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Strategic Decision Analysis for Electric Dump Truck Adoption in Hauling Projects: A Benefit-Cost and Return Evaluation at PT Borneo Indobara

Wahyudi[1]*, Pri Hermawan[2]
Institut Teknologi Bandung, Indonesia
Email: wahyudi_embabib@sbm-itb.ac.id

ABSTRACT
PT Borneo Indobara (BIB), a coal mining company in Indonesia, faces escalating operational costs due to diesel fuel dependency and volatile prices, exacerbated by impending subsidy reductions. Transitioning to electric dump trucks (DT EVs) presents a potential solution, but requires rigorous feasibility analysis. This study evaluates DT EV adoption against hybrid and internal combustion alternatives, aiming to identify the most cost-efficient option while mitigating risks associated with diesel reliance. The SMART method was employed to weight operational, technical, and financial attributes, validated by SWOT analysis and Kepner-Tregoe risk assessment. Data included primary inputs from focus group discussions (FGDs) and field observations, alongside secondary financial and technical metrics. DT EVs emerged as the optimal choice, offering annual savings of IDR 480 billion versus an infrastructure investment of IDR 183 billion. Sensitivity analysis confirmed robustness, with SWOT highlighting alignment with sustainability goals. Risks, such as charging downtime, were mitigated via phased PDCA implementation. The study provides a replicable framework for mining firms transitioning to electrification, emphasizing cost efficiency and strategic risk management. Future research should explore environmental impacts and co-investment models to enhance ROI.

Keywords: SMART Method, Electrification, Dump Truck, Mining Logistics, PT BIB, Sustainability

INTRODUCTION

PT Borneo Indobara (BIB), a leading coal mining company operating in South Kalimantan, Indonesia, is consistently increasing its production capacity to meet growing market demand (Adhi & Taufik, 2021). The company's mining operations rely heavily on heavy machinery and equipment powered by diesel fuel, primarily to transport coal from the Run of Mine (ROM) to the loading point at Bunati Port (Hadi & Rahman, 2020). By 2024, BIB's diesel consumption will reach approximately 240 million liters, reflecting a direct correlation between increasing production levels and fuel requirements (Fauzi & Sulaeman, 2022). This substantial reliance on diesel fuel represents a significant component of operating costs, making the company vulnerable to fluctuations in diesel prices, which have shown a persistent upward trend over time (Purnama & Widodo, 2021). The volatility in global fuel prices directly impacts the mining sector, especially companies that depend on diesel for operational efficiency (Sari & Gunawan, 2020).

Diesel price volatility, coupled with continued price increases, is a significant challenge to BIB's overall cost structure and financial sustainability (Sulaiman & Rahman, 2021). The Government of Indonesia's ongoing subsidy evaluation of Fatty Acid Methyl Ester (FAME) and other diesel fuels further exacerbates this issue (Putra & Yani, 2020). The expected removal of subsidies as early as 2025 is expected to significantly increase fuel costs (Sari & Widodo, 2022). At the same time, the coal mining sector is facing economic pressures due to the decline in global coal prices in early 2025 (Ariani & Widyastuti, 2021). This confluence of rising operating costs and falling revenues underscores the urgent need for innovative strategies to optimize cost efficiency without compromising productivity (Hassan & Iskandar, 2020).

Figure 1. Record Global Fuel Oil Prices

In addition, BIB's mining operations have increasingly shifted further away from Bunati Port, increasing the distance between the mining site and the loading point (Asmu'i, 2025). This logistical expansion requires a larger fleet of haulage trucks, which increases diesel consumption and further increases operating costs. Haulage activities, which account for the majority of fuel usage, are an important area for cost optimization. One viable solution is the use of Electric Vehicle Dump Trucks (DT EVs), which utilize electricity-a more stable and increasingly cost-competitive energy source for large-scale industrial applications. Transitioning to DT EVs has the potential to reduce dependency on diesel, reduce operating costs, and align with global sustainability trends.

