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Fuel Efficiency Improvement Initiatives for Reducing Mining Operation Costs Using Root Cause Analysis and SWOT Method A Case Study Pt. Falcon, 2nd BLOCK, East Kutai, East Kalimantan, Indonesia

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ABSTRACT: PT. FALCON is the one of Owner coal mining company which is doing of monitoring and controlling mining activity process by Contractors from the land clearing until coal hauling to the crusher plant. The contractor already starting mining activity in the 2nd BLOCK since January 2022 until currently. Based on historically data, fuel consumption during Jun 2022 – Jun 2023 still increasing.

Fuel is the main component of the operational in the coal mining industry. Sustainability of the operational is very influenced by the fuel inventory and the fuel price. Because fuel is the main component cost in mining activity (>50% from total mining cost), increasing of the fuel price will be very influencing to operational sustainability in the future, moreover if increasing of the fuel price not accompanied by coal price.

This project aims to find the root cause of the problem using the fishbone method to further determine the right way to make an action plan from solving the root of the problem. In addition, the analysis is also carried out using SWOT analysis to identify the Strengths, Weakness, Opportunities and Threats of the company, so that appropriate recommendations can be submitted to company management so that the company can develop and survive in the future.

KEYWORDS: Coal Mining, Fuel, Fishbone, SWOT analysis.

INTRODUCTION

Indonesia is one of the world's largest coal producers and exporters. Since 2005, when it surpassed Australia's production, Indonesia has been the leading exporter of thermal coal. A significant portion of the exported thermal coal consists of medium quality types (between 5,100 and 6,100 cal/gram) and low qualities types (below 5,100 cal/gram), most of which are demanded from China and India. Based on information provided by the Indonesian Ministry of Energy and Mineral Resources (2021), Indonesia's coal reserves are expected to be depleted in approximately 83 years if current production levels continue.

In terms of global coal reserves, Indonesia currently ranks 9th with approximately 2.2 percent of total proven global coal reserves according to the BP Statistical Review of World Energy (2021). About 60 percent of Indonesia's total coal reserves consist of cheaper, low-grade coal (sub-bituminous) that contains less than 6,100 cal/gram. Based on ESDM data 2021, the 10th regions with the largest coal reserves in Indonesia are:

1. East Kalimantan: 13,61 billion tons (including PT. Falcons 0,965 billion ton)
2. South Sumatra: 9,29 billion tons
3. South Kalimantan: 3,67 billion tons
4. Central Kalimantan: 1,99 billion tons
5. Jambi: 1,65 billion tons
6. North Kalimantan: 531,57 million tons
7. Aceh: 428,65 million tons
8. Riau: 359,12 million tons
9. Bengkulu: 103,3 million tons
10. West Sumatra: 23,63 million tons

The area with the largest reserves is East Kalimantan, which PT Falcons is a part of. (See figure.1)

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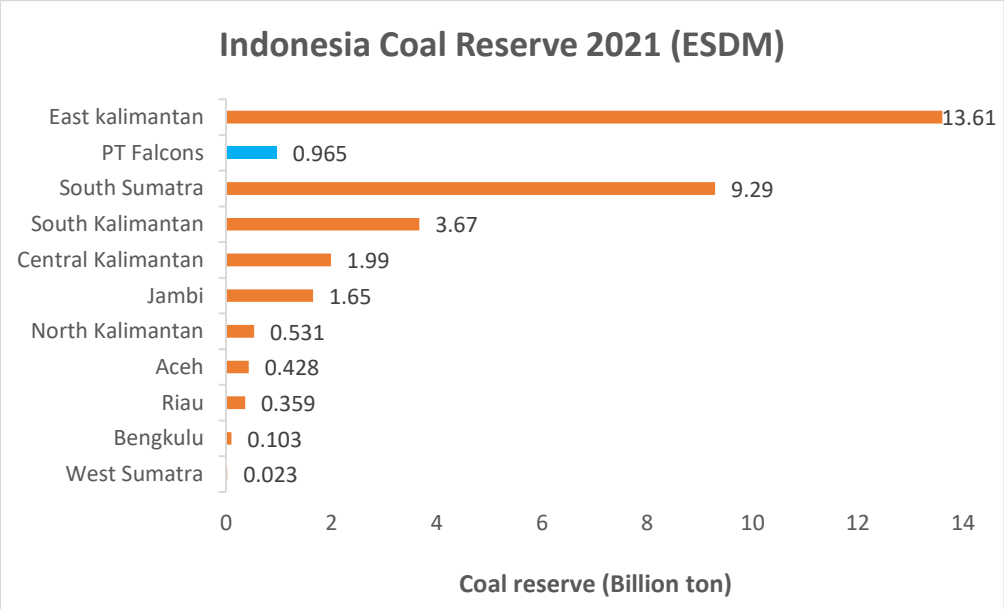

