TRUCKING SYSTEM VS. CONVEYOR SYSTEM FOR COAL MATERIAL TRANSPORTATION IN PT. BUKIT ASAM COAL MINES

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Abstract

PT Bukit Asam Tbk (PTBA), a major state-owned coal producer, has set an ambitious target to increase coal output from 40 million tons in 2024 to 100 million tons by 2029. Using a quantitative research design, the study applies capital budgeting tools such as Net Present Value (NPV), Internal Rate of Return (IRR), and Incremental Analysis, along with risk evaluation methods including sensitivity analysis, scenario analysis, and Monte Carlo simulations. The analysis reveals that transitioning to a conveyor system yields a significant NPV advantage of IDR 6.57 trillion and an incremental IRR of 19.97%, surpassing the project's hurdle rate. Monte Carlo results indicate a 71% probability of achieving positive NPV, affirming the conveyor system's robustness under financial uncertainty. Beyond financial returns, the conveyor alternative offers operational improvements such as lower emissions, higher safety, and more reliable throughput. This feasibility study concludes that the conveyor-based system is both economically and strategically superior, aligning with PTBA's long-term goals for cost efficiency, environmental responsibility, and production scalability.

Keywords: Coal Transportation, NPV, IRR, Monte Carlo Simulation, PT Bukit Asam

INTRODUCTION

Indonesia, with its robust industrial base and growing population, continues to see rising energy demand, much of which is met by coal due to its abundance and low cost. The coal sector has been a cornerstone of economic growth, generating employment, supporting local economies, and contributing foreign exchange through exports. However, global decarbonization trends and stricter environmental expectations have increased pressure on coal companies to adopt more sustainable and responsible practices. Within this landscape, PT Bukit Asam Tbk (PTBA) has emerged as a leading coal producer, balancing its role in supporting Indonesia's energy needs with its commitment to modernization, environmental stewardship, and corporate responsibility.

PTBA has a long history dating back to 1919 and has evolved from a colonial-era operation to a publicly listed, state-majority-owned company under MIND ID. Its diversified operations now include coal mining, power generation, and coal derivatives, backed by strong governance and a clear vision: to become a world-class, environmentally responsible energy company. PTBA manages significant reserves and resources, primarily concentrated in South Sumatra, and integrates mining, logistics, and sales to serve both domestic and international markets. Its strategic roadmap for 2025–2029 emphasizes scaling production, optimizing the value chain, adopting cleaner technologies, and strengthening its ESG profile all while aiming to increase annual production from 40 to over 100 million tons by 2029.

This ambitious growth plan, however, highlights a critical business challenge: how to transport rapidly growing coal volumes efficiently and sustainably. Traditionally, PTBA has relied on dump trucks, which are increasingly costly and environmentally problematic as production scales up. The truck-based system entails high fuel use, maintenance costs, emissions, and road degradation straining infrastructure, raising social and environmental concerns, and conflicting with the company's sustainability commitments. Remote mine locations further complicate logistics, making road maintenance expensive and causing disruptions to local communities. These challenges point to the need for a more efficient, lower-impact transportation solution that aligns with PTBA's strategic and sustainability goals.

REVIEW OF LITERATURE

Capital Budgeting

Capital budgeting is the evaluation and selection of long-term investment projects that align with a firm's goal of maximizing shareholder wealth. It involves analyzing expenditures on infrastructure, machinery, and facilities using methods like NPV, IRR, Payback Period, and Profitability Index (Brealey et al., 2019).

Decision Making Process

The decision-making process in investments follows a structured approach: identifying the problem, gathering data, evaluating alternatives, choosing the best option, and implementing it (Simon, 1997). This process can be rational, boundedly rational, or intuitive, depending on information availability and environmental uncertainty.

Net Present Value (NPV)

Net Present Value (NPV) calculates the value of an investment by discounting future cash flows to present value, considering the initial cost. A positive NPV means the project

adds value, making it a preferred decision-making tool because it accounts for the time value of money and risk (Ross et al., 2020).

Benefit–Cost Analysis (BCA)

Benefit Cost Analysis (BCA) compares the total benefits of a project to its total costs over its lifecycle. A benefit cost ratio above 1 indicates financial viability, making BCA especially useful for large-scale infrastructure and policy projects (Boardman et al., 2018).

