

A Feasibility Study Analysis of Low-Rank Coal Mine in North Musi Rawas Regency, South Sumatera, Indonesia

A Free Cash Flow to Firm (FCFF) and Discounted Cash Flow (DCF) Approach

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ABSTRACT

The coal mining industry in Indonesia faces severe global price volatility challenges that significantly impact the economic viability of low-calorific coal resources. This study aims to analyze the financial feasibility of a low-rank coal mining project at the IUP OP PT GPU concession in North Musi Rawas, South Sumatra, utilizing the Discounted Cash Flow (DCF) methodology. The research employs a quantitative descriptive method, integrating technical parameters from PT GPU with financial data from PT Daaz Bara Lestari Tbk as the Joint Operation partner. The discount rate is established at a Weighted Average Cost of Capital (WACC) of 16.16%, derived via the extended Capital Asset Pricing Model (CAPM) approach. Free Cash Flow to the Firm (FCFF) projections are modeled over a 10-year life of mine based on a peak production capacity of 660,000 MT. The results indicate that the project is highly feasible, delivering an excellent rate of capital return. The investment performance proves remarkably robust, as evidenced by a significantly positive Net Present Value (NPV) of USD 5.81 million (IDR 97.83

billion), an exceptionally high Internal Rate of Return (IRR) reaching 88.00%, an ultra-swift Discounted Payback Period (DPP) of 1.07 years, and a Discounted Profitability Index (DPI) of 5.27. In contrast to conventional modeling, the annualized FCFF streams are projected to maintain a consistent surplus in the green regime until the end of the mine life without leaving any deficits. Sensitivity analysis confirms that the coal selling price is the most critical external variable; however, the project possesses an exceptionally thick margin cushion, ensuring that even a severe -5% price contraction will not trigger serious financial risks and safely preserves a positive NPV. In conclusion, the project demonstrates high fundamental resilience against market risks, and the implementation of operational strategies such as production acceleration and stripping ratio tailoring is highly recommended to maximize and secure corporate investment profitability.

Keywords: sensitivity analysis, low-calorific coal, Discounted Cash Flow, Internal Rate of Return, Net Present Value, feasibility study.

INTRODUCTION

The Indonesian coal mining industry faces significant structural challenges due to commodity price volatility and profound uncertainty in global markets, particularly for low-calorific coal, which inherently carries higher economic and financial risks. Since low-grade coal constitutes over 70% of Indonesia's total national resources, amounting to approximately 67.33 billion tons, rigorous financial feasibility evaluation is crucial for efficient, capital-safe, and sustainable resource utilization (Badan Geologi, 2024). On a macro-framework level, the energy and mining sector serves as a vital strategic pillar for the national economy, acting as a multiplier effect that drives industrialization, secures two-thirds of the domestic electricity supply, and generates substantial fiscal revenue, contributing roughly half of the state's total energy non-tax revenues (PNBP). However, low-rank coal projects operate within tightly constrained economic margins due to deep quality discounts in the global market, where low-grade indexes like the Indonesian Coal Index 4-5 (ICI 4 & 5) can trade at discounts as high as 69% compared to high-calorie equivalents. This commercial vulnerability is further exacerbated by post-pandemic market normalization, which has triggered a steady decline in Price Reference benchmarks (HBA 2 and HBA 3) amid rising global supply and stringent decarbonization policies in major importing nations.

To navigate these intense market fluctuations and mitigate asset valuation risks, conducting a comprehensive, fundamental, and quantitative feasibility study is highly essential. This study focuses on a low-calorific coal mining project located in North Musi Rawas Regency, South Sumatera, evaluating the Production Operation Mining Business License of PT ABC (the company name is anonymized). Boasting a concession area of approximately 4,394 hectares and holding low-rank thermal coal reserves with an

average calorific value of 4,000 kcal/kg (ARB), the project possesses a substantial volume of reserves but remains highly sensitive to market fluctuations and field operational expenditures. To unlock the economic potential of this concession, a strategic commercial partnership is being evaluated for a Joint Operation (JO) by PT DBL, a publicly traded holding company specializing in mineral trading and logistics services. In building a realistic cash flow model for this potential partnership, financial projections are dynamically structured using internal cost data from PT DBL as financial parameters, paired with technical mining data independently verified and provided by PT ABC. Crucially, the financial model anchors its projections on baseline economic parameters established as of November 2025, which incorporates actual historical coal price benchmarks from the Indonesian Coal Index (ICI), contemporary foreign exchange rates, prevailing corporate tax structures, and mandatory government royalty frameworks applicable to the mining sector.

Methodologically, this paper applies a descriptive quantitative approach by implementing a full-scale traditional Discounted Cash Flow (DCF) model to convert technical parameters into exact financial realities. Unlike previous partial frameworks that evaluate project indicators in isolation or without proper discounting, this research evaluates financial robustness through Free Cash Flow to the Firm (FCFF) projections derived strictly from Net Operating Profit Less Adjusted Taxes (NOPAT) and net working capital adjustments. These are engineered specifically to mirror the actual logistical constraints and commercial realities of coal mining. The model utilizes a Weighted Average Cost of Capital (WACC) as the hurdle discount rate, estimated via an extended Capital Asset Pricing Model (CAPM) that integrates country risk premiums and industry betas. Project viability is systematically assessed through

four core financial indicators: Net Present Value (NPV), Internal Rate of Return (IRR) via the Modified IRR approach, Discounted Payback Period (DPP), and the Discounted Profitability Index (DPI). Furthermore, a rigorous sensitivity analysis, including tornado charts, spider web tracking, and elasticity indexes, is conducted to test the project's resilience against fluctuations in coal prices, operating expenditures (OPEX), and initial capital expenditures (CAPEX).