Figure 1. Ten region Indonesia coal reserve based on data ESDM, 2021
(Source: Company internal data with modified)

Coal mining industry have fluctuation conditions depend on coal price which is un controlled and very influenced by the global condition such as government regulation, winter season and war. Based on the New Castle index coal price during Jan 2019 – Jun 2023 very volatile, the coal price under 100 $/ton in Jan 2019 until April 2021, and tend to increasing since May 2021 because there was Government regulation from the Government of China to stop coal imported from Australia. Regulation from the China could be directly impact to coal price due to China is the biggest country consumers of coal in the world.

The coal price jumped to above 300 $/ton in May 2022 due to Rosia commencement war with Ukraine, even the coal price touched 400 $/ton which is the new record of the coal price throughout history, and trend to decrease on Jan 2023. Coal prices from Jan 19 - May 23 can be seen in the table below. (See figure.2)

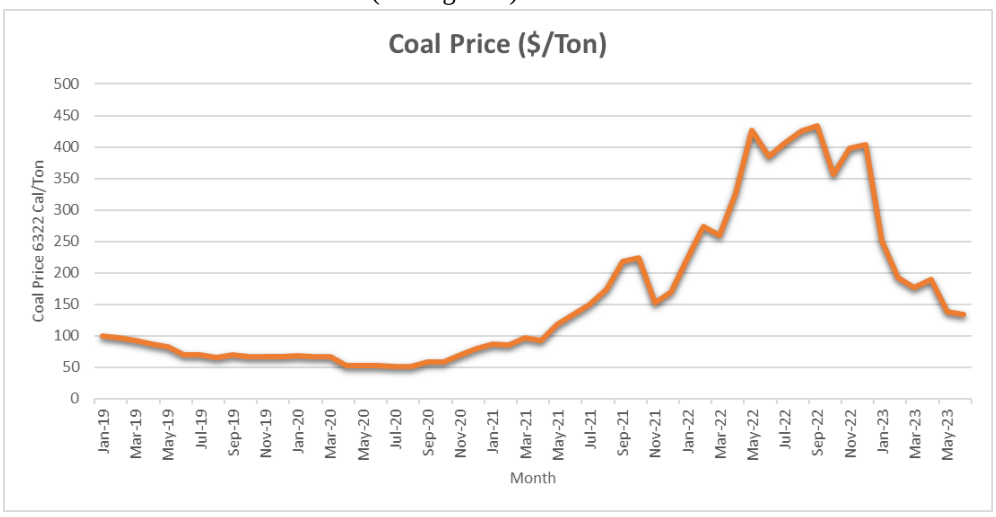

Figure 2. Coal Price based on Newcastle index 6322 Cal/ton
(Source: https://www.investing.com/commodities/newcastle-coal-futures-historical-data)

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Fuel is the main component of the operational in the coal mining industry. Sustainability of the operational is very influenced by the fuel inventory and the fuel price. During the Jan 2022 – May 2023, fuel price tends to increase from IDR 13,000/litter to 23,000/litter. Because fuel is the main component cost in mining activity (>50% from total mining cost), increasing of the fuel price will be very influencing to operational sustainability in the future, moreover if increasing of the fuel price not accompanied by coal price. **(**Company internal data)

Based on fuel price data from Jan 22 to May 23, prices tend to rise. (See figure.3) All the coal mining industry always making improvement in their operational to be more effective and efficient to keep and make sure that company still have maximum profit.