However, the implementation of DT EV technology requires significant capital investment, infrastructure development and operational reconfiguration. Therefore, careful and systematic analysis is essential to assess the feasibility, economic viability and strategic benefits of implementing DT EVs in BIB's transportation operations. This study seeks to develop a robust decision-making framework for evaluating DT EV adoption, thereby contributing to improve operational efficiency, reduce costs, and navigate the evolving economic and regulatory landscape.

PT Borneo Indobara (PT BIB), a leading coal mining company in South Kalimantan, Indonesia, faces critical business challenges that threaten its profitability and long-term sustainability. Operating a 24,100-hectare concession with coal reserves of 641.6 million tons, PT BIB has increased its production to 54 million tons per year by 2023, and relies heavily on diesel-powered haulage trucks to transport coal from the Run of Mine (ROM) to Bunati Port. However, the company is under pressure from rising diesel fuel costs, high dependence on diesel, falling global coal prices (Figure I.3), and the need for greater operational efficiency in transportation. These interrelated issues require strategic solutions to ensure PT BIB remains competitive in a challenging market.

Secondly, the sharp increase in diesel prices to IDR3,000 per liter has significantly increased PT BIB's operating costs, with the company consuming around 240 million liters by 2024, mostly for transportation. This cost burden is compounded by the potential removal of diesel subsidies in Indonesia, including fuels such as Fatty Acid Methyl Ester (FAME), expected as early as 2025, which could increase costs further. In addition, PT BIB's high reliance on diesel-powered trucks exposes it to fuel price volatility and supply risks, while contradicting environmental regulations and public demands for lower carbon emissions. Biodiesel policies in Indonesia, such as the planned B35 and B40, add complexity due to sustainability issues such as deforestation risks. Transitioning to dump truck electric vehicles (DT EVs) can address these issues, but requires significant investment.

The third and most strategic issue is the need for companies to select the most appropriate operational improvement initiatives. Among the options under consideration, electrification of the waste collection truck units has emerged as a viable solution to simultaneously reduce long-term operational costs, reduce emissions, and support sustainability goals. However, transitioning from a conventional diesel system to an electric-powered alternative requires a structured business decision process that considers the financial, technical, and operational implications of each alternative.

Therefore, a systematic approach to decision analysis is required to ensure that PT BIB selects the most feasible electrification solution that aligns with its strategic objectives. The decision should also consider broader industry trends, national sustainability targets and stakeholder expectations to position PT BIB competitively in the long term

The research aims to identify the key attributes influencing the transition to cost-efficient transportation operations at PT BIB, specifically by comparing the operational cost efficiency of electric, hybrid, and internal combustion (IC) dump trucks. It evaluates which of these options is most suitable for PT BIB’s 40-ton dump truck fleet, considering factors such as vehicle acquisition and maintenance costs, fuel or energy consumption, operational reliability, and potential risks associated with each technology. The study also assesses the practical implementation of these options, highlighting possible risks and realistic strategies for mitigation. However, the analysis is limited to operational cost efficiency and does not address carbon emissions, ESG, or other environmental factors, focusing solely on PT BIB’s current 40-ton dump truck operations and its approved production capacity of up to 54 million tons per annum as of 2023, without considering future expansion or changes.

The current research advances existing literature by uniquely applying the SMART method to evaluate electric dump truck (DT EV) adoption in coal mining (Bazerman & Moore, 2013; Keeney & Raiffa, 1993), integrating multi-method validation (SWOT and Kepner-Tregoe) for robust decision-making (Hammond et al., 2015; Anugari, 2025). Unlike prior studies (Wibowo & Deng, 2013; Montibeller & von Winterfeldt, 2015), it quantifies IDR 480 billion in annual savings against infrastructure costs (IDR 183 billion) and proposes a phased PDCA implementation, addressing real-world challenges like charging infrastructure and productivity—filling gaps in cost-benefit analysis and operational frameworks for mining electrification.