Based on the strategic context of this mining partnership and the market realities of low-rank coal, this study addresses four central research problems to provide a comprehensive financial assessment. First, it investigates the explicit formulation of the Free Cash Flow to the Firm (FCFF) projections over the 10-year life of mine, incorporating all specific economic and macroeconomic assumptions grounded in the November 2025 financial parameters. Second, it evaluates the exact technical parameters determining the initial capital expenditures (CAPEX) and operating cost structures (OPEX) derived from ultimate pit limit designs and break-even stripping ratio (BESR) variations. Third, it measures the definite financial viability and investment efficiency of the PT ABC project by analyzing whether the discounted indicators of NPV, IRR, DPP, and DPI comfortably clear the required minimum cost of capital. Finally, it evaluates the specific sensitivity and limits of economic tolerance of the investment model when subjected to independent and simultaneous shocks from key market variables, explicitly identifying which internal or external factors pose the most significant risk to the project's net worth.

LITERATURE REVIEW

A. Investment Feasibility in Low-Rank Coal Mining Projects

Indonesia possesses substantial coal reserves, with low-rank (low-calorific value) coal accounting for over 70% of total national resources (ESDM, 2023). Despite

this abundance, investment in low-rank coal mining remains economically challenging due to relatively low market prices and high sensitivity to operational costs. These characteristics contribute to the uncertainty of financial returns and increase the risk of underperforming investments (Wang et al., 2024). Therefore, project evaluations must be comprehensive, incorporating financial and technical parameters to ensure robust decision-making (Subroto & Faturohman, 2024).

B. Application of Discounted Cash Flow (DCF) Method in Project Appraisal

The DCF method is widely regarded as the most effective framework for evaluating the long-term viability of mining projects, given its ability to integrate time value of money into cash flow projections. Indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Profitability Index (PI) are essential tools in this methodology (Hartati & Isnaeni, 2021; Setianingsih & Husodo, 2022). Suhendar & Yunita (2024) emphasized the importance of using Free Cash Flow to the Firm (FCFF) as a basis for valuation, as it captures cash availability for all capital providers. Hardiman et al. (2024) suggested enhancing traditional DCF by incorporating technical metrics such as stripping ratio (SR) and break-even stripping ratio (BESR), which can significantly influence financial outcomes.

C. Determining Cost of Capital: WACC and CAPM Framework

Accurate estimation of the discount rate is crucial for DCF modeling. The Weighted Average Cost of Capital (WACC) reflects the composite cost of both debt and equity, appropriately weighted by their share in the capital structure. The cost of equity is often estimated using the Capital Asset Pricing Model (CAPM), which includes the risk-free rate, beta coefficient, and market risk premium (Brigham & Ehrhardt, 2020; Srivastava et al., 2021). Several studies,

including Hardiman et al. (2024), have validated the use of an extended CAPM model, which includes country risk premiums and industry-specific adjustments, particularly in resource-intensive sectors like coal mining.

D. Sensitivity Analysis and Risk Management

Sensitivity analysis is a critical component of financial modeling, particularly in high-risk sectors like mining. It evaluates how fluctuations in key assumptions, such as coal selling prices, operating expenditures, and capital costs (CAPEX) affect financial indicators like NPV and IRR (Indrayana & Nainggolan, 2021; Trijayanto & Hakam, 2025). Visual tools like spider and tornado diagrams are commonly employed to illustrate variable impact, enabling investors to assess project resilience under uncertainty.

E. Integration of Technical and Financial Parameters

Recent literature encourages integrating engineering and operational data into financial models to improve forecast accuracy. Technical parameters such as calorific value, stripping ratio, ROM production capacity, and recovery rates, directly influence cash flow estimates and cost structures (Yovanda et al., 2023; Hardiman et al., 2024). This integration is especially important in projects like low-rank coal mining, where marginal changes in productivity or cost assumptions can substantially alter profitability projections.

F. Fiscal Regimes and Regulatory Impacts

The Indonesian coal mining sector operates under a complex fiscal regime, involving royalties, non-tax state revenue (PNBP), corporate income tax (PPh), land and building taxes (PBB), and VAT. These fiscal obligations significantly affect project economics and must be modeled precisely (Gilbran & Hendrawan, 2022). Royalty rates are generally applied as a percentage

of selling price, while land rental (PNBP) is calculated per hectare annually, and the corporate tax is levied at a flat rate of 22% (UU No. 7 Tahun 2021). Adjusting for these variables ensures that cash flow projections reflect actual post-tax returns (Suhendar & Yunita, 2024).

G. Global Perspectives and Best Practices

Although the local context is critical, international benchmarks provide valuable comparative insights. Leedy & Ormrod (2020) and Ghauri et al. (2020) emphasize methodological rigor and transparency in feasibility studies, regardless of geographic location. Lessons from global case studies, such as those in Australia and South Africa, demonstrate the importance of combining technical evaluations with adaptive financial modeling for improved investment decisions.

MATERIALS & METHODS

A. Research Design

This study adopts a descriptive-quantitative research design using a case study approach, as the research aims to analyze the financial feasibility of a specific low-calorie coal mining project in Musi Rawas Utara, South Sumatra. The primary focus is on PT ABC's mining operation, with technical data derived from its site and financial parameters sourced from PT DBL. Descriptive quantitative methods are appropriate for explaining financial and operational dynamics based on numeric data (Leedy & Ormrod, 2020; Sekaran & Bougie, 2021).

B. Research paradigm and Approach

This study aligns with a positivist paradigm, where objective data and financial parameters are emphasized and empirically analyzed. The reasoning follows a deductive approach, starting with established financial concepts such as capital budgeting (e.g., DCF analysis) and applying them systematically to the specific mining project context. This ensures logical consistency

from theory to application (Saunders et al., 2019; Creswell & Creswell, 2023)

C. Method and Strategy

This study employs a quantitative method with a case study strategy, focusing on a low-calorie coal mining project in Indonesia. The financial modeling begins with arranging a 10-year cash flow projection based on a combination of technical and financial data. Technical data such as mineable reserves, production volumes, and stripping ratio are sourced from PT ABC, while financial assumptions including capital cost, operating cost, indirect cost, and escalation rates are obtained from PT DBL. These two sets of data are integrated to form the basis of cost and revenue projections throughout the project lifespan.