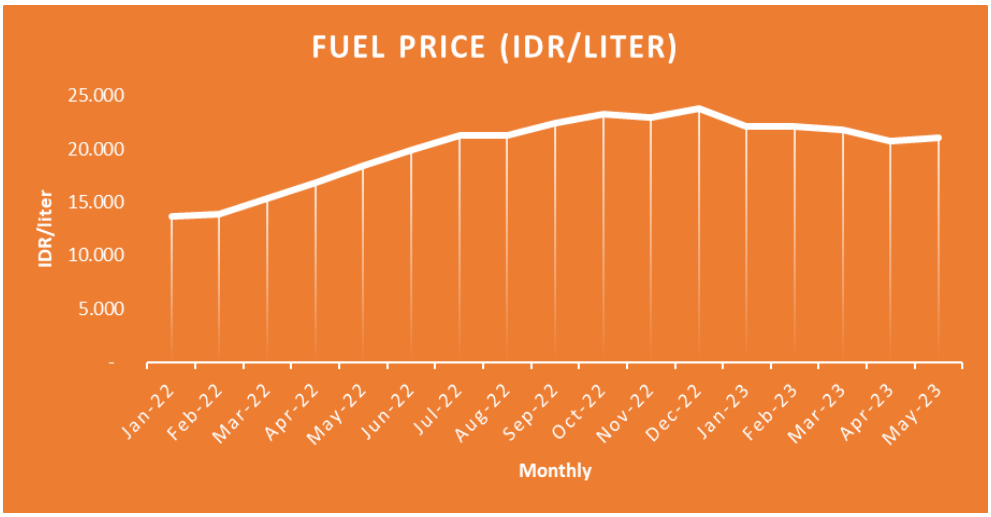

Figure 3 Fuel Price based on internal data
(Source: Company internal data with modified)

BUSINESS ISSUE

PT. FALCON is the one of Owner coal mining company which is doing of monitoring and controlling mining activity process by Contractors from the land clearing until coal hauling to the crusher plant. The contractor already starting mining activity in the 2nd BLOCK since January 2022 until currently. Based on historically data, fuel consumption during Jun 2022 – Jun 2023 still increasing. To operational coal business, detail cost or Cost of Goods Sold (COGS) in every activity is necessary. Some of the component mining cost (COGS) to operating business (excluding direct mining cost and land acquisition cost) consist of (Company current practice):

1. Fuel consumption cost
2. Explosive and Blasting cost
3. Coal processing cost
4. Divisional cost
5. Overhead cost
6. CSR cost
7. Rehabilitation cost
8. Land & Building Tax
9. Bank charge
10. Others

The largest cost component outside of direct mining cost is fuel consumption, which is 52% of the total cost of gods sold (COGS). (See figure.4). Based on cost component above, fuel consumption cost is the biggest contribute 52% from total cost of mining activity.

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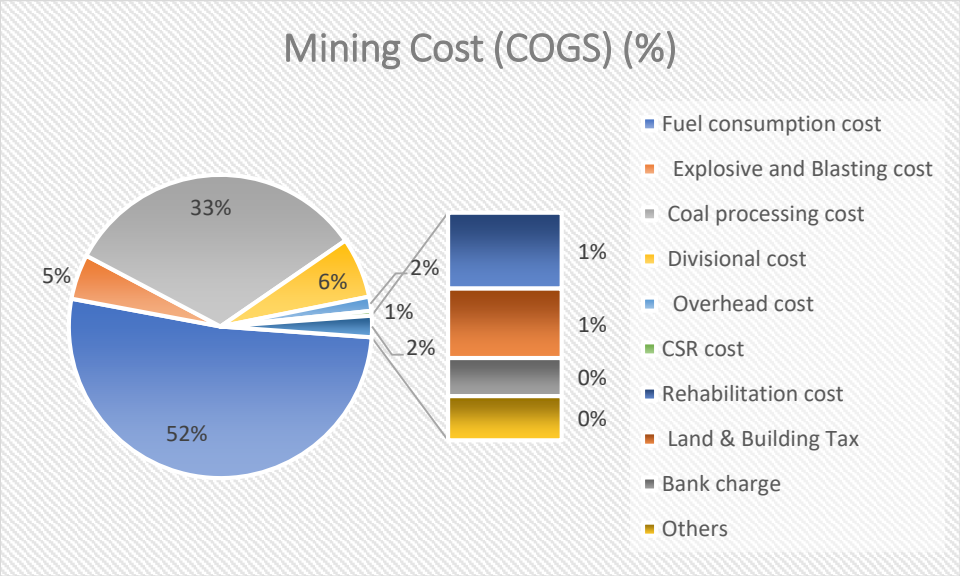