Return on Investment (ROI)

Return on Investment (ROI) measures the profitability of a project by dividing net profit by the total investment cost. It is a simple yet powerful metric for assessing performance and comparing different investment opportunities (Gitman & Zutter, 2019).

Cost of Equity

The cost of equity is the return expected by shareholders and is a key part of the Weighted Average Cost of Capital (WACC). Using the CAPM, it accounts for market risk and helps companies decide between equity and debt financing (Damodaran, 2012).

RESEARCH METHOD

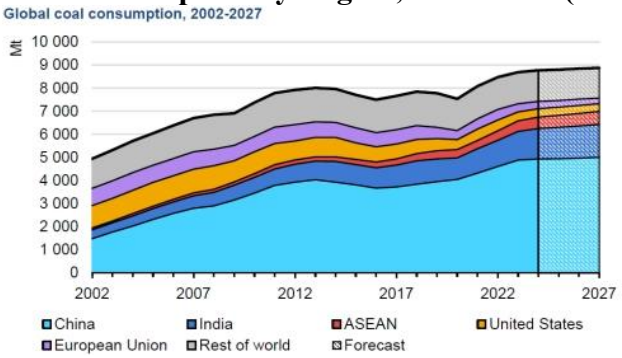
This chapter outlines the research design, data collection, and analysis methods used to evaluate the feasibility of transitioning from a truck-based to a conveyor-based coal transportation system at PT Bukit Asam. The research employs a quantitative, structured approach informed by internal records, external benchmarks, and stakeholder input to assess operational, financial, strategic, and environmental aspects. Data is collected through semi-structured interviews, focus groups, company documents, industry reports, and academic studies to capture both primary and secondary insights. Analysis begins with a business situation and strategic assessment using external market trends, internal VRIO, and SWOT frameworks, followed by a detailed financial comparison of the two systems, applying tools like NPV, IRR, PP, and CBA. Risk is addressed through sensitivity analysis, scenario planning, and Monte Carlo simulation to account for uncertainties, while sustainability considerations ensure alignment with ESG goals.

RESULTS AND DISCUSSION

Analysis

Global Coal Demand

Figure 1.
Global Coal Consumption by Region, 2002–2027 (IEA, 2024)

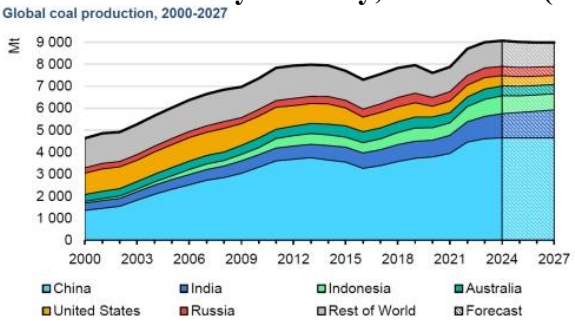


Global coal demand is projected to reach a new peak of 8,771 Mt in 2024, though growth will slow as usage declines in developed nations. By then, China, India, and ASEAN are expected to account for about 75% of global consumption, up sharply from 35% in 2000, while demand in the EU and the U.S. is set to drop due to coal plant retirements. Through 2027, global demand is forecast to plateau, with ongoing declines in Europe and North America balanced by persistent growth in Asia, where rising electricity needs continue to support coal-fired generation despite expanding renewables.

Global Coal Supply

Global coal production reached a new record high of 8,993 Mt in 2023, growing by 3.4% year-on-year, driven mainly by China, India, and Indonesia. China, as the largest producer, increased output to avoid past supply shortages, although its growth rate slowed compared to 2022. Indonesia and India each added over 85 Mt to their production, with Indonesia responding to strong seaborne demand and rising domestic needs, while India focused on boosting supply for power generation to reduce imports and enhance energy security. The graph below illustrates these supply trends across major coal-producing countries:

Figure 2.
Global Coal Production by Country, 2000–2027 (IEA, 2024)