METHOD

This research builds on the strategic need for PT BIB to address three core business issues: falling coal prices, rising fuel costs, and the need for operational improvements. The literature review highlighted the importance of aligning improvement initiatives with measurable business outcomes using a practical framework. To guide this research, the **SMART** (Simple Multi-Attribute Rating Technique) method was adopted as the main tool to evaluate the electrification of conveyance, specifically dump trucks, as a strategic solution.

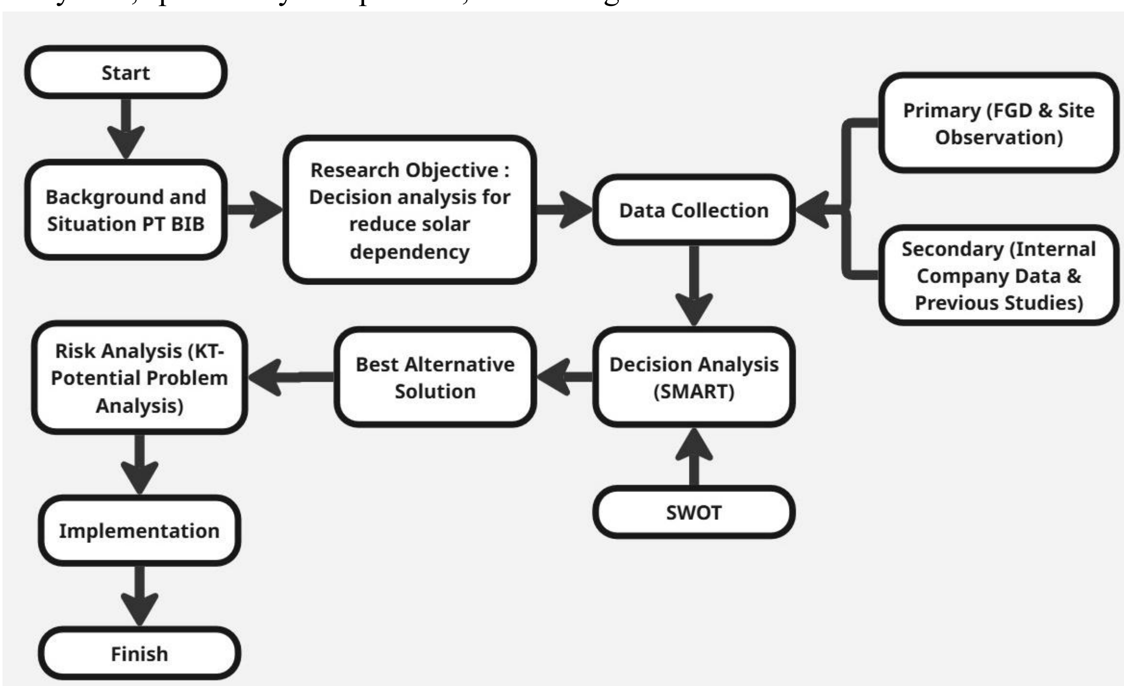

Figure 2. Conceptual Framework

This research design focuses on analyzing the best choice between DT EV, DT Hybrid or sticking with DT IC through a structured cost-benefit analysis. The process began with data collection, which was divided into two main categories: data collection and data analysis. Data collection involved gathering inputs from various stakeholders, including the PMO and finance team, electrical and mechanical engineers, and fleet operations managers. Key data points collected include coal haulage costs, electricity costs, number of operational units, infrastructure and maintenance unit costs, operational sequencing, investment and returns (infra, unit), operational price reductions, operational price comparisons, estimated haulage fuel consumption per month, and trends in haulage unit operational costs with rising fuel prices.

RESULT AND DISCUSSION

In the "Data Collection" section, we establish the basis for determining whether PT BIB's transportation transition can solve the identified problems. The data collected will be analyzed using a SMART approach to ensure measurable outcomes and well-considered decisions. The following data has been collected for this purpose.