Figure 4. Mining activity cost (excluding direct mining cost and land acquisition) (Source: Company internal data with modified, 2022)

Mining area Block 2nd PT. Falcon was opened since January 2022 and continuing operating until present. The mining operational worked by contractor. In the early project, mining cost was higher due to stripping ratio of this area was higher (>SR 17) and gradually reduced as plan became SR 12. During operating Jan 22 – May 2023, actual fuel consumption tends to higher than plan in every month. Some of improvement has been implemented, but there was no significant impact. In the same period, global coal price was going down. It was direct impacting for the profit of the company due to while the operational cost tends to increase but the coal price going down. To keep sustainability of the company, the efficiency must be implemented soon.

3. Data Collection

Data collection is a crucial step in the research and analysis process, whether for scientific research, market analysis, or any other purpose that involves gathering information. There are various methods for collecting data, and the choice of method depends on the research objectives, the type of data needed, available resources, and ethical considerations. For this project, data collection using qualitative and quantitative methods. Some of data are needed to analysis.

3.1. Qualitative Data

Qualitative data is a type of data that deals with descriptions and characteristics that can be observed but not measured numerically. It is often used in social sciences, humanities, and other fields where the focus is on understanding the qualities, characteristics, and meanings associated with a particular phenomenon. Some of qualitative data are:

- **Focus group discussion** between PT. Falcon and Contractors on Weekly meeting, Monthly meeting & SCG (Site Committee Group).
- **Observational** on field Inspection & Monitoring
- **Interview during** field discussion with contractor

Here are some questions related to the productivity of dump trucks in the overburden removal process:

1. What is the average experience of dump truck operators?
2. What is the average load capacity of the dump trucks Overburden?
3. What is the average speed of dump truck?
4. What are the loading point conditions?
5. What are the disposal point conditions?
6. What type of material is being transported?
7. How do road conditions affect the speed and productivity of the dump trucks?

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8. Whether the support equipment is sufficient?
9. How is the schedule for maintenance and routine care of the dump trucks managed to ensure optimal performance?
10. How is supervision and control over dump truck drivers carried out to ensure they follow proper procedures?
11. Are there devices or technologies fleet management systems used to improve operational efficiency of the dump trucks?
12. How is fuel consumption of the dump trucks monitored and optimized?
13. Are there initiatives to reduce downtime or delays in the overburden removal process using dump trucks?
14. How is data reporting and analysis systems used to identify potential improvements in dump truck productivity?
15. How do weather factors, such as rain or dust, affect dump truck operations, and what steps are taken to address these challenges?

3.2. Quantitative Data

Quantitative data is a type of data that is expressed in numerical terms and can be measured objectively. It deals with quantities, amounts, and numerical values, making it suitable for mathematical and statistical analysis. Some of quantitative data are:

- ✓ **Monthly data fuel consumption** budget compared with the actual
- ✓ **Monthly data** equipment performance budget compared with the actual.
- ✓ **Monthly data fuel price** budget compared with the actual.
- ✓ **Monthly data about productivity Dump Truck problems**
- ✓ **Monthly data about speed of Dump Truck** budget compare with the actual

4. Analysis

4.1.Pareto analysis

From the table problem identification (see table.1), we can identify 10 problems related fuel consumption. These ten problems have an impact on reducing the productivity of the equipment, causing the equipment to be less productive in operation and causing inefficient use of fuel.

From the diagram Pareto we can see that the 3rd factor dominant of fuel consumption in the overburden removal activity are low cycle time of DT due to spotting time at front, low cycle of DT due to operator and supervisor behaviour, and low speed of DT due to road condition. The low cycle in question is the speed of the dump truck in operation, if the dump truck speed is lower, the time required for 1 cycle is longer.