Escalation factors are applied to adjust cost and price assumptions over time derived from PT DBL's internal financial planning and historical industry benchmarks. These adjusted values ensure that the projections reflect realistic market and cost dynamics over the investment horizon.

The core financial analysis is conducted using the Discounted Cash Flow (DCF) method, beginning with the calculation of Free Cash Flow to Firm (FCFF), which measures cash availability for all capital providers after considering tax, CAPEX, OPEX, and working capital. FCFF is then discounted using the Weighted Average Cost of Capital (WACC), calculated using an extended Capital Asset Pricing Model (CAPM) that includes the risk-free rate, equity beta, market risk premium, cost of debt, and capital structure weightings. The key financial metrics resulting from this analysis include Net Present Value (NPV), Internal Rate of Return (IRR), Discounted Payback Period (DPP), and Discounted Profitability Index (DPI).

To assess the project's resilience under economic uncertainties, a comprehensive sensitivity analysis is carried out. This analysis evaluates the impact of changes in

critical variables such as coal price, OPEX, and CAPEX on financial outcomes. Sensitivity is visualized using two-way data tables, spider web charts, tornado diagrams, and is quantitatively summarized with sensitivity indexes. These tools provide a robust overview of which variables most significantly affect project feasibility and support informed decision-making.

D. Unit of Analysis and Time Frame

The unit of analysis in this research is the project-level financial feasibility of PT ABC's coal mining operation. The feasibility is assessed by analyzing the cash flow and investment return over the full operational span of the project. The time frame used in the study is cross-sectional with future projection, where all base assumptions (e.g., prices, costs, taxation, royalties) are standardized as of November 2025, the month when the study is conducted. The financial model then projects forward for 10 operational years, covering the project's planned commercial lifespan. This ensures consistency and relevancy in economic assumptions and aligns with industry norms in mining feasibility studies.

E. Data Type and Sources

The study uses both primary and secondary data. Primary data include technical inputs such as reserve quantities, stripping ratio, production schedules, and mining costs, all of which are obtained directly from PT ABC's internal mining and planning database. These technical parameters serve as the backbone for determining production volume, cost estimates, and overall mine productivity. Meanwhile, secondary data consist of financial assumptions and external variables such as capital cost benchmarks, operational cost assumptions, escalation factors, coal price references (such as ICI and HBA), corporate tax rates, and royalty structures. These financial parameters are sourced from PT DBL's corporate projections and PT DBL's

financial planning data, as well as official regulatory sources including the Indonesian Ministry of Energy and Mineral Resources (Geoportal Minerba ESDM), Government Regulation No. 26/2022, and pricing databases like Argus Media and Coalindo.

F. Population and Sampling

The population in this study includes all IUP OP (Production Operation Mining License) holders in Indonesia. The sample is selected using purposive sampling, where PT ABC is chosen because it represents a typical low-rank coal mine with substantial reserves and high market sensitivity, characteristics that align with the purpose of this study.

G. Researcher Involvement and Setting

The level of researcher involvement is moderate interference, as the researcher is affiliated with PT PT DBL and has access to internal financial parameters, but does not influence PT ABC's operational processes directly. The study setting is non-contrived, using actual company data and industry assumptions without simulated environments.

H. Data Analysis Technique

The analysis begins by calculating the Free Cash Flow to Firm (FCFF) using technical and financial parameters gathered from PT ABC and PT PT DBL. The FCFF captures the cash flow available to all capital holders after accounting for taxes, OPEX, CAPEX, and changes in working capital. The WACC is then calculated using the extended CAPM approach, which integrates the cost of equity (based on risk-free rate, beta, and market risk premium) and cost of debt (adjusted for tax benefits), weighted according to the firm's capital structure. This WACC is used as the discount rate for computing the NPV of the project. Additional financial indicators such as IRR, DPP, and DPI are also derived to measure return performance and capital efficiency. To complement this, a sensitivity analysis is conducted to evaluate how key financial outputs (particularly NPV and IRR) respond to fluctuations in critical variables such as coal price, OPEX, and CAPEX. This analysis helps determine the project's resilience under varying economic scenarios and provides a deeper insight into risk factors that influence project viability.

Table 1 Measurement Scale for Variables

No	Varbiabile	Definition	Formula	Scale
1	WACC (Extended CAPM)	The weighted average cost of capital (WACC) represents the average cost of all sources of a company's funding and serves as the minimum required return demanded by investors (Ross, Westerfield, & Jaffe, 2019).	$WACC = (E/V \times Re) + (D/V \times Rd \times (1 - Tc))$ $Re = Rf + \beta \times (Rm - Rf) + CRP + SP$ di mana Rf = Risk-free rate, β = beta industri, CRP = Country Risk Premium, SP = Size Premium	Ratio
2	Free Cash Flow to the Firm (FCFF)	Representation of operational cash flows available to all capital providers, both creditors and equity holders, reflecting the project's fundamental ability to generate cash (Brigham & Ehrhardt, 2020).	$FCFF = EBIT \times (1 - Tc) + Depretiation - Capital Cost - \Delta Working Capital$	Ratio
3	Net Present Value (NPV)	Difference between the present value of cash inflows and the initial investment, indicating the net added value of the project (Brigham & Ehrhardt, 2020).	$NPV = \sum_{t=1}^n \frac{FCFF_t}{(1+r)^t} - Initial Investment$	Ratio

