurgence of the coal business after a challenging period, highlighted by a sharp increase in coal prices, which briefly exceeded US$100 per ton. The average coal price in 2024 is projected to reach around US$125 per ton, relatively stable compared to this year, though much lower than the record highs achieved in 2021–2022. *PT Borneo Indobara* is trying to obtain new reserves because the existing reserves are not sufficient to produce at 54 million tons per year until the end of the operational license.

PT Borneo Indobara operates five mining pits, namely *Pasopati Pit*, *West Girimulya Pit*, *Batulaki Pit Km21–33*, *Kusan Girimulya Pit*, and *Sebamban Pit*. *Kusan Girimulya Pit* has the highest production capacity. From the location of the pit, there is potential to obtain additional coal reserves due to the completion of detailed exploration activities and by observing the continuity of the existing coal layers.

PT BIB's business processes include activities from exploration to shipping coal products. The exploration process aims to obtain data and information about the coal contained in the concession area, including the thickness, distribution, and quality of the coal. Data obtained from exploration activities are then processed through geological modeling. By using this geological model, calculations of coal resources and reserves are carried out in the *PT BIB* concession, then continued with the mine planning process and scheduling. Furthermore, mining operations are carried out using an open-pit system. Operations start with land clearing, followed by stripping the topsoil and waste rock using a 300–400-ton loading excavator and a 120–180-ton dump truck. To support the transfer of material, blasting of the overburden is also carried out. The topsoil is placed in the *Waste Dump* area with an average height of 65 meters and a slope of 4.5%. The topsoil is stored separately for later use in land reclamation. Loading of exposed coal is carried out using an 80-ton loading excavator and an 80-ton dump truck to be disposed of in the *ROM* (*Run-of-Mine*) area. Coal transportation from *ROM* to the port is carried out using a 25–60-ton dump truck. Coal is transported to the port via a reinforced and continuously maintained haul road. *BIB* only carries out the process of reducing the size of coal from the mine, using a crusher at the crushing plant facility. *BIB*'s crushing plant facilities are available at each stockpile. Coal size reduction is carried out until the coal diameter reaches around 50 mm. The processed coal is then transferred to a coal carrier ship to be sent to consumers. Reclamation and revegetation activities are carried out on overburden material piles that have been declared final. Reclamation and management of former mining pits are carried out continuously, even after the mine is closed.

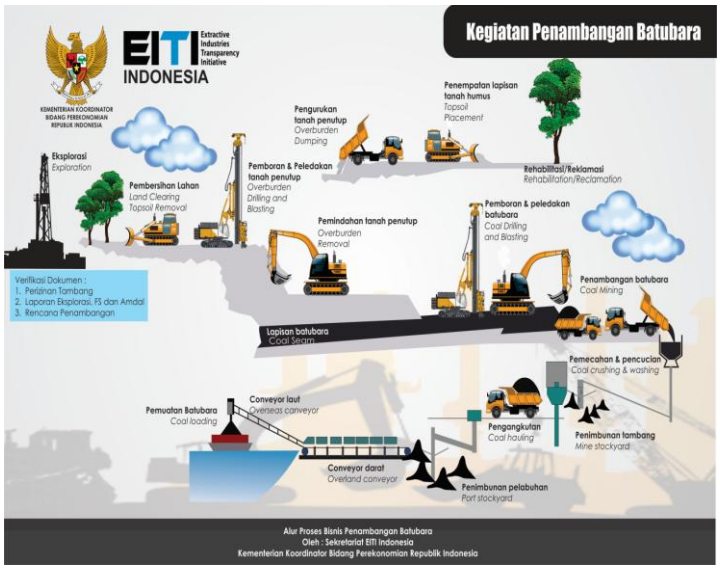

Figure 1. Business Process of Coal Operation

Coal Production

Coal production at PT BIB reached 42 million tons in 2023, with a target of 46.8 million tons for 2024. The production target will increase to 50 million tons in 2025 and 54 million tons in 2026. The current mining operations to support these production goals are in the Eastern Block, including Pit Kusan Girimulya and Pit Sebamban Utara, and in the Western Block, including Pit Batulaki.

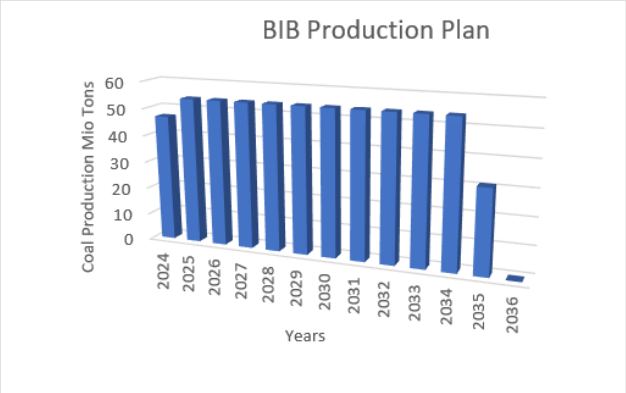

Figure 2. Business Process of Coal Operation

The remaining reserves in PT.BIB's concession using August 2023 cut-off data are 641 million. With a peak production target of 54 Mio Tons/years, the number of reserves can only last until the end of 2035, while PT BIB's operational permit is valid until 2036. Therefore, find of new reserves is needed, so PT BIB can operate until the end of the operational permit it has.

Mine Planning Process

With the limited coal reserves so that PT BIB cannot operate until the end of the operational permit, it is necessary to find new reserves. As an alternative to obtain new reserves, PT BIB plans to acquire a corridor area located to the west of the Kusan Girimulya Bawah Pit which borders the PT TIA Concession. The corridor acquisition plan faces several dilemmas including those related to COGS, how much reserves are obtained, the availability of dump locations for overburden material from the acquisition of the corridor area, the distance for disposing of overburden material, whether or not to carry out joint operations with PT TIA, the operating period in the corridor area and the adequacy and capacity of equipment to mine overburden material to obtain coal.

In order to be able to provide consideration of all these factors, a mining simulation needs to be created in order to obtain clearer data related to the comparison of each factor. Several alternatives that can be done to increase reserves by acquiring a corridor area are to acquire the corridor area or to acquire the corridor area and carry out operational cooperation with TIA.

To start this process, it is necessary to collect technical data that will support the planning so that it will get a picture of each alternative that has been determined. The technical data collection consists of topographic data, morphology, exploration, rock strength and secondary data related to legislation from the Ministry of Energy and Mineral Resources, the environment or forestry. The data is then modeled in 3 dimensions, to provide an overview of the coal layers in the PT BIB concession, then a mine design is made by considering the rock strength and a mining simulation is carried out. The simulation provides an overview of additional coal, and the costs that must be incurred to carry out mining, so that from these parameters the most appropriate alternative can be selected.