Table 1: Problem identification (Jan 2022 – May 2023)

No	Description	Problem units	Total	%
1	High Cycle time due to spoting time at front	DT	51.200	39%
2	High Cycle time due to others activity	DT	25.675	20%
3	Low speed DT due to substandard road condition	DT	19.218	15%
4	Hard Material	Digger	12.070	9%
5	Soft material	Digger & DT	8.946	7%
6	Preparing front area	Digger	5.351	4%
7	Top loading/Double Bench	Digger	3.580	3%
8	Thin material	Digger	3.303	3%
9	Lack of DT	DT	1.043	1%
10	Low speed DT due to crowded	DT	1.002	1%
TOTAL			131.388	100%

Source: Company internal data with modified)

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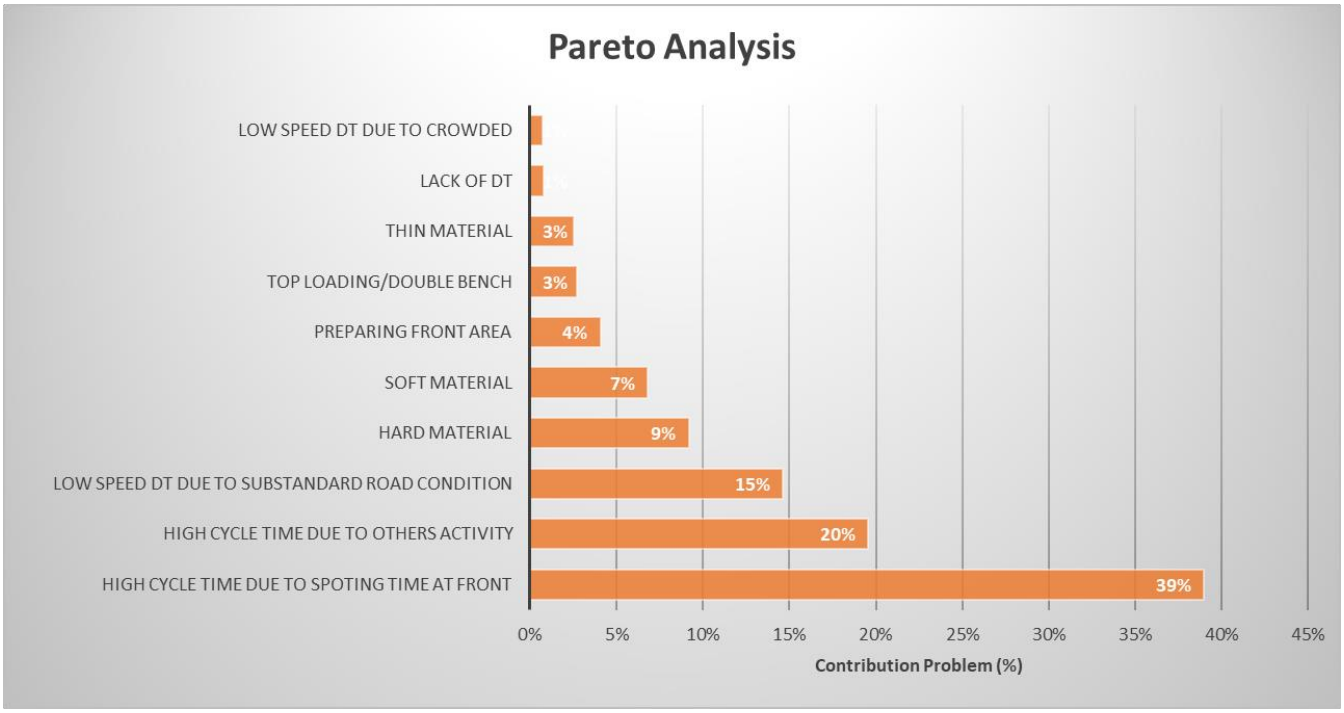

Figure 5: Graph of Pareto Analysis
(Source: Author image.)

4.2. Ishikawa/Fishbone analysis

From the Ishikawa/Fishbone analysis we can see that most of dominant problem factor on DT operational due to impact of lack of unit support and operator skills and experiences. The root causes founded by Focus Group discussion (FGD) which is conducted in every week and interview directly.