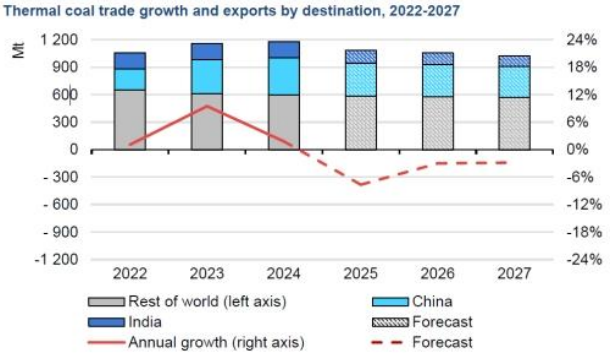
Source: Coal 2024 Analysis and Forecast to 2027 by International Energy Agency (IEA)

In 2024, global coal production is expected to surpass 9 billion tonnes for the first time, driven mainly by India, though declines in the U.S., Russia, and the EU temper this growth, marking the first stagnation since the pandemic. Between 2025 and 2027, production is projected to decline slightly due to weak demand and oversupply, with further reductions in the U.S., EU, and Indonesia offsetting India's continued growth, leaving global output at around 8,984 Mt by 2027, just below the 2023 peak.

Global Coal Trade (Updated with 2024 Forecast)

Global coal trade hit a record high in 2023, rising 10% to 1,510 Mt, driven largely by Asia-Pacific demand, which accounted for 84% of imports amid strong economic and industrial growth. Thermal coal dominated trade, making up over 75% of volumes, while seaborne routes carried over 90% of shipments. China, India, and Japan together made up nearly 60% of global imports, with China leading at 481 Mt. On the export side, Indonesia, Australia, and Russia contributed about 75% of global supply, with Russian exports shifting heavily toward Asia following EU sanctions. In 2024, trade is projected to reach a new peak of 1,545 Mt, led by rising Chinese imports exceeding 500 Mt for the first time.

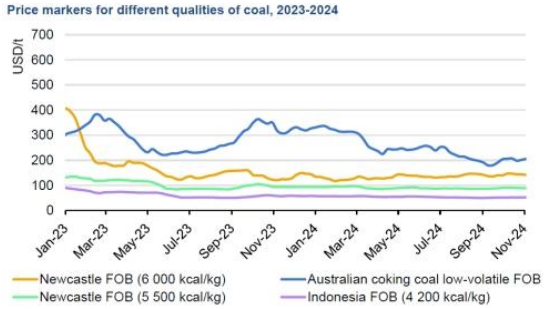
Figure 3.
Thermal Coal Trade Growth and Exports by Destination, 2022–2027 (IEA, 2024)



Source: Coal 2024 Analysis and Forecast to 2027 by International Energy Agency (IEA)

In 2024, Vietnam is set to become one of the world's top five coal importers, overtaking Chinese Taipei with nearly 19% higher imports driven by rising electricity demand, while Russian exports are expected to drop 6% due to sanctions, infrastructure limits, and shrinking profitability. Although global coal trade remains strong in the short term, it is projected to plateau or slightly decline by 2027 as China maintains steady production, India boosts self-reliance, and Western nations phase out coal. Coal prices, which spiked above USD 400 per tonne during the 2022 energy crisis briefly surpassing coking coal returned to normal by 2023 as fundamentals stabilized and the traditional price hierarchy was restored.

Figure 4
Price Markers for Different Qualities of Coal (2023–2024)



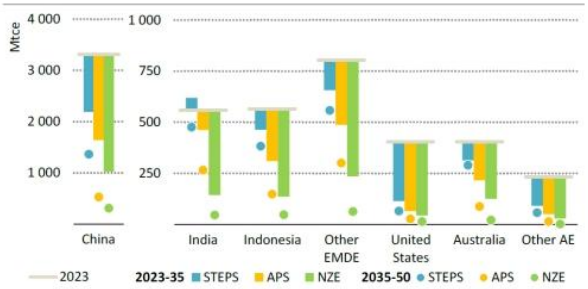
Source: Coal 2024 Analysis and Forecast to 2027 by International Energy Agency (IEA)

In 2023–2024, coal prices varied widely, with Australian coking coal topping USD 350/t in Q3 2023 amid strong Asian demand, while thermal coal saw smaller fluctuations and more stability in mid and low CV grades. Regional factors shaped prices: China's steady domestic output, Australia's weather disruptions, and discounted Russian coal under sanctions. By mid-2024, coking coal prices softened as Mongolian exports rose, reducing the gap with thermal coal. Despite higher costs, producers maintained strong margins, increasing payouts and investing profits into critical minerals like lithium and copper to support long-term resilience in the energy transition.