No	Varbiabile	Definition	Formula	Scale
4	Internal Rate of Return (IRR)	Discount rate that equates the present value of cash inflows to the initial investment amount (Brigham & Ehrhardt, 2020).	$0 = \sum_{t=1}^n \frac{FCFF_t}{(1+IRR)^t} - \text{Initial Investment}$	Ratio
5	Discounted Payback Period (DPP)	Amount of time required to recover the initial investment from annual discounted cash flows (Brigham & Ehrhardt, 2020).	$DPP = t + \frac{\text{Remaining Investment at year } t}{FCFF_{t+1}}$	Ratio
6	Discounted Profitability Index (DPI)	Ratio of the present value of cash flows to the initial investment (Brigham & Ehrhardt, 2020).	$DPI = \frac{\sum_{t=1}^n \frac{FCFF_t}{(1+r)^t}}{\text{Initial Investment}}$	Ratio
7	Sensitivity Analysis	Used to assess how changes in key variables affect financial outcomes (Brealey et al., 2020).	$\text{Sensitivity} = \frac{(\Delta \text{Output} / \text{Output}_0)}{(\Delta \text{Input} / \text{Input}_0)}$	Ratio

Source: Processed Data (2025)

RESULT

A. Baseline Technical Inputs and Macroeconomic Parameters

The financial model for the low-rank coal mining project is developed based on comprehensive technical data and economic assumptions as of November 2025. The project is located on a concession area of approximately 4,394 hectares, which determines the statutory land rental obligations under prevailing regulations. Total extractable reserves are estimated at 6 million metric tonnes (MT), with an average gross as-received (GAR) calorific value of 4,000 kcal/kg. This coal specification is directly tied to the low-rank coal pricing index used in the market, ensuring consistent revenue estimation aligned with the Indonesian Coal Index (ICI).

The mine design is constrained by a maximum allowable stripping ratio of 6:1, in line with the geological and operational parameters of the pit. Logistical infrastructure constitutes a significant cost element, starting with a 2.5 km hauling route from the pit to the ROM stockpile, followed by an overland transport of 125.97 km to the port, and concluding with a transshipment distance of approximately 130 nautical miles to the offshore anchorage point.

Macroeconomic assumptions include a benchmark exchange rate of IDR 16,815.66 per USD, a Value Added Tax (VAT) of 11%, and an applicable income tax rate of 1.5% in accordance with the fiscal regulations. Market price projections are anchored on the ICI as published in November 2025, with a reference price of USD 46.21 per metric tonne for 4,000 GAR coal quality.

B. Valuation Methodology and Cost of Capital (WACC)

To evaluate the project's present values under a traditional, conservative framework, the discount rate was modeled via an extended Capital Asset Pricing Model (CAPM) utilizing financial data from PT DBL. The Cost of Equity (CoE) was determined to be 26.18%, integrating a sovereign risk-free rate of 6.14% (based on Indonesian government bonds), an equity risk premium of 7.03%, a country risk premium of 2.82%, and a highly market-sensitive corporate equity beta of 2.45. On the debt side, the pre-tax cost of borrowing is set at 12.00%, which translates to a post-tax Cost of Debt (CoD) of 9.36% when factoring in the statutory 22% corporate tax shield. Given DBL's highly leveraged capital structure comprising 59.61% debt and 40.39% equity, the resulting Weighted

Average Cost of Capital (WACC) is established at 16.16%. This represents the minimum hurdle rate required to satisfy all capital providers and is used as the sole discount factor for the project's cash flows.

C. Direct Operational and Indirect Cost Breakdown

The total production cost required (table 2) to deliver one ton of coal on a Free-On-Board (FOB) basis is USD 31.71 (excluding VAT) or USD 34.18 (including VAT). Direct operational expenditures (OPEX) sum-up to USD 22.50 per ton, exhibiting an extreme concentration in overland logistics. Coal hauling and intermediate stockpile (ISP) fees account for USD 15.26 per ton, constituting 67.80% of total OPEX and 49.56% of the overall project cost due to long-distance third-party road fees. Other direct mining activities are highly optimized; overburden removal is fixed at USD 2.24 per

bcm (amounting to USD 9.92 per ton at a 4:1 stripping ratio), pit-level coal getting costs USD 1.77 per ton, and port loading/barging requires USD 3.78 per ton. Indirect costs add an additional USD 9.211 per ton to the expenditure profile. This category is heavily dominated by statutory government royalties (9% rate for low-rank coal) at USD 4.16 per ton, and a corporate management fee of USD 2.00 per ton. The remaining balance covers corporate administration (USD 1,34 per ton), environmental reclamation and legal insurance bonds (USD 0.35 per ton), and Corporate Social Responsibility (CSR) allocations (USD 0.46 per ton). To insulate field margins from volatile energy shocks, commercial contracts embed a Rise and Fall clause pegged to industrial diesel, budgeted at USD 0.08 per ton for mining and USD 1.84 per ton for hauling.

Table 2 Direct Operational and Indirect Cost Breakdown

Items	Unit	Nominal (\$ exc VAT)	Nominal (\$ Inc VAT)
Operational Cost			
Overburden Removal Cost			
OB Removal @1 SR	\$/bcm	2.04	2.26
Overhaulage Distance @500 M	\$/bcm	0.20	0.22
Overburden Removal Total Cost	\$/bcm	2.24	2.48
Coal Mining Cost			
Coal Getting	\$/t	0.80	0.89
Jasa Coal Hauling (Pit To ROM CPP @2.5 km)	\$/t	0.20	0.22
Crushing/Processing Coal at ROM CPP	\$/t	0.49	0.54
Rise and Fall (Base Rate Fuel) Pit to ROM CPP @2.5 km	\$/t	0.07	0.08
Road Maintenance Pit to ROM CPP	\$/t	0.04	0.04
Coal Mining Total Cost	\$/t	1.60	1.77
Coal Hauling & ISP Cost			
Coal Hauling Services Fee (ROM CPP To ISP) @57.97 km	\$/t	4.65	5.17
Coal Hauling Services Fee (ISP to Port) @68 km	\$/t	5.46	6.06
Hauling Road Fee	\$/t	3.00	3.33
Rise and Fall (Base Rate Fuel) ROM CPP To ISP @57.97 KM	\$/t	1.65	1.84
ISP Location Rental Fee	\$/t	0.14	0.16
ISP Rehandling Fee	\$/t	0.35	0.39
Coal Hauling & ISP Total Cost	\$/t	15.26	16.94