Jadwal Produksi Tambang PTBIB	Unit	Periode Penambangan														Total
		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	
Schedule Produksi Total PTBIB																
Pemindahan OB	kbcm	79.503	274.898	251.500	254.068	244.527	255.413	241.860	238.955	260.367	249.176	242.518	219.200	164.825		2.976.810
Penambangan Batubara ROM	kt	16.445	54.000	54.000	54.000	54.000	54.000	54.000	54.000	54.000	54.000	54.000	54.000	31.139		641.584
Stripping Ratio ROM	bcm/t	4,83	5,09	4,66	4,70	4,53	4,73	4,48	4,43	4,82	4,61	4,49	4,06	5,29		4,64
Cadangan Marketable	kt	16.445	54.000	54.000	53.439	53.439	53.439	53.439	53.439	53.439	53.439	53.439	53.439	30.579		635.975
Jarak Angkut OB	km	4,1	3,9	5,5	3,9	3,5	4,7	4,6	4,7	5,1	4,3	4,4	4,0	4,1	-	4,4
Kelebihan Jarak Angkut OB (> 1.5 km)	km	3,1	2,9	4,5	2,9	2,5	3,7	3,6	3,7	4,1	3,3	3,4	3,0	3,1	-	3,4
Jarak Angkut Batubara dengan Truk dari Pit ke ROM Stockpile	km	1,9	1,8	1,8	1,8	1,9	1,9	1,9	2,0	2,0	2,0	2,0	2,0	2,0	-	1,9
Jarak Angkut Batubara dengan Truk dari Pit ke Pelabuhan	km	25,6	24,8	24,7	24,9	25,1	25,1	25,6	25,9	25,9	25,9	26,0	26,0	26,2	-	25,5
Jarak Barging ke transhipment point	km	28,1	28,3	28,2	28,2	28,2	28,2	28,2	28,2	28,2	28,2	28,1	28,0	28,0	-	28,2
Schedule Kualitas Batubara PTBIB																
CV-adb	kcal/kg	5.151	5.206	5.141	5.136	5.108	5.112	5.077	5.105	5.043	5.075	5.107	5.073	5.032	-	5.105
CV-gar	kcal/kg	4.000	4.047	4.023	4.027	4.033	4.031	4.006	4.039	4.045	4.079	4.056	4.078	4.051	-	4.042
TM-ar	%	35,51	35,65	36,01	35,73	35,63	35,51	35,42	34,98	34,84	34,53	35,20	34,70	34,70	-	35,27
IM-adb	%	16,91	16,74	17,,76	17,61	18,05	17,80	17,70	17,38	18,31	18,02	17,88	18,19	18,39	-	16,27
Ash-adb	%	6,35	6,05	5,94	6,09	5,66	5,92	6,28	6,18	6,21	5,67	5,59	5,73	6,11	-	5,96
TS-adb	%	0,33	0,39	0,43	0,35	0,29	0,28	0,28	0,24	0,24	0,22	0,24	0,24	0,23	-	0,29
FC-adb	%	37,96	37,73	37,51	37,45	37,45	37,33	37,19	37,22	36,74	37,23	37,31	37,15	36,82	-	37,30
VM-adb	%	40,55	40,30	39,53	39,59	39,49	39,59	39,41	38,85	39,34	39,69	39,93	39,68	39,40	-	39,60

Figure 3. BIB Production Plan Based on FS document

Research Question and Research Objective

Research questions consist of specific questions designed to guide and direct research. These questions serve to determine the focus, objectives, and scope of the research, as well as to help identify the data or information that needs to be collected. The characteristics of research questions are that they are specific and focused, measurable and answerable, relevant, feasible (doable), and open-ended.

Research objectives are statements that describe the specific goals of the research to be conducted, detailing what is intended to be achieved through the study. They provide clear focus and help determine the direction of the research methodology.

RESEARCH METHOD

The research design used in this study is the Qualitative Method. Qualitative methods can be used to dig deeper into the factors that determine coal reserves in the corridor area. This method aims to understand the phenomenon in depth in the research subject. This method is used when researchers need to consider complex and dynamic contexts, involving direct and in-depth interaction between researchers and participants. The methods used are often in the form of open interviews or group discussions. Qualitative methods are carried out on a small scale with the aim of digging deeper than broad generalizations.