Table 2: Problem identification

No	Description	Problem units	Condition	Root Cause	Total	%
1	High Cycle time due to spoting time at front	DT	Substandard loading point	Impact lack of support	51.200	39%
2	High Cycle time due to others activity	DT	Impact operator and supervisor behaviour	Lack of Operators and Supervisors skills & experiences	25.675	20%
3	Low speed DT due to substandard road condition	DT	Substandard of road	Impact lack of support	19.218	15%
4	Hard Material	Digger		Blasted impact	12.070	9%
5	Soft material	Digger & DT		Uncontroled	8.946	7%
6	Preparing front area	Digger	Substandard loading point	Impact lack of support	5.351	4%
7	Top loading/Double Bench	Digger		Sekuence condition	3.580	3%
8	Thin material	Digger		Uncontroled	3.303	3%
9	Lack of DT	DT		Low PA DT	1.043	1%
10	Low speed DT due to crowded	DT	Substandard of road	Impact lack of support	1.002	1%
TOTAL					131.388	100%

(Source: Company internal data with modified)

Based on the problem of identifying the root cause of the problem, 10 possibilities were found (see table 2). However, there are several root causes caused by the same thing such as lack of support equipment, so only 7 are obtained as potential causes of the problems (see table.3 and Figure. 6).

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The lack of skills and knowledge of operators and supervisors indirectly affects cycle time because operators and supervisors do not understand the importance of road conditions, loading points, and dumping points in increasing the speed of dump trucks.

Table 3. Root cause identification

POSSIBLE ROOT CAUSE	DISCUSSION EFFECT	ROOT CAUSE?
MAN		
Lack of Operators and Supervisors skills & experiences	Low speed and high cycle time of dump truck	Yes
Lack of Operators and Supervisors knowledege	Poor awareness of operators and supervisors	Yes
MACHINE		
Lack of support equipment	Poor of road condition	Yes
MATERIAL		
Hard material blast	Need to improvement on Blasting process	Yes
Soft material	Actual condition and uncontrolled	No
METHOD		
Road design not properly	SOP available, need to sosialization	Yes
Road traffic not properly	SOP available, need to sosialization	Yes

(Source: Company internal data with modified)