Items	Unit	Nominal (\$ exc VAT)	Nominal (\$ Inc VAT)
Coal Loading & Barging Cost			
Port Rehandling & Loading Fee	\$/t	0.77	0.85
Port Rent Fee	\$/t	2.50	2.78
Coal Sampling	\$/t	0.04	0.04
Transshipment Fee (To MV - Anchorage @130 NM)	\$/t	-	-
MV Loading Fee	\$/t	-	-
Surveyor Independent	\$/t	0.10	0.11
Stevedoring	\$/t	-	-
Coal Loading & Barging Total Cost		3.41	3.78
Total Operational Cost		22.50	24.97
Indirect Cost			
Administration & Overhead	\$/t	1.34	1.34
Corporate Social Responsibility (CSR)	\$/t	0.46	0.46
Reclamation	\$/t	0.20	0.20
Management Fee	\$/t	2.00	2.00
Government Royalty @9%	\$/t	4.16	4.16
PNBP (PP No. 26 Tahun 2022) @Rp 6000/Ha/Year	\$/t	0.003	0.003
PBB	\$/t	0.10	0.10
PNBP Forestry	\$/t	-	-
JAMREK & RPT	\$/t	0.35	0.35
Coordination etc	\$/t	0.10	0.10
Land Compensation	\$/t	0.50	0.50
Total Indirect Cost		9.211	9.211
Total Cost	\$/t	31.71	34.18
Coal Price (FOB)	\$/t	46.21	50.60
Margin	\$/t	14.50	16.42
Break Even Stripping Ratio (BESR)	bcm/t	7.49	7.62

Source: Processed Data (2025)

D. Pit Optimization and Economic Margin Analysis

Before establishing full financial projections, a tactical geological and pit limit optimization was conducted on the PT ABC low-rank coal concession to align technical mine constraints with maximum economic returns. To determine the most feasible pit boundary, a multi-scenario simulation across eight distinct stripping ratio (SR) levels was evaluated, as tabulated in Table 3. The economic trade-off framework explicitly shows that profit margins contract systematically as the stripping ratio increases due to the

exponential surge in overburden removal costs.

Based on the quantitative metrics, Opsi 1 with a Stripping Ratio (SR) of 4:1 was selected as the optimal technical and economic threshold to exploit the asset's reserves. At this base geometry, the project minimizes early-stage stripping costs, requiring an overburden expenditure of USD 59,540,400 against a total cost framework of USD 253,559,014. This balanced cost structure yields a highly secure Gross Profit Margin of USD 52,810,129.14 (17.39% of gross revenue),

or equivalent to a unit profit of USD 8.802 per ton.

In contrast, scenarios with higher strip ratios exhibit severe margin erosion. Beyond Opsi 4 (SR 7), which marks the final boundary of positive returns with a razor-thin Gross Profit Margin of 2.85% (USD 1.445/t), any further pit expansion drops directly into structural deficits. Opsi 5 (SR 8) through Opsi 8 (SR 11) shift entirely into the red zone, with accumulated net losses deepening from -USD 13.38 million to a catastrophic deficit of -USD 210.86 million, driven by unsustainable waste-hauling expenditures that heavily outpaced top-line revenue capacity.

By optimizing the pit limit specifically at an SR of 4:1, the operation locks in a highly resilient and thick operational cushion. This geological configuration ensures that subsequent mining sequences strictly target the most economically viable coal blocks, insulating the corporate joint venture from market shocks and setting a mathematically robust baseline for the financial projections and cash flow modeling detailed in the next section.

E. Financial Projections and Cash Flow Analysis

To evaluate the venture's financial delivery, the Free Cash Flow to the Firm (FCFF) is projected across a 10-year Life of Mine (LOM). This financial model incorporates a multi-tiered annual escalation adjustment; a conservative 1.0% growth for coal selling prices, a 4.0% indexing for operational expenditures (OPEX) to offset core maintenance inflation, and a 1.0% escalation for indirect cost blocks. Operationally, the mine implements a realistic 50% capacity ramp-up in Year 1, translating to an initial output of 300,000 MT. The remaining 300,000 MT of commercial capacity is introduced progressively as a 60,000 MT annual volume increment from Year 2 through Year 6, bringing peak extraction to 660,000 MT per annum, before contracting

back to a stable 600,000 MT baseline during the late-stage production years.

The project's liquidity curve begins in Year 1 with a net cash deficit of -USD 150,537.11. This front-loaded deficit is driven by an initial infrastructure capital expenditure (CAPEX) of USD 1,025,000 paired with a Net Working Capital (NWC) injection of USD 1.24 million, which is required to bridge the standard 30-day Day Sales Outstanding (DSO) credit cycle. To mitigate the inherent spontaneous combustion risks associated with low-rank coal stockpiles, inventory holding periods are strictly optimized at a tight 15-day window. Combined with a balanced 15-day accounts payable cycle, the cumulative net working capital exposure scales efficiently, reaching its peak requirements in Year 6 at USD 2.92 million.

A major liquidity reversal occurs in Year 2, where the FCFF shifts dramatically into a positive surplus of USD 2,662,533.59. This immediate financial turnaround is powered by a robust Net Operating Profit Less Adjusted Taxes (NOPAT) of USD 4.08 million generated from peak-volume sales, which comfortably absorbs the parallel working capital expansions. By Year 3, as infrastructure outlays fall to zero and incremental working capital adjustments stabilize, the free cash flow accelerates to its historic maximum of USD 3,705,288.69.