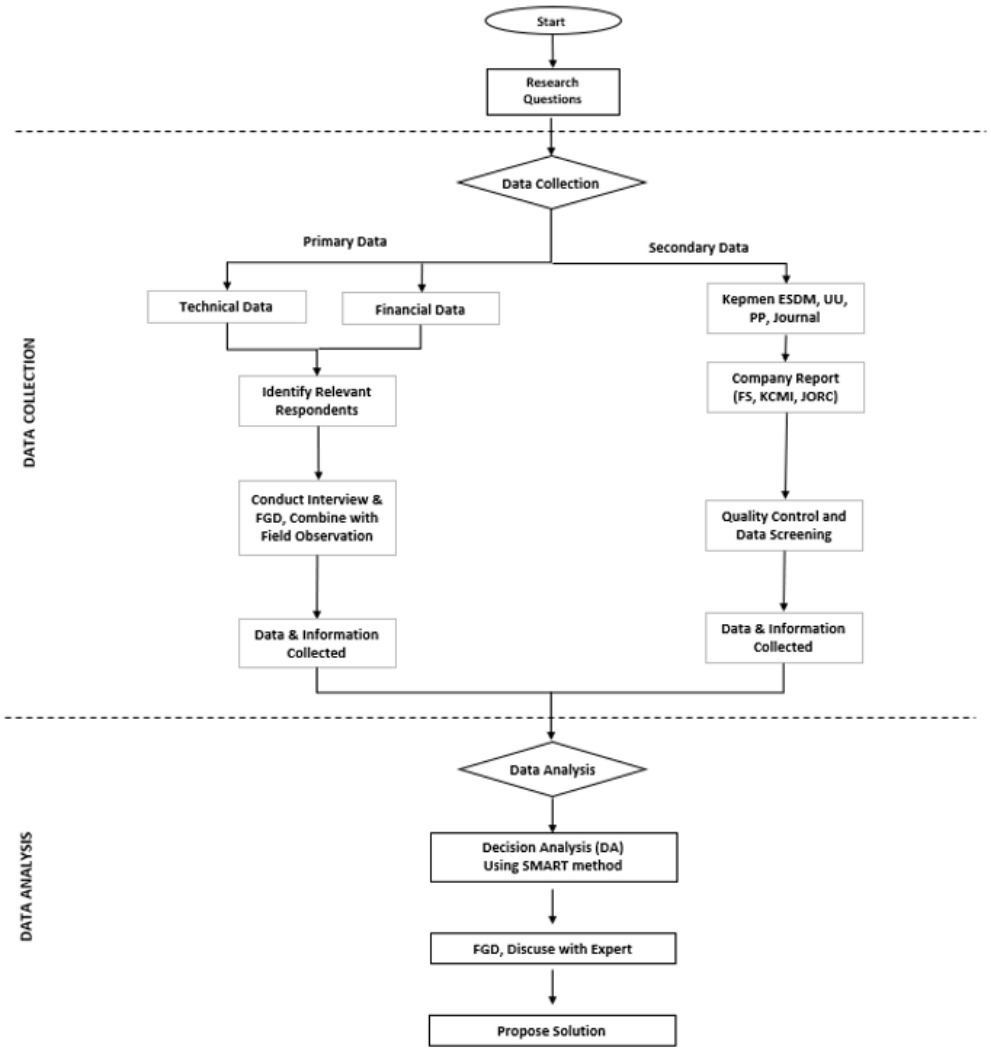

Figure 4. Research Design Diagram

The beginning of the research process, starting with the identification of research problems. Formulate research questions that will be answered with qualitative methods. Collecting qualitative data and continuing to analyse the data collected. Interpreting the research results using the results of qualitative data analysis, linking back to the research questions and decision analysis literature. Formulate options that can be a solution to obtain the research objectives. Draw conclusions based on decision analysis and provide recommendations for further action or research.

The process of collecting data and information for this research was carried out based on the type of data needed, namely primary data and secondary data.

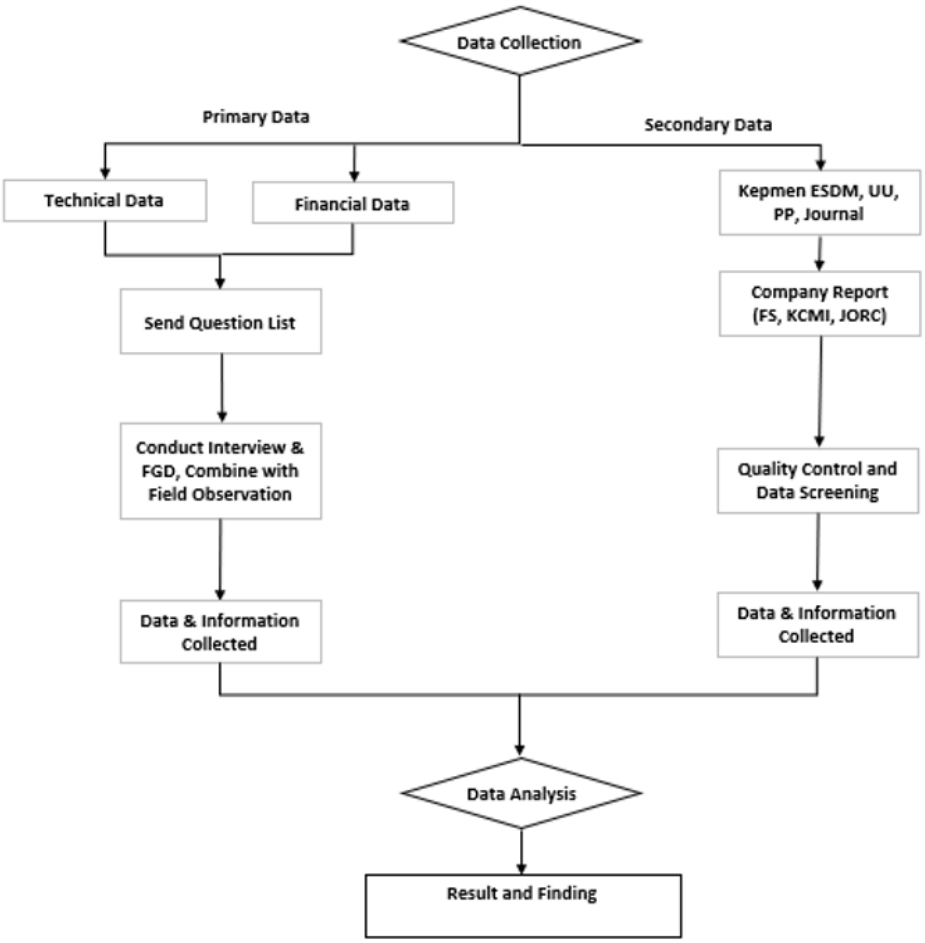

Figure 5. Data Collection Method Diagram

Primary data are data obtained directly from data sources, so the author is attempting to collect data from data sources in the field. Primary data are obtained by conducting interviews and Focus Group Discussions (FGDs) with parties related to the research questions in this study and conduct field observation at Kusan Girimulya, Corridor and PT TIA's Area.

Interviews and focus group discussions (*FGDs*) are essential qualitative methods for collecting data on attitudes, behaviors, experiences, and expectations, as described by Vredenbregt (1979). In this research, semi-structured interviews—often called 'qualitative research interviews'—were conducted using a predetermined list of themes and key questions. The process began with the creation of comprehensive questions, followed by the identification and selection of relevant respondents. Data were gathered through interviews and *FGDs*, with responses recorded either in writing or by audio. The collected data were then filtered and checked for quality; if gaps or ambiguities were found, follow-up interviews or additional questionnaires were conducted. Secondary data were sourced from company documents, reports, public records, journals, books, and government regulations, with careful filtering to ensure confidentiality. Both primary and secondary data were analyzed to inform decision-making and develop alternative options.

The qualitative data analysis involved several systematic steps, as outlined by Corbin and Strauss (2015). The process began with familiarization, which included reading and transcribing data, and making initial notes to identify early themes. Coding followed, where relevant data segments were labeled and grouped to facilitate pattern recognition. Main themes or patterns were then identified by clustering similar codes, evaluating their

relevance, and refining them as needed. Conceptual or thematic analysis was used to relate these themes to the research questions, interpret their significance, and construct a narrative of the findings. Additionally, the SMART (Simple Multi-Attribute Rating Technique) method was employed as a decision-making tool to evaluate alternatives based on multiple criteria, enabling the selection of the most effective solution aligned with the research objectives.