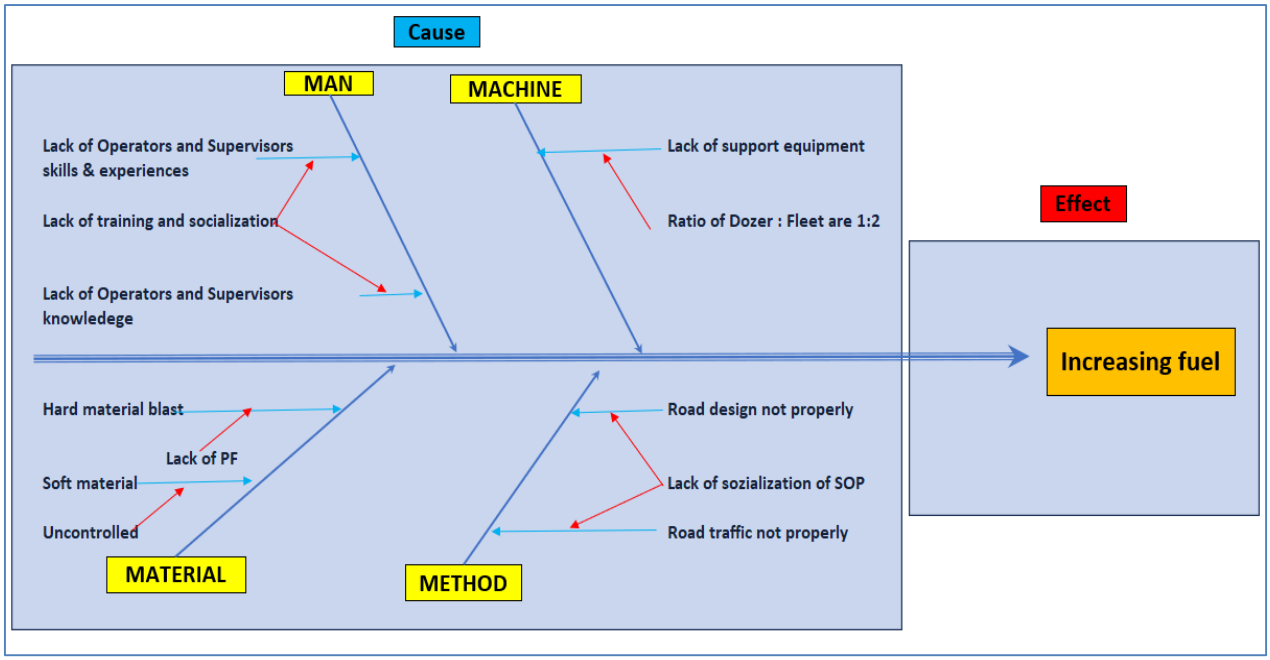

Figure 6. Ishikawa/Fishbone analysis
(Source: Author image.)

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4.3. SWOT analysis

Based on SWOT analysis we can identify Strength, Weakness, Opportunities and Threats for a coal mining operation related to fuel efficiency:

Strengths:

- Abundant Coal Resources: The company has access to rich coal reserves, allowing for sustainable production.
- Large Scale Operations: Large production capacity can enhance fuel efficiency per ton of coal extracted.
- Investment in Modern Technology: The company has invested in the latest technology and equipment that can improve operational efficiency.
- Effective Logistics Management: The ability to manage the supply chain and transportation efficiently can reduce fuel consumption.

Weaknesses:

- Dependence on Fuel Supply: Relying on specific fuel supplies can make operations vulnerable to fuel price fluctuations.
- Limited operational permit
- Need for Investment in Innovation: To achieve higher efficiency, the company may need to invest more in research and development of more fuel-efficient technologies.
- Limited Human Resources: Skills shortages in operating fuel-efficient technology can be a barrier.

Opportunities:

- Energy Diversification: Market developments and increased awareness of climate change present opportunities to develop alternative fuel solutions.
- Partnerships with Fuel Producers: Collaboration with fuel producers for the development of more fuel-efficient solutions.
- Use of Renewable Energy: Integrating renewable energy sources into mining operations to reduce fuel consumption.
- Technological Innovation: Continued investment in research and development for more fuel-efficient technology.

Threats:

- Volatile Fuel Prices: Fuel price fluctuations can disrupt operational planning and reduce profitability.
- Stringent Environmental Regulations: Changing regulations related to greenhouse gas emissions and the environment can add operational costs and require investment in cleaner technologies.
- Stringent Environmental Regulations: Strict regulations related to greenhouse gas emissions and the environment can limit technology choices.
- Intense Competition: Intense competition in the coal market can limit the ability to raise prices and enhance efficiency.
- Technological Advancements: Rapid changes in technology can render older technology obsolete and threaten operational efficiency.

5. Solution and Proposed Implementation Plan

From SWOT analysis we can find out the strengths, weaknesses, opportunities and threats for the company. Based on this analysis we can provide input to the company on what to do so that the company can operate effectively and efficiently, profitably, and can survive in the future. The results of SWOT analysis of the impact of our company can be seen in the table below (See table.4).

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Table 4. Corrective action plan

No	SWOT Analysis	Posibility Impact
1	**Company Strength**	**The company has the potential to grow quickly and earn large-scale profits.**
	Abundant Coal Resources	
	Large Scale Operations	
	Investment in Modern Technology	
	Effective Logistics Management	
2	**Company Weakness**	**The company has the potential to lose money if it does not carry out mining effectively and efficiently. in addition, it also has the potential not to get an extension permit from the government.**
	Dependence on Fuel Supply	
	Stringent Environmental Regulations	
	Limited operational permit	
	Need for Investment in Innovation	
	Limited Human Resources	
3	**Company Opportunities**	**The company has the potential to diversify its business so that it does not depend on the current business so that it can survive in the future.**
	Energy Diversification	
	Partnerships with Fuel Producers	
	Use of Renewable Energy	
	Technological Innovation	
4	**Company Threats**	**There are many similar companies in Indonesia, if you do not immediately make improvements by doing work efficiency, the company will lose its future competition with other companies.**
	Volatile Fuel Prices	
	Stringent Environmental Regulations	
	Intense Competition	
	Technological Advancements	

(Source: Company internal data with modified)

From the results of the RCA analysis we can provide input to the company regarding what things are needed by the company to increase efficient work productivity. Corrective action plan can be seen in the table below (See table.5).