Most notably, the asset exhibits remarkable financial resilience during its final operational stretch from Year 8 through Year 10, completely evading the risk of a late-stage capital deficit. The project maintains a solid, debt-free green posture, locking in substantial cash surpluses of USD 1,304,887.60 in Year 8, USD 891,766.27 in Year 9, and safely wrapping up the concession in Year 10 with a positive cash clearance of USD 478,644.93. This late-stage profitability confirms that the underlying NOPAT structure is strong enough to insulate the project from both the compounding 2.0% annual cost inflation

and the planned volume reduction back to the 600,000 MT quota. Enhanced by the annual non-cash straight-line depreciation add-back of USD 102,500, the venture remains thoroughly protected from late-stage losses. Pursuant to the commercial Joint Operation (JO) agreement, this highly

lucrative cash flow profile is split proportionally; 60% is distributed to PT DBL as the risk-bearing technical contractor, while the remaining 40% is retained by PT ABC as the underlying concession owner.

Table 3 Optimum Pit by Gross Profit Margin

OPTI ON PIT	COA L (MT)	S R	OB REMO VAL COST (\$)	COAL MINE D COST (\$)	INDIR ECT COST (\$)	CAPIT AL COST (\$)	TOTAL COST (\$)	GROSS REVENU E (\$)	GROSS PROFIT MARGIN (\$)	GRO SS PRO FIT MAR GIN (%)
1	6,000, 000	4	59,540, 400	134,95 2,221	58,041, 393	1,025,0 00.00	253,559, 014	307,755,4 28.57	54,196,41 4.85	17.61 %
2	6,500, 000	5	80,627, 625	146,19 8,240	62,878, 175	1,025,0 00.00	290,729, 040	333,401,7 14.29	42,672,67 4.43	12.80 %
3	8,000, 000	6	119,080, 800	179,93 6,295	77,388, 523	1,025,0 00.00	377,430, 618	410,340,5 71.43	32,909,95 3.14	8.02%
4	12,000 ,000	7	208,391 ,400	269,90 4,442	116,08 2,785	1,025,0 00.00	595,403, 627	615,510,8 57.14	20,107,22 9.71	3.27%
5	13,000 ,000	8	258,008 ,400	292,39 6,479	125,75 6,350	1,025,0 00.00	677,186, 230	666,803,4 28.57	(10,382,80 1.15)	- 1.56%
6	15,000 ,000	9	334,914 ,750	337,38 0,553	145,10 3,481	1,025,0 00.00	818,423, 784	769,388,5 71.43	(49,035,21 2.86)	- 6.37%
7	20,000 ,000	1 0	496,170 ,000	449,84 0,737	193,47 1,308	1,025,0 00.00	1,140,50 7,046	1,025,851, 428.57	(114,655,6 17.15)	- 11.18 %
8	25,000 ,000	1 1	682,233 ,750	562,30 0,922	241,83 9,136	1,025,0 00.00	1,487,39 8,807	1,282,314, 285.71	(205,084,5 21.44)	- 15.99 %

Source: Processed Data (2025)

F. Investment Appraisal and Feasibility Metrics

Discounting the projected net cash flows against the 16.16% WACC hurdle rate confirms that the mining investment delivers exceptionally strong feasibility metrics across all primary appraisal criteria. The cumulative Net Present Value (NPV) settles at a superior positive surplus of USD 5,817,877.85 (equivalent to IDR 97,831,455,860.11), vastly exceeding the baseline economic requirement of NPV > 0 and proving the project's capacity to generate significant corporate wealth.

Capital efficiency and asset returns are further validated by the Internal Rate of

Return (IRR), which accelerates to an elite 88.00% under a Modified IRR (MIRR) framework to maintain realistic corporate reinvestment expectations. This extraordinary rate of return establishes a highly secure 71.84% safety spread above the mandated cost of capital. Concurrently, project liquidity risk is minimized to an exceptionally low level, as evidenced by a swift Discounted Payback Period (DPP) of only 1.07 years, ensuring full capital recovery within approximately the first thirteen months of operations. Finally, the asset's superior capital utilization efficiency is anchored by a Discounted Profitability Index (DPI) of 5.27, demonstrating that the venture captures USD 5.27 in discounted

present value terms for every single dollar of infrastructure capital initially deployed.

Table 4 Profit and Loss Projections

PROFIT & LOSS (\$)	PERIOD									
	1	2	3	4	5	6	7	8	9	10
Revenue	15,179,829	33,729,579	34,063,535	34,397,492	34,731,448	35,065,404	32,181,237	32,484,833	32,788,430	33,092,026
Operating Cost (-)	12,488,072.1	28,390,321.9	29,306,885.1	30,223,448.4	31,140,011.6	32,056,574.8	29,975,580.1	30,808,819.4	31,642,058.7	32,475,298.0
Operating Margin (EBITDA)	2,691,756.46	5,339,257.20	4,756,650.19	4,174,043.18	3,591,436.17	3,008,829.17	2,205,656.51	1,676,013.77	1,146,371.04	616,728.30
Depretiation & Amortization (-)	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00
EBIT	2,589,256.46	5,236,757.20	4,654,150.19	4,071,543.18	3,488,936.17	2,906,329.17	2,103,156.51	1,573,513.77	1,043,871.04	514,228.30
Interest (-)	73,314	73,314	73,314	73,314	73,314	73,314	73,314	73,314	73,314	73,314
Earning Before Tax (EBT)	2,515,942.05	5,163,442.79	4,580,835.79	3,998,228.78	3,415,621.77	2,833,014.76	2,029,842.10	1,500,199.37	970,556.63	440,913.90
Corporate Rate Tax (-)	553,507.25	1,135,957.41	1,007,783.87	879,610.33	751,436.79	623,263.25	446,565.26	330,043.86	213,522.46	97,001.06
Net Income	1,962,434.80	4,027,485.38	3,573,051.91	3,118,618.45	2,664,184.98	2,209,751.51	1,583,276.84	1,170,155.51	757,034.18	343,912.84