A. Primary Data Results

1. **Forum Group Discussion (FGD)**

   The focus group discussion was attended by representatives from various departments with different responsibilities and expertise. The discussion was led by the Chief Operating Officer (COO), with participation from the General Manager Support & Technical, the Operations team, and several team leaders. The COO-led forum addressed the high dependency on diesel fuel, rising production costs, and preparations for the FAME policy, which could increase diesel-related costs. Key topics discussed included:

   a. What options are available to reduce dependence on diesel fuel?
   b. What are the considerations and studies associated with the transition away from diesel fuel, and what are the potential impacts?

   Based on these topics, the discussion resume is shown in Table 1 below:

Table 1. Forum Group Discussion Conclusion

Department/Division	Methods	Results
COO	FGD	• Unstable and declining coal prices make dependence on diesel fuel intolerable. While we cannot control the price of diesel, managing the operational costs is our responsibility. Therefore, instructions have been given to conduct a study on the most suitable solution for this case and to evaluate whether transitioning to electrification can be a breakthrough in addressing this issue.
General Manager Coal Loading Road (CLR)	FGD	• The operations team continues to support innovations and initiatives that can reduce operating costs. However, it is important to note that this transition should not come at the expense of the productivity of the transportation operations, given the production targets that continue to increase each year.
General Manager Coal Chain	FGD	• Switching to electricity is a very favorable option as electric vehicles (EVs) offer significant benefits, including lower

Department/Division	Methods	Results
Maintenance Project Support (CCMPS)		operational and maintenance costs. In addition, electricity prices tend to be more stable than diesel fuel prices.
PLN UP3 Kota Baru	FGD	● By switching to electricity, increased power demand can reduce the cost per kilowatt-hour (kWh). However, it is important to evaluate the reliability of electricity supply at the mine site and the cost of developing infrastructure to support charging stations and other necessary equipment.
Section Head Project Manager Officer (PMO)	FGD	● Switching to electricity is a very favorable option as electric vehicles (EVs) offer significant benefits, including lower operational and maintenance costs. In addition, electricity prices tend to be more stable than diesel fuel prices.
Infrastructure Project Maintenance	FGD	● This could potentially require a very large infrastructure. Therefore, a quick decision is preferable in this case due to the duration of mining
Mining plan project	FGD	● This has the potential to reduce reliance on solar power, especially as the length of haulage grows longer each year.
Electrical Engineering team leader	FGD	● Electric cars are a good option as long as manufacturers can provide good options
Electrical and contracting consultant	FGD	● This upgrade will be in line with government regulations and will be a mining power leader
AEK's transportation partner	FGD	● As a logistics mining company, it will support all innovations, especially reducing operating costs and increasing company profits.
Haul road operations	FGD	● Our operational concern is productivity. This is not allowed because low productivity will increase the number of units. Due to limited haul roads
Electrician	FGD	● The design must be reliable and long-term and must be able to absorb the dynamic mining process that is moving all the time.