Global Coal Demand Outlook

The future of global coal demand increasingly depends on the ambition of climate policies, with advanced economies advancing steadily toward decarbonization while emerging markets transition more gradually. Between 2024 and 2035, projections vary by scenario: under the Stated Policies Scenario (STEPS), demand falls about 25% from 2023 levels, with sharper reductions in advanced economies; under the Announced Pledges Scenario (APS), demand drops more steeply by 45%; and in the Net Zero Emissions (NZE) Scenario, which aligns with limiting warming to 1.5°C, coal demand plunges 70% by 2035 and over 90% by 2050.

Figure 5.
Change in Coal Production by Country/Region and Scenario, 2023–2050



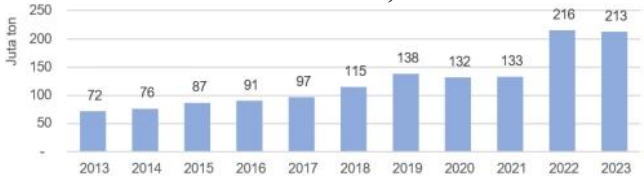
Source: World Energy Outlook 2024 by International Energy Agency (IEA)

China, the largest coal consumer, is expected to cut demand and production as it shifts to renewables but will still exceed half of global use by 2035. India's coal use rises through 2030 under STEPS before stabilizing or falling sooner in APS and NZE, while Southeast Asia's demand grows more slowly in ambitious scenarios. By 2050, global coal demand could drop 45% under STEPS, 75% under APS, and over 90% under NZE, with industrial use surpassing power generation by 2035 in NZE. Coal trade is projected to decline sharply, falling 25–40% under STEPS, ~75% under APS, and to just 10% of 2023 levels under NZE.

Development of the Domestic Coal Industry

Domestic coal demand in Indonesia has significantly increased over the past decade, rising from 72 million tonnes in 2013 to 213 million tonnes in 2023. Although demand dipped in 2020 and 2021 to 132 million tonnes and 133 million tonnes, respectively, due to the COVID-19 pandemic, domestic coal consumption rebounded in 2022, reaching 216 million tonnes, an increase of over 60%. This was driven by post-pandemic recovery and the resurgence of economic, industrial, and societal activities. However, in 2023, demand slightly declined to 213 million tonnes.

Figure 6.
Domestic Coal Sales, 2013–2023



Source: Handbook of Energy & Economic Statistics of Indonesia 2023, Ministry of Energy and Mineral Resources (MEMR)

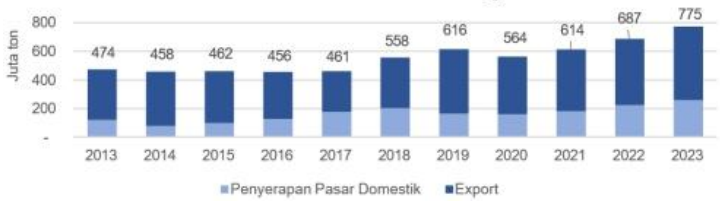
Indonesia's high domestic coal consumption has been driven mainly by the electric power sector (PLTU), which used 129 million tonnes in 2022 and 121 million tonnes in 2023, accounting for 57% of total domestic sales. The metallurgical industry, including iron, steel, and nickel smelting, also grew rapidly, consuming 49 million tonnes in 2022 and 60 million tonnes in 2023, up sharply from 11 million tonnes in 2021, thanks to Indonesia's efforts to build a nickel smelting ecosystem for the electric vehicle and battery supply chain. Other sectors like cement, textiles, and fertilizers followed, using 13 million tonnes in 2022 and 9 million tonnes in 2023, more than double their 2021 consumption.

Figure 7.
Domestic Coal Sales by Industry, 2013–2023

Source: Handbook of Energy & Economic Statistics of Indonesia 2023, MEMR

Indonesia is one of the world's largest coal producers, alongside China, India, and Australia. By 2023, national coal production reached 775 million tonnes, up from 474 million tonnes in 2013. While a portion of production fulfills domestic demand, the majority is exported. With domestic demand at 213 million tonnes, national coal production remains sufficient to support both domestic use and export markets.