Source: Processed Data (2025)

G. Risk Sensitivity Analysis and Strategic Interventions

Deterministic and multi-variable sensitivity simulations across 5% stress spectrum reveal a distinct variance between volatile external market forces and highly controlled internal cost structures. Market Coal Price emerges as the most hyper-sensitive and dominant variable, commanding an absolute wealth swing of USD 9.57 million and a primary Sensitivity Index (SI) of 16.71. Because commodity pricing dictates top-line revenue

realizations without baseline deductions, it remains the most critical risk vector. However, reflecting the updated robust financial model, the venture demonstrates exceptional structural resilience; a severe -5% market price contraction fails to jeopardize the project's viability, safely preserving a positive Net Present Value (NPV) of USD 1,100,478.17. Conversely, a favorable +5% price expansion surges the asset's net worth up to an expansive USD 10,678,168.90.

Table 5 Free Cash Flow to the Firm Projections

Items (\$)	PERIOD									
	1	2	3	4	5	6	7	8	9	10
NOPA	2,019,620.04	4,084,670.61	3,630,237.15	3,175,803.68	2,721,370.22	2,266,936.75	1,640,462.08	1,227,340.74	814,219.41	401,098.08
Depretiation & Amortization (+)	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00	102,500.00
Capital Cost (-)	1,025,000	-	-	-	-	-	-	-	-	-
ΔWorking	1,247,657.14	1,524,637.03	27,448.46	27,448.46	27,448.46	27,448.46	(237,054.86)	24,953.14	24,953.14	24,953.14

Items (\$)	PERIOD									
	1	2	3	4	5	6	7	8	9	10
Capital (Δ NW C)(-)										
FCFF	(150,53 7.11)	2,662,5 33.59	3,705,2 88.69	3,250,8 55.22	2,796,4 21.76	2,341,9 88.29	1,980,0 16.93	1,304,8 87.60	891,7 66.27	478,6 44.93
FCFF @DBL	(90,322 .26)	1,597,5 20.15	2,223,1 73.21	1,950,5 13.13	1,677,8 53.06	1,405,1 92.98	1,188,0 10.16	782,93 2.56	535,0 59.76	287,1 86.96
FCFF OWNE R	(60,214 .84)	1,065,0 13.43	1,482,1 15.48	1,300,3 42.09	1,118,5 68.70	936,79 5.32	792,00 6.77	521,95 5.04	356,7 06.51	191,4 57.97

Source: Processed Data (2025)

Operating Expenditures (OPEX) exhibit a low-to-moderate risk elasticity, returning a sensitivity index of -0.86. While inflationary cost overruns in contract mining activities compress profit margins, the risk exposure is thoroughly insulated by the project's thick operational margin baseline; a +5% operational cost shock leaves the project highly profitable, retaining a secure green NPV of USD 5,566,301.23. Lastly, Capital

Expenditures (CAPEX) exert a mathematically negligible impact on long-term wealth creation, carrying a minor index of only -0.08. A 5% infrastructure development cost overrun trims the cumulative present worth minimally, settling at USD 5,794,655.59 due to the heavily discounted, one-time nature of front-loaded Year 1 outlays.

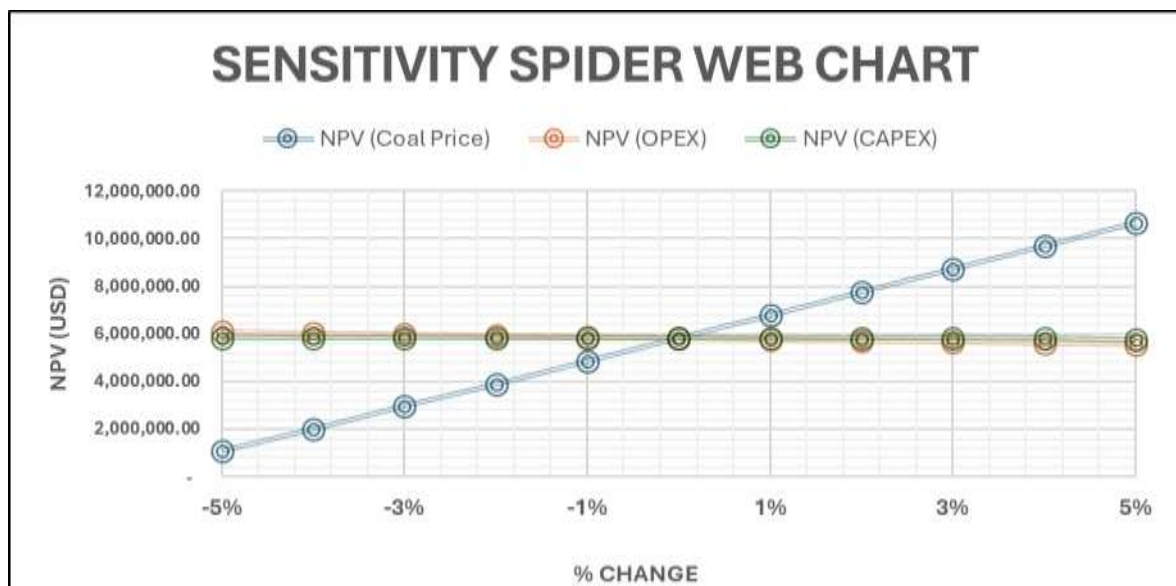


Fig. 1 Sensitivity Spider Web Chart
Source: Processed Data (2025)

Although the updated cash flow model confirms that the project naturally maintains a debt-free, positive cash regime until the end of the concession, four corporate value-enhancement strategies are recommended to

further accelerate capital returns and maximize overall asset worth. First, strategic production acceleration should be deployed; re-engineering the mine schedule to consistently maintain the peak 660,000 MT

capacity through the late stages front-loads cumulative revenues, shortens the project lifespan, and capitalizes on the time value of money while bypassing compounding late-stage operational cost escalations. Second, aggressive logistical cost controls must be prioritized; management can leverage corporate scale to secure volume discounts via long-term hauling contracts, deploy digital tracking over fuel efficiencies to neutralize automatic Rise and Fall clauses, and explore shorter bypass routes to cut road fee expenditures. Third, price hedging through fixed-price off-take agreements remains vital to lock in top-line revenue stability, protecting the project's superior yields from sudden global price downturns. Finally, progressive stripping ratio tailoring should be engineered during the final operational stretch; modifying pit boundaries to target shallower coal seams with an optimized stripping ratio below the 4:1 baseline (e.g., 3.5:1) directly reduces waste-removal outlays, significantly boosting late-stage Net Operating Profit Less Adjusted Taxes (NOPAT) and maximizing net cash distributions for the Joint Operation stakeholders.