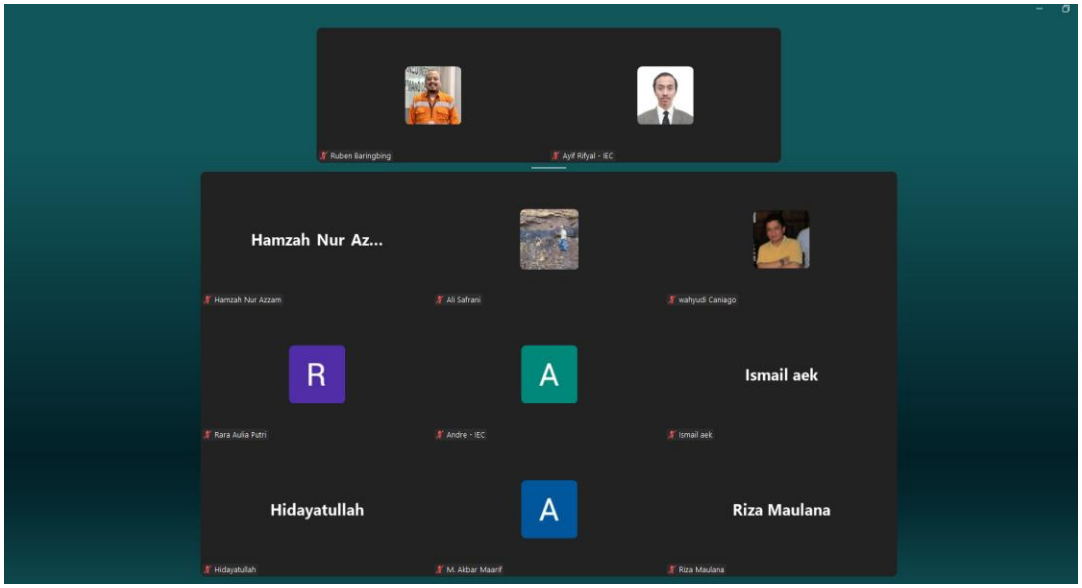

Figure 3. FGD Documentation

2. **Field Observation**

Field observations involve collecting authentic primary data from workers to verify whether a problem actually exists in the field. This data then helps evaluate whether the proposed solution fits the conditions on the ground and can be fully integrated into the operational process. The questions asked include:

a. What is the fuel consumption rate for one trip (a cycle that includes trips for loading and unloading)?
b. How many cycles are generally achieved per shift, and does this match the set target?

For the first question, the data concerns the material pickup at ROM A1, which covers a distance of 28 km. For the second question, according to the transportation operation, the target for one shift is 3 - 4 trips. The results of the interview are as follows:

Table 2. The Results of The Interview

Driver Company	Unit Number	Methods	Results
Various	AEK 18011	interview	● The fuel consumption of the DT 40T is about 35-40 liters for one rit. Each shift is almost half of the tank capacity ● Every single day about 4
RBT	RBT 3002	interview	● About 1.5-2 liters every kilometer for a 40ton dump truck ● Sometimes it is 3 cycles, but if the queue is short, it often reaches 4 cycles.

B. Secondary Data Results

Secondary data collected based on the research design is expected to provide a wealth of information to enrich the input for analysis. The required data include the number of operational units, operational sequence, electricity cost (PLN), unit maintenance cost, coal handling and transportation cost, and infrastructure investment. The details are described in the following subsections.

1. **Supporting infrastructure and electricity**

   This section discusses data collection on the support and infrastructure required to obtain the secondary data. The discussion on support and electricity includes the current electrification status of the transportation area, the prevailing PLN electricity tariff, the facilities required to switch the transportation to electric power, and the technical specifications of the DT EVs and hybrid units to be used.

   Power supply in mining areas is complex due to its remote and dynamic nature, increasing the possibility of voltage fluctuations. Therefore, a thorough analysis of this issue is essential. Below is a mapping of the existing power grid in PT BIB's transportation area.

2. **Finance**

   Once the technical specifications to support transport operations are established, estimates for infrastructure development are required, as they will impact operational costs.

C. Decision Analysis with SMART

Following the data collection process, this section outlines the analysis conducted using the methodology described earlier. The analysis starts with evaluating the proposed business solution, providing justification, and formulating an implementation plan to be adopted by the authors. In the final section of this chapter, a recommended solution will be presented for decision-making, derived from the data analyzed using the Simple Multi-Attribute Rating Technique (SMART).

The SMART methodology is highly effective for decision-making as it systematically evaluates alternatives based on weighted criteria, ensuring a balanced and transparent approach. This increases the reliability of recommended solutions, especially in complex operational contexts such as those involving transport electrification.