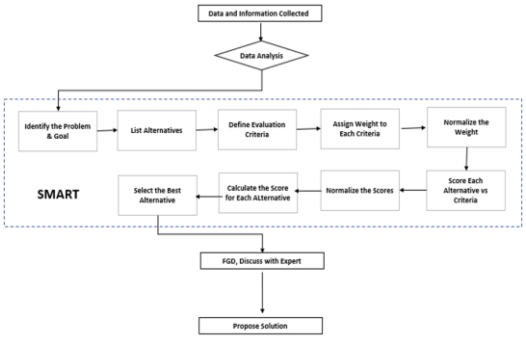

Figure 6. Data Analys Diagram

RESULT AND DISCUSSION

The researcher collects data from organization in PT Borneo Indobara who related with exploration, mine plan and operation, the Division Head of MDC Division, the Manager of Strategic Plan Department, the Manager of Geology exploration and engineer and geology team. Interviews and FGDs were conducted to obtain an exploration data, land category, material properties, dump location, mine operational, truck and excavator class and distribution, potential area go get additional reserve, permit to government with the aim of to get solutions that could be implemented to get additional reserve so that it can extend the mining life.

Tabel 1. Interviewer's Description

Interviewer	Person	Methode	Topics
Division Head of MDC Division	1	Direct interview	a. PT BIB Production Plan until life of mine b. Limitation of Stripping ratio and overburden distance c. Plans provide area to support mining operation d. Cost of overburden removal each contractor e. Production limit and contract each contractor
Manager of Strategic Plan Department	1	Direct interview	a. Mining sequence of PT BIB b. Area Plot for mining support, hauling road, sediment pond, office, mess, explosive area c. Treatment for reclamation area
Engineer and section head MDC	15	FGDs meeting	a. Availability of geology and geotechnical drills. b. Continuity of coal seam at Kusan Girimulya Bawah c. Geotechnical recommendation for Kusa Bawah Area d. Unit Capacity and population at Kusan Girimuya Bawah e. Limitation at Kusan Bawah Area that potential gets additional reserves f. Morphology and waterflow pattern at Kusan Girimulya Bawah. g. SR indicator at Highwall Kusan Girimulya Bawah

Field Observation

From the results of field observations, research obtained a related overview:

1. Description of the continuity of the coal seam based on the final mining floor that has been formed.
2. Types of digging tools used in the PT BIB mining block.
3. Required work area dimensions for each digger used by PT BIB's mining activities.
4. The type of work area material which will influence the type and size of digger that can be used in the PT BIB mining area.
5. Distance between the mining front and the waste material disposal location from PT BIB's mining activities.

Company and Public Document Review

A review of company documents was conducted to obtain an overview of PT Borneo Indobara's future mining planning. Documents used include:

1. Document of explorations report PT BIB
2. Feasibility Study (FS) Tecno Economi of PT BIB with production to 54 million tons per year.
3. Document of explorations report PT TIA
4. Feasibility Study (FS) PT TIA

General publication documents used as regulatory references in the implementation of coal exploration include:

1. *Undang Undang No.3 tahun 2020 tentang Pertambangan Mineral dan Batubara.*
2. *Peraturan Pemerintah No.96 Tentang Rencana Pengelolaan Mineral dan Batubara.*
3. *Keputusan Menteri ESDM No.266K/MB.01/MEM.B/2022 tentang Pedoman Permohonan, Evaluasi, dan Pemrosesan Perluasan Wilayah Izin Usaha Pertambangan dan Wilayah Izin Usaha Pertambangan Khusus Dalam Rangka Konservasi Mineral dan Batubara.*

Analysis

With the data obtained, the process of formulating decision making was carried out, by using SMART methods, then measurable and effective alternative are obtained in trying additional reserve at corridor area.

This research discusses the stages of decision-making formulation by applying. The SMART method. This method is used to ensure the decision-making process meets the criteria of specific, measurable, achievable, relevant, and time-bound objectives. The stages of analysis in the SMART method consist of identify the decision maker, identify the alternatives courses of action, identify the attributes with are relevant, assign value to measure the performance of each alternative on each attribute, determine a weight for each attribute, make a provisional decision, perform sensitivity and proposed solutions.

Identify the Problem and Goal

In this case, the main problem faced is the lack of coal reserves, so that PT BIB cannot operate until its operational permit expires, for that PT BIB needs to find coal reserves so that it can extend the life of mine. The addition of coal reserves can be done by acquiring the corridor area located to the west of the Kusan Girimulya Bawah pit.

Identify the Option

In determining alternative options that will be taken as steps to resolve the problem. From the results of interviews with the MDC Division Head and Strategic Plan and Optimization Department Head and FGDs with the Engineering Team, the following 3 options were obtained:

Widening of the Kusan Girimulya Bawah Pit by placing the crest pit at the boundary of the corridor area (Option 1)

With this option, it means that PT BIB must set back the existing crest design by 30 meters, so that it is on the PT TIA concession boundary. Some of the things that Option 1 Covers area as follow:

a) This option provides additional coal reserves of 3,63 million tons with waste of 15,61 million Bcm.

b) This option only acquires the corridor area, without involving joint operational with PT TIA.
c) The application for PKP2B expansion is only between PT BIB and Ministry of Energy and Mineral Resources.
d) Easier Operationally, because there is no need for MoU to share profits from coal mining between PT BIB and PT TIA.
e) No additional permits are required to re-use reclamation areas
f) Dump availability unit to accommodate additional overburden can be covered by the existing disposal area.
g) The distance for overburden disposal by acquiring corridor area has not increased significantly, even though the mining area has become wider, however based on mining simulation the distance for overburden disposal has only increased around 50 m.
h) Possible can still use the existing unit capacity, this is due to the additional of overburden material and the working space is not too large.
i) Flexible in carrying out operations, because operations in the corridor area follow the operational permit in the PT BIB.

Widening of the Kusan Girimulya Bawah pit by placing the toe pit on the PT BIB concession boundary (Option 2)

This option means that PT BIB must set back the existing crest design by 150 meters, and the design of toe of Kusan Girimulya Bawah will be within the outer limit of PT BIB concession. Some of the things that Option 2 Covers are as follows:

a) This option provides additional coal of 60,57 million tons and waste material 320,09 million Bcm.
b) This option requires acquisition of the corridor area and join operational with Pt TIA.
c) The application for PKP2B expansion will involve PT BIB, PT TIA and Ministry of Energy and Mineral Resources.
d) Expansion of PKP2B or IUP can be carried out by PT TIA or By PT BIB and required more detail discussion.
e) The need to discuss with PT TIA regarding profit share, because the composition of coal is obtained from the joint operational process if it is assessed that the operation areas of each company are not balanced.
f) Required additional permits to re-use reclamation areas.
g) Dump availability to accommodate additional overburden, a new location is required, because the mining volume of overburden is very large, namely 321 million Bcm.
h) The increasing volume of overburden with such a large capacitu required the development of a new area which is located quite far from the planned pit, resulting in an increase in the distance to dispose of overburden material, namely 4.800 meters or an increase distance of 1.750 meters.
i) This option uses part of the PT TIA area; therefore, the mining operation will follow a faster operational permit. In this case the PT TIA operational permit until 2031, while the PT BIB operational permit until 2036, so the additional overburdenn of 321 million Bcm must be complete for mining no later than 2031.
j) The large volume of overburden must be mined, so that to dig layers of overburden with a volume 321 million bcm by 2031, PT BIB must upgrade the existing digger with a large class, if using the current units, the existung digger capacity will not be enough to dig all overburden material.