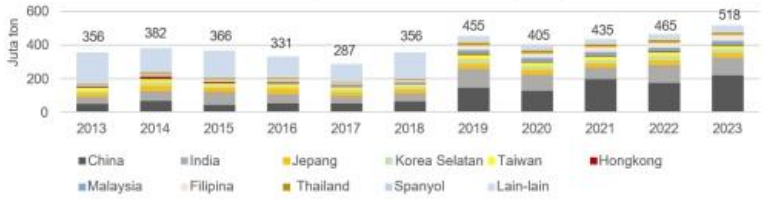
Figure 8.
Domestic Coal Production and Market Absorption, 2013–2023



Source: Handbook of Energy & Economic Statistics of Indonesia 2023, MEMR

By 2023, Indonesia's domestic coal allocation rose to 257 million tonnes, more than double the 118 million tonnes in 2013, driven by rising electricity demand and the expansion of nickel processing industries. This supply is governed by Ministerial Decrees mandating a 25% Domestic Market Obligation (DMO) at a capped price of USD 90/ton for key sectors like electricity, cement, and fertilizers. Meanwhile, coal exports also grew steadily, reaching 518 million tonnes in 2023 from 365 million tonnes in 2013, despite a brief decline during the 2020 pandemic.

Figure 9.
Coal Exports by Destination Country, 2013–2023



Source: Handbook of Energy & Economic Statistics of Indonesia 2023, MEMR

Since 2019, developing Asian countries have emerged as Indonesia's main coal export markets, with China and India together making up 50–60% of annual exports, about 170 to 320 million tonnes, compared to just 20% during 2013–2018. This shift has been fueled by China's rapid industrial growth and India's rising population and infrastructure demands, significantly increasing their coal import needs.

SWOT Analysis

SWOT analysis is a strategic planning framework used to identify and evaluate the Strengths, Weaknesses, Opportunities, and Threats. The detailed analysis is presented as follows:

1. Strengths

Operational safety also improves under the conveyor system. By eliminating thousands of truck movements per year, the company can reduce accident risks, road damage, and exposure to traffic-related disruptions. Furthermore, the continuous material flow enabled by conveyors supports PTBA's strategic production target of increasing output to over 100 million tons by 2029, reinforcing its pursuit of operational excellence.

2. Weaknesses

Despite these advantages, the conveyor system presents several internal limitations. Most notably, it entails a high capital expenditure (CAPEX) upfront, with construction spanning up to two years before any operational returns are realized. This initial financial burden creates short-term liquidity pressures, particularly during the grace period where cash inflows are absent, and interest costs accumulate. Moreover, the fixed-route nature of conveyor systems makes them less flexible compared to trucks, which can easily adapt to shifting excavation zones. In dynamic mining environments like Tanjung Enim, this rigidity can pose a logistical constraint unless accompanied by adaptive mine planning. Additionally, the project's dependency on regulatory approvals including environmental permits and construction licenses may introduce delays and bureaucratic risk.

3. Opportunity

The conveyor investment is strategically positioned to leverage strong coal demand in Asia, particularly from China, India, and Southeast Asia, ensuring long-term market access for PTBA's output and supporting efficient, high-volume logistics. It aligns with Indonesia's national energy and industrial policies that prioritize sustainable, low-emission infrastructure, while also appealing to the global ESG movement, enhancing PTBA's reputation and attracting environmentally conscious investors. Additionally, technological

advances in automation, monitoring, and digital integration offer opportunities to optimize conveyor performance and reliability. Together, these factors make the investment both timely and competitive.

4. Threats

The conveyor project faces notable external threats, particularly from macroeconomic volatility, as sensitivity analysis shows that exchange rate and interest rate fluctuations could impact NPV by up to IDR 1.6 trillion, requiring robust hedging and capital planning. Community resistance is another risk, as land acquisition and environmental concerns may cause delays, reputational damage, or legal challenges. Additionally, the project competes with other strategic priorities within PTBA, potentially limiting internal funding and delaying implementation.