1. **Step 1: Identifying Decision Makers**

   Decision-makers should adopt a broad perspective and consider the best outcome based on input from experts in their respective fields. In this context (Table IV.9), there are decision-makers at level C, including:

Table 3. Decision Makers of PT BIB

Decision Makers	Position
COO Permata	Director of Operations
CEO Gems	Chief Executive Officer
CME BIB (SUMMIT)	Mining Chief Engineer

a. Chief Operation Officer (COO GEMS)
The COO plays an important role by overseeing the company's operations, providing direction and guidance, and setting targets to improve the company's efficiency, productivity, and growth.

b. Chief Executive Officer (GEMS CEO)
The CEO is responsible for aspects related to feasibility, including sales, procurement, relationships and networks, which affect the company's inputs and outputs.

c. Chief Mining Engineer (CME BIB)
CME is fully responsible for all aspects of the mining process, from planning and supervision to ensuring the safety, security and health of all mine workers.

2. Step 2: Identifying Action Alternatives

In identifying issues related to the potential increase in diesel fuel prices and the decline in coal selling prices, reducing dependence on coal is a necessary action. One approach is to reduce diesel consumption in transportation operations at PT BIB. As a result, three operational alternatives were identified.

a. Internal combustion of garbage truck (DT IC)
Currently, the DT IC has been in operation for quite some time and can keep pace with the company's productivity growth, as evidenced by the increase in production. Therefore, staying with this option is advantageous in terms of work patterns; however, DT IC is highly dependent on diesel.

b. Hybrid dump truck (DT Hybrid)
The DT Hybrid is a dump truck that uses two engines (IC and electric motor). Operationally, this option serves as a middle ground, offering the advantage of not significantly changing existing work patterns while reducing diesel consumption by up to 25%. However, the drawbacks of the DT Hybrid are higher maintenance costs, monthly tax obligations, and limited manufacturing options.

c. Garbage truck electric vehicle (DT EV)
Using the electrical energy stored in the battery, the DT EV can operate similarly to the DT IC. This option has low spare parts and maintenance costs. In addition, the efficiency of its electric motor is up to 50% higher than that of a combustion engine. However, a significant drawback of DT EVs is that when the battery or motor fails, the battery usually cannot be repaired and must be replaced.

3. Step 3: Identify Relevant Attributes

After identifying each alternative, the next step is to determine the attributes to measure the objective. These attributes facilitate the establishment of correlations with objectives to support decision-making. The attributes are expected to serve as a scale that better aligns needs with values. Below (Figure IV.8) is the value tree for this problem.

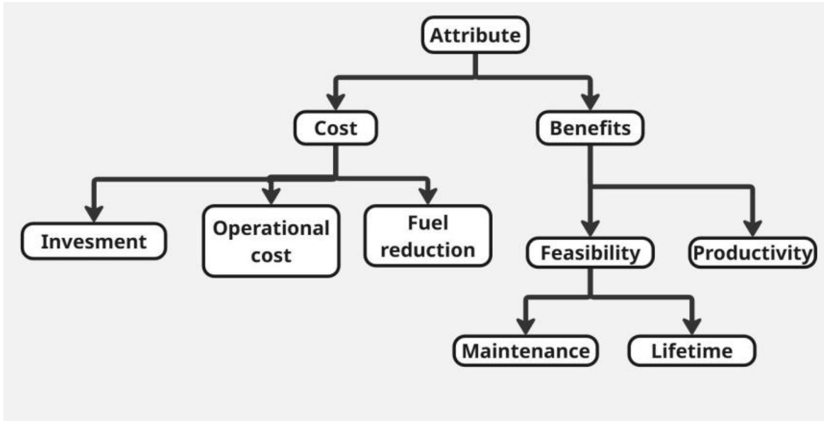

Figure 4. Value Tree Hierarchy Attributes

The value tree represents a hierarchy of attributes as a framework for the decision-making process at PT BIB, in accordance with the objectives to be achieved. Below are the two main attributes in this case.