Widening of the Kusan Girimulya Bawah pit by placing the toe pit on the PT TIA concession boundary (Option 3)

This option means that PT BIB must set back the existing design crest by 180 meters, so the toe design of the Kusan Girimulya Bawah pit will be within the outer limits of the PT TIA concession. Some of the things that Option 3 Covers area as follow:

a) This option provides additional coal reserve of 63,44 million tons with waste material 338 million Bcm.
b) This option requires acquisition of the corridor area, and joint operational with PT TIA.

c) The application for PKP2B expansion will involve PT BIB, PT TIA and Ministry of Energy and Mineral Resources.
d) Expansion of PKP2B or IUP can be carried out by PT TIA or PT BIB and required for more detail discussion.
e) The need to discuss with PT TIA, regarding profit share, because the composition of coal obtained from the joint operational process if it is assessed the operational area of each company is not balanced.
f) Required additional permits to re-use reclamation areas.
g) Additional coal reserve, the planned acquisition corridor area and joint operational with PT TIA is more than option 2.
h) Dump availability to accommodate additional overburden, a new location is required, this is because the mining volume is very large, namely 338 million Bcm.
i) The increase in overburden volume with such a large capacity requires the development of a new area which is located quite far from the planned it, resulting in an increase the distance to dispose of OB material, namely 4.950 meters or an increased distance of 1.900 meters.
j) This option uses part of the PT TIA area, therefore mining operation will follow the operational permit which expires more quickly, in this case, PT TIA operational permit has a permit until 2031, while PT BIB operational permit until 2036, so the additional overburden of 338 million BCM must be complete for mining no later than 2031.
k) Due to the large volume of overburden that must be mined, to dig the overburden layer with a volume 338 million Bcm by 2031, PT BIB must upgrade the existing digger to large class, if using the current units, the existing digger capacity will not be enough to dig all the overburden material, and mining at corridor area will not be optimal.

The summarize between option 1 -3, can show in table below:

Table 2. Summarize additional Coal, waste Volume and COGS Option 1-3

Pit Koridor & JO BIB TIA (USD/Mt)	Unit	OPTION 1	OPTION 2	OPTION 3
Coal Mined	(Kton)	3.635	60.570	63.440,00
Waste Removal	(KBcm)	15.609	320.090	338.000
SR	(bcm/ton)	4,29	5,28	5,33
OB Haul Distance	m	3.350	4.800	4.950
OHD Additional Cost > 1Km	$/t	0,26	0,26	0,26
Waste Removal Cost Incl fuel (cost/bcm)	$/bcm	3,00	3,38	3,41
Waste Removal Cost Incl fuel (cost/ton)	$/t	12,87	17,84	18,19
Coal mining incl fuel (cost/ton)	$/t	0,58	0,58	0,58
Land Cost	$/t	0,31	0,31	0,31
Coal Hauling (Cost per ton)	$/t	2,56	2,56	2,56
Rental, HSE and Other Cost	$/t	0,65	0,65	0,65
Cost of road maintenance and fee	$/t	1,87	1,87	1,87
Depreciation	$/t	0,42	0,42	0,42
Amortisation	$/t	0,73	0,73	0,73
Coal Crushing and Stockpile Management	$/t	0,82	0,82	0,82
Loading, Bargging and transhipment	$/t	5,29	5,29	5,29
royalty	$/t	4,46	4,46	4,46
minesite and HO Overhead	$/t	0,73	0,73	0,73
TOTAL COGS	$/t	**31,29**	**36,26**	**36.61**

Identify the Attribute Are Relevant

The next step is to weight each alternative option that has been determined previously. Weighting begins with determining the relevant attributes for all alternative options, then determining the weight scale for each attribute. The method used is a direct assessment of each attribute of each option conducted during the FGD. An overview of the flow chart for weighting is shown in Figure 7 below.

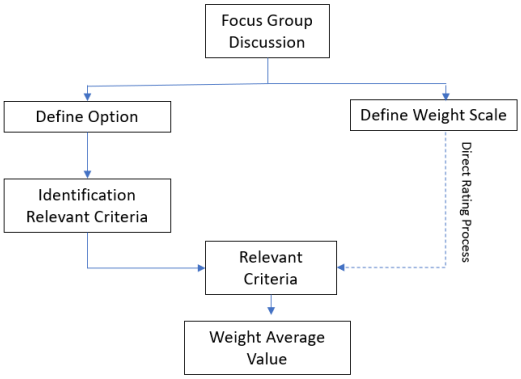

Figure 7. Flow Chart of Grup Measured

After determining several alternative decision-making solutions, next step with FGD process conduct identify relevant attributes that can be used to assess the superiority of each alternative. These attributes consist of values that are considered when determining alternatives, in this case we divide them into 2 criteria, namely cost criteria and Technical Aspect criteria. Cost criteria are COGS and technical aspect is additional reserve, dump availability, overburden distance, permit, joint operational, flexibility operation period and digger size. The explanation of each sub-criterion is as follows:

1) COGS
   Cost of Goods Sold in this case is the total direct costs incurred to mine, process, and ship mining products until they are ready to be sold. The main components of COGS include mining costs (drilling, blasting, hauling), processing costs (crushing, milling, refining), direct labor, and fuel and spare parts. In addition, equipment depreciation and environmental costs can also be included in the calculation. Efficient COGS reflects good cost management, thereby increasing the profitability of mining companies.
2) Number of additional reserves
   The large number of additional coal reserves is the main factor that must be considered, this is in accordance with the background of the problem being faced, namely related to the lack of coal reserve in PT BIB concession, which has resulted in PT BIB not being able to operate until the end of operational permit.
3) Dump availability
   The additional coal reserve means an increase in the amount of overburden volume that PT BIB must be removed. The additional overburden requires a disposal area. Currently BIB is also experiencing limited area that can be used as disposal locations for overburden material, so there are volume restrictions regarding the amount of overburden material that can be added from the discovery of new reserves.
4) Size of Digger
   Currently, the type of digger that is used in Kusan Girimulya Bawah is CAT 6020. The amount of overburden that can be excavated to obtain additional reserve also needs to be adjusted to the size of the digger.
5) Overburden Hauling Distance
   Overburden hauling distance to disposal is an influential factor, especially on mining cost. This is because the further overburden distance, the greater fuel consumption.