VRIO Analysis

The VRIO analysis of PT Bukit Asam's conveyor-based coal transportation system highlights its strong internal capabilities and competitive potential. The system creates significant value by reducing costs, improving safety and environmental performance, and enabling the company's production scale-up to over 100 million tons by 2029. Its rarity stems from the fact that conveyor-based infrastructure is still uncommon in Indonesia's coal industry, especially at large scale and integrated with rail and port logistics. While the technology itself is not proprietary, its imitability is low due to high upfront costs, complex implementation, and Bukit Asam's first-mover advantage. Finally, the company's organization is well-prepared to support the project through strategic alignment, robust governance, advanced financial planning, and proven experience in executing large infrastructure initiatives, positioning it to sustain a competitive advantage.

Financial Analysis

1. Revenue Calculation Approach: Incremental Analysis

Incremental Analysis, also called Marginal Analysis, Relevant Cost Approach, or Differential Analysis, is a strategic financial method for comparing the costs and benefits of alternative business decisions by focusing only on the costs and revenues that change between options (Horngren, Datar, & Rajan, 2015). This approach identifies relevant incremental costs, both CAPEX and OPEX, that vary with the decision, while excluding irrelevant, fixed, or sunk costs that remain unaffected (Brigham & Ehrhardt, 2016). It also helps optimize resource allocation by evaluating incremental revenues against incremental costs to assess the economic feasibility of each alternative.

2. Incremental Analysis Related to Coal Hauling Optimization

At PT Bukit Asam's Banko Tengah mining site in Tanjung Enim, coal is currently transported through a sequential process involving excavation, short-haul dump truck transport to intermediate sites, rehandling, and another 6 km dump truck haul to the Coal Handling Facility (CHF 3), followed by rail transport to Kertapati Port and barge delivery to buyers. The heavy reliance on dump trucks, particularly for the 6 km segment to CHF 3, results in high costs, greater environmental impact, and safety risks from intense vehicle traffic.

3. Sales Projections Under Different Hauling Scenarios

The sales and transport projection shows a gradual transition from dump trucks to a conveyor system over several years. In 2025, all coal around 6 million tons is transported entirely by dump trucks. When the conveyor becomes operational in 2026, it begins carrying about 2.67 million tons, with dump trucks still handling the remaining volume. Between 2027 and 2030, both systems operate side by side, supporting an increased annual capacity of 8 million tons. From 2031 onward, the conveyor fully takes over, transporting the entire projected 8 million tons each year. This step-by-step shift highlights the conveyor's contribution to improved efficiency, cost savings, and reliability compared to the dump truck system.

4. Incremental Revenue and Cost Analysis

In the incremental analysis, both revenue and cost components directly affected by the conveyor system are considered relevant. On the revenue side, the key metric is the incremental margin between the mine mouth coal price (Pmm), which includes production costs plus a 25% margin as set by Ministerial Decree, and the mother vessel coal price (Pmv). Incremental revenue comes from efficiency gains through lower transport costs, higher throughput, and reduced downtime. On the cost side, relevant incremental costs include the CAPEX and OPEX specifically tied to building and operating the conveyor system, while unrelated mining and selling costs are excluded as they remain unchanged. This focused approach allows decision-makers to clearly assess whether the efficiency and savings justify the conveyor investment.

5. Coal Sales

The coal sales projection for this project allocates 25% of total sales to the non-captive domestic market and 75% to international markets. Domestic sales focus on short-term contracts with industrial sectors like steel, smelters, and mineral processing, offering flexibility and opportunities to secure competitive prices. The majority of sales target international markets, primarily China and India, which have high energy needs and remain reliant on coal. Additionally, exports are directed to Southeast Asian countries and some developed nations that continue to use coal during their energy transitions.

2. Coal Selling Price Projection

In projecting the coal price for this project, assumptions are derived from Wood Mackenzie Coal Market Service Thermal data (GAR 4000, ICI 4) for 2024–2035, but adjusted based on discussions with the Company's internal team to account for the specific calorific values of coal from the two production blocks. For 2026–2050, the estimated calorific value is GAR 4138. Since the calorific values of the blocks differ from the benchmark used in the reference pricing, adjustments are made to reflect the production characteristics of each block. These adjusted prices form the revenue base for the project's financial model, calculated using simple adjustment formulas.

$$\text{Adjusted Price for GAR 4138} = \text{Price for GAR 4200} \times \left(\frac{4138}{4200}\right)$$