4. **Step 4: Assess Alternative Performance on Each Attribute**

Evaluating the performance of each alternative in each attribute is necessary to facilitate graphical consideration or measurement of each attribute. This process aims to provide values that simplify a more measurable analysis. The performance summary is presented as follows:

Table 4. Value Assessment of All Attributes

Alternative	Invesment		Operational cost (Rp/km)		Fuel Reduction (litre)	Maintenance (Rp/tahun)		Productivity (hour)
DT IC (1)	Rp	13.228.812.000	Rp	10.856	0,6	Rp	500.000.000	22
DT Hybrid (2)	Rp	14.882.413.500	Rp	8.700	0,4	Rp	550.000.000	23
DT EV (3)	Rp	19.843.218.000	Rp	2.672	-	Rp	300.000.000	20

5. **Step 5: Determine the Weight for Each Attribute**

Next, each attribute is assessed by decision makers. This assessment will be the benchmark for determining the contribution weight of each component. The following table presents the weight given to each attribute:

Table 5. Weighting of Each Attribute

Alternative	COO	CEO	CME	average
Invesment	2	3	2	2,3
Operational cost (Rp/km)	5	5	4	4,7
Fuel Reduction	5	5	5	5,0
Maintenance (Rp/tahun)	4	5	3	4,0
Productivity (hour)	2	4	2	2,7
Total				18,7

Based on the weight assessment in the table above, by applying the formula, the results are obtained:

$$\text{Normalized weight} = \frac{W_j}{\Sigma W_j} \times 100\%$$

Where,

W_j= the original weight of an attribute

ΣW_j=total original weight of all attributes

6. **Step 6: Calculate the Weighted Average for Each Alternative**

In this step, a weighted average of the individual ratings for each attribute is calculated to determine the overall advantage of each option. The normalized weights, which must add up to one, are combined to reflect the relative importance of each attribute in the decision-making process. Below are the detailed combined benefits for each alternative.

Table 6. Aggregate value

DT IC				DT Hybrid				DT EV			
Attribute	Value	Normalize Weight	value x normalize	Attribute	Value	Normalize Weight	value x normalize	Attribute	Value	Normalize Weight	value x normalize
Invesment	3	0,13	0,38	Invesment	2	0,13	0,25	Invesment	1	0,13	0,13
Operational cost (Rp/km)	1	0,25	0,25	Operational cost (Rp/km)	2	0,25	0,50	Operational cost (Rp/km)	3	0,25	0,75
Fuel Reduction (litre)	1	0,27	0,27	Fuel Reduction (litre)	2	0,27	0,54	Fuel Reduction	3	0,27	0,80
Maintenance (Rp/tahun)	1	0,21	0,21	Maintenance (Rp/tahun)	2	0,21	0,43	Maintenance (Rp/tahun)	3	0,21	0,64
Productivity (hour)	3	0,14	0,43	Productivity (hour)	2	0,14	0,29	Productivity (hour)	1	0,14	0,14
Total	9	1	1,54	Total	10	1	2,00	Total	11	1	2,46

7. **Step 7: Make an Interim Decision**

Since the main factor in this calculation is the cost per ton per kilometer, the highest aggregate value is achieved by DT EV (2.5), followed by DT Hybrid (2.0) in second place, and DT IC (1.5) in last place. The following is the breakdown:

Table 7. Aggregate Value of Each Scenario

Alternative	Invesment	Operational cost (Rp/km)	Fuel Reduction (litre)	Maintenance (Rp/tahun)	Productivity (hour)	Agregate value	cost yearly
DT IC (1)	3	1	1	1	3	1,5	Rp 1.560.000.000.000
DT Hybrid (2)	2	2	2	2	2	2,0	Rp 1.200.000.000.000
DT EV (3)	1	3	3	3	1	2,5	Rp 1.080.000.000.000

Before making a decision, a preliminary evaluation should be conducted to provide decision makers with complete information about the options. The table below presents details of the total value and total cost for each alternative, reflecting the costs incurred by PT BIB for each year for handling transportation costs.

8. **Step 8: Perform Sensitivity Analysis**
   The next step in the SMART method is to perform sensitivity analysis by adjusting the weights of different attributes to see the impact on the ranking of alternatives. In this step, the weight of one criterion is set to zero (0), and the aggregate value is recalculated to assess the stability of the choice when the weight level is modified. In this study, 11 attributes were categorized into two groups: costs and benefits.