6) Licensing/Permit
   Acquisition of corridor areas to obtain additional coal reserve requires additional permits. This permit can be in the form of an area acquisition permit and a permit for the re-use of reclamation areas.
7) Joint Operational
   Acquisition of corrido areas to obtain additional coal reserve can be done by simply acquiring corridor areas, or by acquiring corridor areas and carrying out joint operational with PT TIA.
8) Flexibility Operation Period
   The alternative that will be chosen to increase the coal reserve also affects the mining operational time. This is because there is an option to acquire the corridor area only or acquire the corridor area plus joint operational with PT TIA. And this decision influent with operational time.

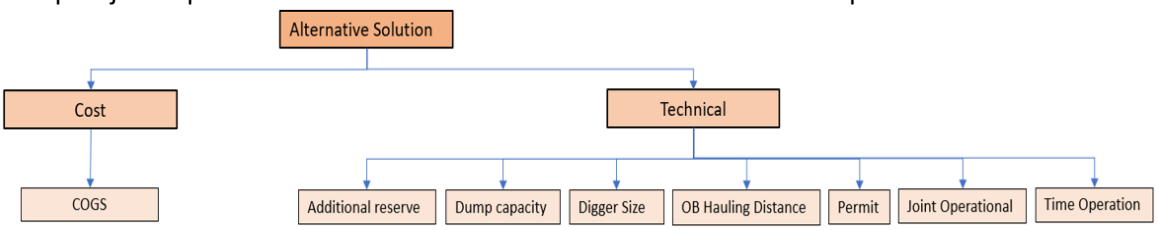

Figure 8. Value tree of Decision Making

After determining the criteria for each alternative option, the next step is to measure and calculate the performance of each option directly through the FGD process involving all engineer representatives for implementation. The initial step for this measurement is to first create a score scale for each option that shows an explanation of the concept of assessment of each benefit criterion. The score scale for each criterion is shown in table 3.

Table 3. Score Scale for each Criterion

No.	Criteria	Requirement	Class	Score
1	Additional Reserve	More additional coal reserve, the value is better	Slow	0
			Medium Slow	33
			Medium High	67
			High	100
2	Dump Availability	Easier to get dump location, the value is higher	Complex	0
			Moderate	33
			Mild	67
			Easy	100
3	Digger Size	The easier it is to adapt to the existing condition; the value is higher	Complex	0
			Moderate	33
			Mild	67
			Easy	100
4	OB Hauling Distance	Shorter OB hauling distance, the value is higher	Long	0
			Fairly Long	33
			Fairly Short	67
			Short	100
5	Permit	Easier/less to process permit, the value is higher	Complex	0
			Moderate	33
			Relatively Simple	67
			Simple	100
6	Joint Operational	If it does not require joint operations, it will have higher value		
			Excluded	0
			Required	100

No.	Criteria	Requirement	Class	Score
5	Flexibility Time Operational	Longer mining life, the value is higher	Very Short	0
			Short	33
			Medium	67
			Long	100

From interviews and FGDs with Engineering team, then conducted a direct assessment of each sub-criterion. The identification of the status of each sub-criterion is shown in table 4 below:

Table 4. Result of FGD's Assessment for Each Criterion

No.	Criteria	OPTION 1	OPTION 2	OPTION 3
1	Additional Reserve	A little	Many	More
2	Dump Availability	Available	Limited	Very Limited
3	Digger Size	Use Existing	Need Upgrade	Need Upgrade
4	OB Hauling Distance	Short Distance	Long	Longer
5	Permit	Simple	Complex	Complex
6	Joint Operational	Not Required	Required	Required
7	Flexibility Time Operation	Flexible	Not Flexible	Not Flexible

Based on the COGS sub criteria assessment, option 1 will provide the lowest COGS value, namely 31,29 $/t, while option 2 provides a COGS 36,26 $/t and Option 3 provides a COGS 36,61 $/t.

Next, a direct assessment is made of the benefits sub-criteria and given a score value from 0 to 100 for each option according to its status. A score of 0 is the lowest score and 100 is the highest score. The process of assessing the sub-criteria for each option was conducted through FGDs with engineering teams and interviews with experts.

The assessment of the sub-benefit criteria begins with the criteria for additional coal reserve. From the assessment results, it is found that option 3 provides the most additional coal reserves, option 2 provides fewer additional coal compared with option 3 , while option 1 gets the least coal. The results of Additional sub-criteria assessment are shown in table 5 below.

Table 5. Direct Rating for Additional Reserve

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Little	Medium Low	33
2	OPTION 2	Many	Medium High	67
3	OPTION 3	More	High	100

The next assessment is carried out for dump availability criteria. This assessment is carried out to assess whether the overburden material thaat must be excavated to obtain coal has available space for disposal. Option 1 produces the least amount of waste material, so it does not require an additional landfill area. Option 2 produces additional overburden material to be disposed of in a large volume, so it requires additional area or requires a wider disposal location, likewise with option 3. assessments in table 6 below:

Table 6. Direct Rating for Dump Availability

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Available	Easy	100
2	OPTION 2	Limited	Moderate	33
3	OPTION 3	Very Limited	Moderate	33

Next, an assessment is carried out for the digger size criteria. With additional overburden material to obtain coal reserve, it is necessary to calculate whether the existing digger has sufficient capacity to excavate additional material or requires an upgrade to digger with a large size. Based on the calculation of the amount of material to obtain additional coal, option 1 has the smallest additional

overburden material so it can be done with the current type of excavator. Option 2, additional material that must be excavated is quite large, its need to upgrade the excavator size with a large bucket size. Option 3 got the most additional coal reserves among these three options, its need to be upgraded with a unit size that is larger than option 2. The result of the digger size criteria assessment can be seen in table 7 below:

Table 7. Direct Rating for Digger Size

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Use Existing	Easy	100
2	OPTION 2	Need Upgrade	Mild	67
3	OPTION 3	Need Upgrade	Moderate	33

Next, an assessment of the criteria for OB hauling distance is carried out. Based on data from the mine planning simulation, Option 1 provides the shortest OB hauling distance value, option 2 provides the longest OB hauling, and option 3 has the longest OB hauling distance. The results of the assessment of the OB hauling distance criteria can be seen in table 8 below:

Table 8. Direct Rating for OB Haul Distance

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Short Distance	Short	100
2	OPTION 2	Long Distance	Fairly Long	67
3	OPTION 3	Longest Distance	Long	33