The resulting coal price projections, which have been processed and adjusted according to the calorific value of each production block, are presented as follows:

Tabel. 3
Forecasted ICI 4 Coal Prices

Coal Price (USD/Ton)	2024	2025	2026	2027	2028	2029	2030
ICI 4 (Woodmac H1 24) – Nominal	55.40	57.08	56.67	58.66	58.75	56.78	
ICI 4 (Woodmac H1 24) – Nominal Adjusted	54.58	56.23	55.87	58.74	57.99	55.94	

Coal Price (USD/Ton)	2031	2032	2033	2034	2035
ICI 4 (Woodmac H1 24) – Nominal	57.69	59.34	61.30	60.14	61.00
ICI 4 (Woodmac H1 24) – Nominal Adjusted	56.83	58.47	60.20	59.22	60.97

Source: Wood Mackenzie's H1 2024 Coal Market Service Report

3. General Assumptions for Financial Model Development

Assumptions are crucial for building the financial model to assess project feasibility, considering both external and internal factors. These include macroeconomic, operational, sales, and investment assumptions. The inflation rate is set at 2.95% annually, based on Indonesia's 10-year historical average (2014–2024) from BPS, reflecting long-term macroeconomic stability.

Tabel. 4
Inflation Calculation

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Annual Inflation	3.33 %	2.98 %	3.55 %	3.11 %	2.68 %	1.70 %	1.86 %	5.40 %	2.58 %	2.30 %

Source: Internal Analysis

Inflation significantly impacts cost escalation in production inputs and operations, such as fuel, wages, spare parts, and maintenance. For exchange rates, the model uses Bank Indonesia's JISDOR: the 2025 rate is based on the average from January–May 2025, while rates from 2026 onward assume a 2.82% annual growth, reflecting the 2014–2024 historical CAGR.

Tabel. 5
Projection Dollar to Rupiah Exchange Rate

Year	2025
Average /USDIDR	16,815

Year	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Dollar to Rupiah Exchange Rate	13,892	13,807	13,884	14,250	14,144	14,377	14,312	14,876	15,254	15,850

Source: Internal Analysis

The loan scheme in the financial model is crucial for projecting cash flows and assessing the project's viability, as it affects USD-linked components like coal prices, imported equipment, and operational costs. The assumed interest rate is 7.15% per annum, based on the 3-month JIBOR plus a 0.7% spread, consistent with benchmarks from similar coal projects. The loan structure provides a two-year grace period during construction (Years 1–2), when only interest is paid, and no principal repayment occurs, with the tenor and repayment terms designed to support financial performance. The loan principal repayment begins in Year 3 and follows a structured repayment plan over three years:

Tabel. 6
Loan Structure Repayment

Year	Principal Repayment (%)
1	0% (Interest only)
2	0% (Interest only)
3	30%
4	30%
5	40%

Source: Internal Analysis

This loan structure reduces cash outflows during the initial investment years, supporting the capital-intensive development phase and mitigating early financial strain. The Weighted Average Cost of Capital (WACC), reflecting the average cost of debt and equity weighted by their proportions, serves as the discount rate for NPV and other financial analyses. The assumed capital structure for this project comprises 70% debt and 30% equity, with the WACC calculated using updated market data, starting from the estimation of the unlevered beta.

Tabel. 7
Estimation of Unlevered Beta for Comparable Companies in the Coal Industry

Peer Company	Levered Beta	Debt Market Value	Market Capitalization Value	Debt/Equity	Marginal Tax Rate	Unlevered Beta
PT Mitrabara Adiperdana Tbk		24.15	4,074.54	0.01	22.00%	69.74%
PT. Indika Energy Tbk	1.37	17,750.63	7,778.02	2.28	22.00%	49.13%
Banpu Public Company Limited	1.29	49,472.25	2,325.55	4.45	20.00%	26.34%
Lanna Resources Public Company Limited	0.86	665.01	3,208.67	0.21	20.00%	74.03%
PT Harum Energy Tbk	0.92	30,707.81	17,796.93	0.68	22.00%	62.09%
PT Indo Tambangraya Megah Tbk	1.06	795.77	30,169.00	0.08	22.00%	103.59%