DISCUSSION

The findings of this research indicate that the low-rank coal mining project analyzed is not only financially feasible but also resilient against fluctuations in market price and operating cost variables. This aligns with the assertion made by Suhendar & Yunita (2024), who emphasized the significance of Free Cash Flow to the Firm (FCFF) as a reliable basis for valuation since it reflects the project's fundamental ability to generate cash for both creditors and equity holders. In this study, FCFF projections incorporated a comprehensive assessment of revenues, operating expenditures, taxes, capital expenditures, and working capital adjustments, all adjusted using macroeconomic assumptions as of November 2025.

The implementation of the Discounted Cash Flow (DCF) method in the project evaluation further supports prior studies by Hartati & Isnaeni (2021) and Setianingsih & Husodo (2022), who advocate DCF as the most dependable method for long-term investment appraisal due to its consideration of the time value of money. Here, financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), Discounted Payback Period (DPP), and Discounted Profitability Index (DPI) all yielded highly positive results, with an IRR of 88% and a DPI of 5.27, well above the minimum investment viability threshold.

In terms of risk assessment, the sensitivity analysis conducted in this research corroborates findings by Indrayana & Nainggolan (2021) and Trijayanto & Hakam (2025), who underscore the critical role of sensitivity testing in mining investment decisions. Using spider diagrams, tornado charts, and sensitivity indices, the analysis revealed that coal selling price is the most influential variable, with a sensitivity index of 16.71. However, even in the pessimistic scenario (a 5% price reduction), the project maintained a positive NPV, indicating strong financial resilience.

The integration of technical parameters into the financial model, as recommended by Yovanda et al. (2023) and Hardiman et al. (2024), added further precision to future cash flow estimates. For instance, the determination of the optimal stripping ratio at 4:1 was not only derived from operational simulation but also evaluated from a financial efficiency perspective, identifying the best gross profit margin structure. This highlights the importance of harmonizing technical and financial data in obtaining a realistic and accurate project evaluation.

The study also reaffirmed the relevance of using the extended Capital Asset Pricing Model (CAPM) in calculating the Weighted Average Cost of Capital (WACC). By incorporating a country risk premium and sectoral beta, as suggested by Srivastava et al. (2021) and Putri et al. (2023), the

resulting WACC of 16.16% appropriately represents the required return in the context of Indonesian mining investment.

Lastly, the proposed value enhancement strategies including production acceleration, logistic cost efficiency, coal price hedging, and the reduction of stripping ratio in later operational years—are consistent with adaptive project management approaches in high-risk industries, as explored by Leedy & Ormrod (2020) and Ghauri et al. (2020). These measures demonstrate that with proper financial modeling and proactive operational strategies, low-rank coal projects can generate substantial economic value even under marginal market conditions.

CONCLUSION

This research concludes that the low-rank coal mining project under the PT ABC concession is financially viable and strategically sound. Through a rigorous application of the Discounted Cash Flow (DCF) method, the study evaluated the financial outlook of the project by integrating technical parameters, baseline cost structures, and macroeconomic assumptions effective as of November 2025. The Free Cash Flow to the Firm (FCFF) approach served as the core framework, constructed from a comprehensive breakdown of operating revenues, cost assumptions, taxes, capital expenditures, and changes in working capital. These were projected annually over the 10-year mine life and adjusted using cost escalation factors provided by PT DBL.

The analysis confirmed that the project meets all key financial feasibility criteria. The Net Present Value (NPV) indicates strong economic profitability, while the Internal Rate of Return (IRR) reflects a high level of capital efficiency relative to the cost of capital. Liquidity risk is minimal as seen through the rapid payback period, and overall profitability is reinforced by the high Discounted Profitability Index (DPI). These outcomes demonstrate that the financial

foundation of the project is robust, even when challenged by long-term inflation and operational dynamics.

Sensitivity analysis further validates the resilience of the project by identifying the key cost and revenue drivers. The coal selling price emerges as the most influential factor, but the project retains a profitable status even under adverse price movements. Internal variables such as operational and capital expenditures exhibit relatively low sensitivity, underscoring the stability of the financial model. This confirms that the assumptions used in FCFF, particularly for baseline costs and revenue projections, are critical to the success of the financial structure.

Based on these findings, several strategic recommendations are proposed. First, maintaining or accelerating production levels through optimized mine scheduling is essential to maximize early cash flows and reduce exposure to late-stage cost inflation. Second, cost containment, particularly along logistical transport routes should be prioritized through contractual efficiencies and infrastructure optimization. Third, management is advised to pursue hedging mechanisms or fixed-price off-take agreements to stabilize revenue streams against market volatility. Finally, pit design strategies should be refined to reduce stripping ratios in the later stages of the project, thereby decreasing operational costs and enhancing profit margins.

Overall, this study emphasizes the importance of integrating detailed technical and financial assumptions within a structured valuation framework. The findings provide a strong foundation for investment decisions, and the recommendations offer practical avenues for enhancing the long-term financial sustainability of low-rank coal mining ventures.

Declaration by Authors

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