The next step is to provide an assessment of the permit criteria. In this criterion, a score will be given for the complexity of the permit that must be obtained. In option 1, the permit required is only a permit to acquire the corridor area. In options 2 and 3, complex permits are required. This is because in addition to acquiring the corridor area, the addition of coal reserves will affect concessions owned by other parties which are reclamation areas, so additional permits are needed. The results of the permit criteria assessment can be seen in table 9 below:

Table 9. Direct Rating for Permit

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Simple	Simple	100
2	OPTION 2	Complex	Complex	0
3	OPTION 3	Complex	Complex	0

The next stage is to provide an assessment of the joint operational criteria. Option 1, because it only acquires the corridor area, so this option does not require a MoU related to joint operational with TIA, while options 2 and 3 require a MoU for joint operational with TIA. The results of the assessment of the Joint Operational criteria can be seen in table 10 below:

Table 10. Direct Rating for Joint Operation

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Not Required	Excluded	100
2	OPTION 2	Required	Required	0
3	OPTION 3	Required	Required	0

The final stage of the assessment is carried out to assess the flexibility time operation criteria. Option 1 has flexibility in carrying out easier mining operations or is categorized as flexible, this is because the operational permit will follow the operational permit owned by BIB, namely until 2036, while Options 2 and 3, because they involve joint operations with concessions adjacent to BIB, so that the operational permit will adjust to the operational permit that has a shorter life, namely the

operational permit owned by TIA which operates until 2031. The results of the assessment of the Flexibility time Operation criteria can be seen in table 11 below:

Table 11. Direct Rating for Flexibility Time Operational

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Flexible	Long	100
2	OPTION 2	Not Flexible	Short	33
3	OPTION 3	Not Flexible	Short	33

Determine Weight for Each Attribute

Based on the 7 Technical attributes, each attribute is given a weight value to show how important it is compared to other attributes in realizing get additional reserve for PT BIB. The attributes additional reserve, dump availability, OB haul distance are the top priority in decision making, followed by the attributes of digger size, permit, flexibility time operation, and Joint Operational. The weight assessment was conducted using the direct rating method through the FGD and interview process. The classification of attribute priorities is shown in Figure 9:

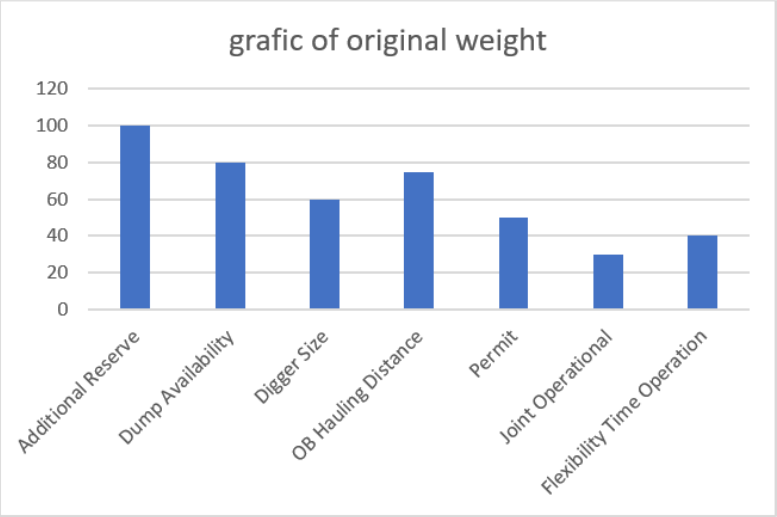

Figure 9. Graphic of Original Weight Each Attribute

Furthermore, the normalized weight in this stage with following formula:

$$Normalized\ Weight = \frac{Original\ Weight}{Total\ Original\ Weight}\ x\ 100\%$$

The result of calculated normalized weight each attribute showing in Table 12 below.

Table 12. Calculated Normalize Weight

No.	Attribute	Original Weight	Normalized Weight
1.	Additional Reserve	100	0,23
2.	Dump Availability	80	0,18
3.	Digger Size	60	0,14
4.	OB Hauling Distance	75	0,17
5	Permit	50	0,11
5.	Joint Operational	30	0,07
6.	Flexibility Time	40	0,09

For Each Alternative, take a Weighted Average of Values Assigned to That Alternative

The next step is to determine the weight value of each option, after determining the normalized weight in the previous stage. This method is done by converting the original value with the normalized

weight of each criterion, then adding up the results of the assessment of all criteria. The aggregate calculation of each option is shown in table 13 to Table 15.

Table 13 Total Weight Value for OPTION 1

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Additional Reserve	0,23	33	7,59
2	Dump Availability	0,18	100	18,39
3	Digger Size	0,14	100	13,79
4	OB Hauling Distance	0,17	100	17,24
4	Permit	0,11	100	11,49
5	Joint Operational	0,07	100	6,90
6	Flexibility Time Operation	0,09	100	9,20
Total				**84,60**

Table 14 Total Weight Value for OPTION 2

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Additional Reserve	0,23	67	15,40
2	Dump Availability	0,18	33	6,07
3	Digger Size	0,14	67	9,24
4	OB Hauling Distance	0,17	67	11,55
4	Permit	0,11	0	0,00
5	Joint Operational	0,07	0	0,00
6	Flexibility Time Operation	0,09	33	3,03
Total				**45,30**

Table 15 Total Weight Value for OPTION 3

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Additional Reserve	0,23	100	22,99
2	Dump Availability	0,18	33	6,07
3	Digger Size	0,14	33	4,55
4	OB Hauling Distance	0,17	33	5,69
4	Permit	0,11	0	0,00
5	Joint Operational	0,07	0	0,00
6	Flexibility Time Operation	0,09	33	3,03
Total				**42,33**

The calculation of total values for all alternatives solutions are summarized in table 16 below.

Table 16 Aggregate Value for Each Alternative Solutions

Alternatives	Additional Reserve	Dump Avalilability	Digger Size	OB Haul Distance	Permit	Joint Operational	Flexibility Time Operational	Aggregated of Weighted Value
OPTION 1	33	100	100	100	100	100	100	84,60
OPTION 2	67	33	67	67	0	0	33	45,30
OPTION 3	100	33	33	33	0	0	33	42,33

Making A Provisional Decision

In the next stage, a temporary decision is made, namely by considering the costs and technical aspects of each option that has been assessed. The researcher did this because it was difficult to assess costs and technical factors equally. A recapitulation of costs and technical aspects for all alternative options can be seen in the following table 17:

Table 17 Weight Value COGS VS Technical Aspect

Alternatives	Cost	Technical Aspect
OPTION 1	31,29	84,60
OPTION 2	36,26	45,30
OPTION 3	36,61	42,33

To illustrate the comparative position of each option, a cost and technical aspect plotting graph is made which is displayed in the diagram below. An option will be more attractive if its technical aspect is higher or moves up and its cost is low or moves far to the right.