Table 5. Corrective action plan

ROOT CAUSE?	DISCUSSION EFFECT	CORRECTIVE ACTION PLAN	Priority	WHO
MAN				
Lack of Operators and Supervisors skills & experiences	Low speed and high cycle time of dump truck	Giving training and socialization related fuel consumption	2nd	Contractors
Lack of Operators and Supervisors knowledege	Poor awareness of operators and supervisors	Provide warnings with fuel consumption-related campaigns through banners, radio broadcasts, stickers, slogans, etc.	3rd	Contractors
MACHINE				
Lack of support equipment (actual ratio between Dozer and fleet are 1:2)	Poor of road condition and low cycle time at front loading	Proppose to additional dozer to ratio 1:1	1st	Company & Contractors
MATERIAL				
Hard material blast	Need to improvement on Blasting process	The need for improvements to the blasting design	4th	Company & Contractors
METHOD				
Road design not properly	SOP available, need to sosialization	Giving training and socialization SOP	2nd	Contractors
Road traffic not properly	SOP available, need to sosialization	Giving training and socialization SOP	2nd	Contractors

(Source: Company internal data with modified)

The prioritization of action plans is based on the magnitude of the impact caused and the level of difficulty of its implementation. the parties involved in carrying out this corrective action plan are the company and its contractors by means of joint discussions to determine a mutual agreement.

Based on analysis above we can create implementation plan propose to contractor management. Some of implementation plan are:

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- Provide training and socialization to operators and supervisors regarding the importance of fuel efficiency. This aims to provide an understanding of the importance of fuel efficiency and what factors can increase the use of fuel by dump trucks and impact to cost.
- Provide awareness with fuel consumption-related campaigns using banners, radio broadcasts, stickers, slogans and others. This aims to make it easier for operators and supervisors to understand the importance of using fuel efficiently.
- Propose the addition of dozers with a ratio of dozers: fleet is 1:1 in accordance with the rules of good mining practice.
- Provide training and socialization of SOPs related to road design and mine traffic signs.

The time schedule for working on this action plan can be seen in the table below (See table.6).

The most critical activity in this action plan is the addition of the dozer ratio from 1:2 to 1:1, because this procurement takes a long time and must get approval as soon as possible.

Table 6: Corrective action plan schedule

CORRECTIVE ACTION PLAN	Target Schedule							
	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Giving training and socialization related fuel consumption								
Giving awarness with campaign related fuel consumption using banners, radio broadcasts, stickers, slogans and others								
Need to impprovement on blasting design								
Giving training and socialization SOP related Road design not properly								
Giving training and socialization SOP related Road traffic not properly								
Proppose to additional dozer to ratio 1:1								

(Source: Company internal data with modified)

6. Conclusions

Based on the results of the analysis using the fishbone and swot diagram analysis, we can draw the following conclusions. Increased fuel usage during the period January 2022 - May 2023 due to 3 main factors, namely:

1. Lack of skill and understanding of dump truck operators and supervisors in the field related to the use of units and the importance of doing fuel efficiency. this is related to most operators lack of experience (<2 years) and come from other sites.
2. Lack of understanding of engineers in the field regarding existing SOPs and the importance of saving fuel.
3. Lack of dozers as support equipment.

Proposed improvement initiatives to reduce fuel consumption include

1. Propose to additional dozer to ratio 1:1
2. Giving training and socialization SOP
3. Giving training and socialization related fuel consumption
4. Provide warnings with fuel consumption-related campaigns through banners, radio broadcasts, stickers, slogans, etc.
5. The need for improvements to the blasting design

6.1. Recommendations

From the results of the analysis above, we can provide recommendations to company management, including:

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- Deliver the implementation plan that must be done by the contractor related to fuel efficiency.
- Ensure the implementation of the plan is carried out by the contractor with a certain deadline.
- Conduct regular monitoring and coordination related to the use of fuel in accordance with the agreed plan.
- Re-evaluate the performance of the contractor
- Review the contract with the contractor
- Benchmark against other contractors as an option to add/replace contractors

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