D. Business Solution

With the issue of volatile and declining coal prices, as well as news about the potential elimination of subsidies for diesel fuel through the FAME program, a more in-depth analysis is needed, especially for coal commodities. In practice, the mining process is highly dependent on diesel fuel. This dependency is directly proportional to the level of production, where higher production will increase diesel consumption. Therefore, a solution is needed to overcome this problem, one of which is by optimizing coal handling during transportation operations.

To address this issue, the proposed solution is to reduce dependency on diesel by adopting hybrid dump trucks and electric vehicles (EVs). With these three options (conventional, hybrid and EV), a strategic analysis was conducted using the SMART (Simple Multi-Attribute Rating Technique) method. This analysis identified EVs and hybrids as the top two options. To validate this, a SWOT analysis was conducted to confirm that the transition to electric vehicles offers superior value, as shown through sensitivity testing and aggregate weighting. In addition, EVs were shown to be more cost-effective, saving approximately IDR480 billion per year in operating costs if all transport units were converted to DT EVs.

E. Risk Analysis with Kepner Tregoe

The next analysis, after getting the best evaluation results, is to analyze potential scenarios that may occur, along with their possible impacts. From here, PT BIB can consider strategies to address and refine the approach based on criteria and attributes.

Table 8. Risk Analysis

Atrribute	Potential Problem	Consequences	Preventive Action	Contingency Actions
investment	mistake in calculation or design engineering	Overrun budget during support establish	Plan Do Action Check (PDAC) and hiring consultant	Strict with the final capture and focus in the solution
Operational cost	potential business partner propose similar cost	Operational budget can be reduce, only in fuel consumption	briefing the partner and ask they for joining process	Create the official certificate or letter that obey the law firm
fuel reduction	Fuel consumption and fuel dependency still occures	overrun budget for operational dan production	analyze and create the research for the calculation with all sectors	Make sure the fuel plan is nearly based on the data exist. Not asssumption
Maintenance	Electrical EV have a toruble	can operation to cargo handling	create trusted partnership supplier that proven in EV	trial several before massive investment
Productivity	queue charging during operational	lost time operational	using simulation for predictive the charging habbits	create the plan B and soon for preventive action

Based on the risk analysis, the transition to DT EVs presents several opportunities and challenges, including the significant initial investment required to build the supporting infrastructure, potential decrease in productivity due to charging duration, increase in transport population to maintain production levels, and difficulties when the main battery source breaks down and not having spare parts or authorized workshops for unit repair. Suggestions for infrastructure and implementation should be done in a phased manner (phase by phase) applying plan-do-check-analyze (PDCA).

F. Implementation Plan

After analyzing the problems at PT BIB, several resolution options were considered. After conducting a SMART analysis to determine the best outcome, it was decided to adopt EV DT for PT BIB's transportation operations. Before proceeding further, a risk analysis was conducted using the Kepner-Tregoe theory. The results showed that growth was one of the recommended options. Therefore, using the Plan-Do-Check-Analyse (PDCA) cycle, an implementation plan was developed, as shown in the following figure.

CONCLUSION

The research concludes that PT BIB's coal mining operations are heavily reliant on diesel fuel, making them vulnerable to fluctuating coal prices and potential reductions in diesel subsidies, thereby necessitating robust cost-reduction strategies, especially in transportation. By applying the SMART method and validating results through SWOT analysis, the study identifies Electric Dump Trucks (DT EV) as the most cost-efficient solution, with sensitivity analysis and SWOT comparison indicating potential annual savings of IDR 480 billion compared to an infrastructure investment of IDR 183 billion, while associated risks are effectively managed using the PDCA method. The research recommends a phased implementation of EV DTs with ongoing evaluation, and highlights the need for future studies to address environmental and ESG considerations, as well as to explore co-investment models and detailed ROI assessments to further optimize investment strategies.

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