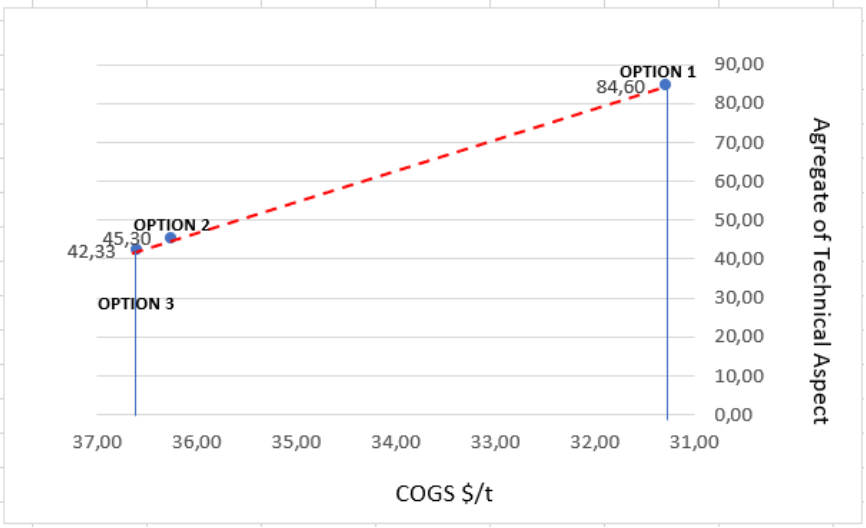

Figure 10. Graphic Plot COGS VS Technical Aspect

Perform Sensitivity Analysis

Sensitivity analysis is a method to observe the stability of the selected solution when the level of importance for the criteria is changed. The sensitivity of this analysis serves as a tool to assess how robust or strong the solution is when faced with uncertainty or variations in technical aspects (Aladejare & Akeju, 2020; Alipour et al., 2021; Bankauskaite et al., 2021; Pizarroso et al., 2022; Tennøe et al., 2018). In this case, sensitivity analysis is done by changing the weights on the technical aspect criteria additional reserve, digger size and OB haul distance to 0, because these three criteria have an influence on each option in solving the problem. With this change, option 1 is shown as the main choice with a benefit value of 100. Furthermore, changes are made to the weight values for dump availability, permit, joint operational and flexibility time operational data to 0, which are minor variables, this change still displays option 1 as the main choice with a benefit value of 77.67. The results of the sensitivity analysis are shown in table18 below:

Table 18. Aggregate of weight value after sensitivity analysis

Alternatives	Aggregate of Weighted Value (Progress = 0)	Aggregate of Weighted Value (Original)	Aggregate of Weighted Value (Data Generated = 0)
OPTION 1	100,00	84,60	73,73
OPTION 2	29,67	45,30	56,33
OPTION 3	18,33	42,33	59,27

The values in the table above are then plotted in a graph, as in the image below which shows that option 1 is the best solution that is not affected by changes in the weights of either the priority or minor variables.

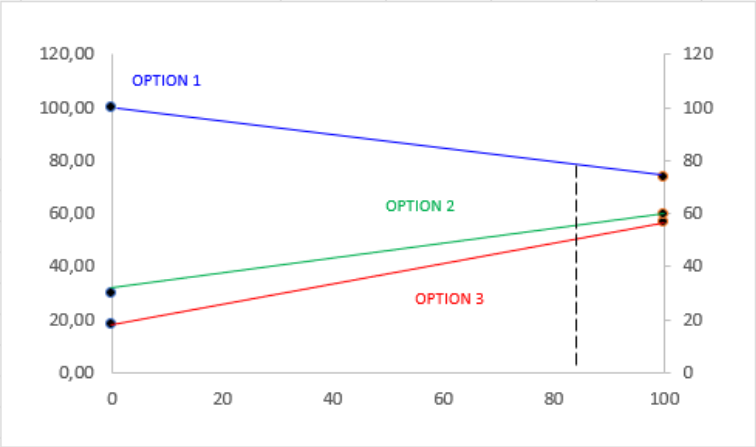

Figure 11. Sensitifity Analysis Result

Propose Business Solution

To obtain additional coal reserves so that it can operate until the end of the operational permit, as described in the sub-chapter identify the option which includes:

1. Widening of the Kusan Girimulya Bawah Pit by placing the Crest Pit at the boundary of the corridor area.
2. Widening of the Kusan Girimulya Bawah Pit by placing the Toe Pit on the BIB concession boundary.
3. Widening of the Kusan Girimulya Bawah Pit by placing the Toe Pit on the TIA concession.

Based on the results of the analysis of the three alternative solutions using the SMART method as described above, it is known that there are benefit criteria attached to each alternative, namely technical criteria which include additional reserve, dump availability, OB Hauling distance, digger size, permit, flexibility time operational and joint operational while cost is seen from the benefits that have a low COGS value.

Each subsequent criterion is given a value and weighted in sequence, the weighting results show that option 1 is the best option, by providing additional coal reserves of 3.63 million tons. Option 1 provides a disposal distance to overburden material that is still in accordance with the Plan, which is at 3,350 m, and provides ease in licensing and flexibility of operational time. Option 1 also does not require joint operations with the TIA concession and has the lowest COGS value.

CONCLUSION

This study identifies key factors influencing the acquisition of mining corridors in the *Kusan Girimulya Bawah* Block to secure additional coal reserves for *PT BIB*, emphasizing the importance of available material disposal sites, overburden transport distances, and their effects on production costs (COGS). The analysis concludes that option 1—acquiring the corridor without operational cooperation with *PT TIA*—is the optimal choice, despite offering the smallest additional reserves (3.63 million tons), due to its operational and permitting simplicity. However, implementation challenges include preventing competing permit applications, revising the *FS* and *AMDAL* in coordination with relevant ministries, verifying equipment capacity, and obtaining *IPPKH* permits since the area is within a forest zone. These additional reserves allow *PT BIB* to extend operations until 2036 by gradually reducing production. For future research, it is suggested to conduct an environmental feasibility study to assess the impact on forest ecosystems and develop sustainable reclamation strategies, perform a comprehensive cost-benefit analysis including hidden costs and stakeholder conflicts, optimize technology for low-emission operations, explore alternative legal frameworks such as partnerships with indigenous peoples to expedite permitting, and develop dynamic modeling to predict long-term economic viability under fluctuating coal prices or policy changes.

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