PT Adaro Energy Indonesia Tbk	1.29	23,518.29	82,833.32	0.28	22.00%	105.35%
PT Delta Dunia Makmur Tbk	1.12	15,565.97	3,039.33	5.12	22.00%	24.82%
Average	1.08			0.99		0.64

Source: Internal Analysis

The Mine Mouth Coal Selling Price (MMCP) is determined by adding a 25% margin to the Cost of Goods Manufactured (COGM), which includes mining, crushing, stockpiling, and internal hauling activities at the site. This margin aligns with Ministerial Decree No. 7424 K/30/MEM/2016, which permits a 15–25% markup over production costs. The use of the escalated 2023 HPP as a basis ensures that the MMCP reflects actual cost structures while remaining adaptable to macroeconomic conditions. A financial and operational comparison between truck-based and conveyor-based coal transportation systems shows that the conveyor offers greater cost efficiency and higher margins. Revenue projections, based on the Newcastle Coal Index and adjusted for coal quality, favor the conveyor due to its lower operating expenses and improved resource utilization. Although both systems see operating costs rise moderately with inflation, the conveyor maintains a clear advantage by reducing costs such as rail, port, transshipment, royalties, and export taxes, thus improving profitability.

Long-term projections indicate that the conveyor achieves superior financial performance despite higher upfront capital expenditure. Its construction debt peaks in 2025–2026 but is fully repaid by 2030, after which it outperforms the truck system in cash flow, equity ratios, and profitability through 2035. Feasibility analysis shows the conveyor's economic value with a payback period of about nine years, an incremental NPV advantage of IDR 6.57 trillion, and an IRR of nearly 20%, far exceeding the hurdle rate. Sensitivity and Monte Carlo analyses reinforce its resilience, showing a ~71% probability of positive NPV even under adverse scenarios, making it a robust and sustainable investment choice.

Business Solution

Based on the comprehensive financial, operational, and risk analysis, implementing the 6-kilometer conveyor system at PT Bukit Asam's Banko Tengah mine emerges as a superior, sustainable alternative to the existing dump-truck method. Strategically, the conveyor supports the company's goals of boosting production beyond 100 million tons by 2029, lowering logistics costs, and improving environmental and safety standards. By eliminating rehandling, reducing diesel dependency, and streamlining coal flow to the Coal Handling Facility, the system aligns with the 2025–2029 roadmap and reinforces PTBA's vision of becoming a world-class, environmentally responsible energy company. Financially, the project delivers strong results: an incremental NPV of IDR 6.57 trillion (even under stress scenarios, it remains above IDR 4.9 trillion), an IRR of 19.97% well above the hurdle rate, and a discounted payback period of 9.14 years, with operating cost savings materializing from Year 3 and persisting throughout the system's lifespan.

The risk analysis further confirms the project's resilience. Sensitivity and Monte Carlo simulations highlight exchange rate and loan interest rate as the most critical risks,

accounting for about 75% of NPV variance. Nonetheless, even in worst-case scenarios (−20% IDR and +20% interest rate), the conveyor maintains a positive NPV. Monte Carlo simulations reveal a 71% probability of achieving a positive NPV, reflecting robust downside protection. Operational risks, such as equipment downtime or maintenance issues, are mitigated through vendor service agreements, condition-based maintenance, and redundant design features. Collectively, these findings validate the conveyor as a financially sound, operationally efficient, and strategically aligned investment for PT Bukit Asam.

CONCLUSION

This study evaluated the economic and strategic feasibility of replacing the dump-truck coal transportation system with a 6-kilometer conveyor belt at PT Bukit Asam's Banko Tengah site, finding that the conveyor offers substantial financial and operational advantages. The analysis showed an incremental NPV of IDR 6.57 trillion, an IRR of 19.97%, and a discounted payback period of 9.14 years, exceeding the hurdle rate despite higher initial capital costs. Operational benefits include lower diesel use, elimination of rehandling, improved safety, reduced emissions, and better throughput, aligning with the company's growth and sustainability goals. Sensitivity and Monte Carlo analyses confirmed the project's resilience, with a 71% probability of positive NPV even under adverse scenarios, and key risks concentrated in exchange rates and interest rates. Overall, the conveyor system emerges as a robust, cost-efficient, and sustainable solution for PT Bukit Asam's long-term operations.

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