



## Evaluation of the Implementation and Improvement Plan for Energy & Pollution Control at PT Borneo Indobara's (BIB) Bunati Port to Support ESG Improvements

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### ABSTRACT

The coal mining industry, particularly in coal handling and shipping operations, has raised significant environmental concerns due to its high energy consumption and emissions. PT Borneo Indobara (BIB), one of Indonesia's major coal producers, operates a crusher plant facility at Bunati Port, which plays a critical role in coal processing before distribution. Historically, the plant relied heavily on diesel-powered heavy equipment, contributing to substantial greenhouse gas emissions and inefficiencies. However, from 2017 to 2024, BIB implemented strategic initiatives to enhance energy efficiency and reduce environmental impact, including operational redesigns, transitioning from diesel generators to PLN grid electricity, and optimizing coal handling processes. This research *evaluates* the *effectiveness* of these measures by analyzing energy intensity (energy per ton of coal processed) and emission intensity (CO<sub>2</sub> emissions per ton of coal). Findings indicate a significant reduction in diesel consumption—from 4.7 million liters annually in 2017 to 1.7 million liters in 2024—alongside increased production capacity. Energy intensity decreased from 0.0145 GJ/ton to 0.0041 GJ/ton, while emission intensity dropped from 1.06 kg CO<sub>2</sub>/ton to 0.30 kg CO<sub>2</sub>/ton. Despite these improvements, challenges remain, particularly in the newly operational North Stockpile, which still relies on conventional heavy equipment. The research highlights the success of BIB's initiatives in aligning with *ESG* (Environmental, Social, and Governance) goals but underscores the need for further optimization, such as adopting electric or hybrid heavy equipment and integrating renewable energy. These recommendations aim to sustain efficiency gains while supporting Indonesia's broader climate commitments under the Paris Agreement.

**Keywords:** Crusher Plant; Operational Activities; Heavy Equipment; Diesel Fuel; Greenhouse Gas Emissions; ESG; Energy Intensity; Emission Intensity

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### INTRODUCTION

The coal mining industry, especially at the crushing stage, has long been in the spotlight because of its significant impact on the environment. Crushing activities produce coal dust, liquid waste, and gas emissions which *pollute* air, water, and soil (Anggoro & Simorangkir, 2019; Chu et al., 2021; Le & Dong, 2021; Mbedzi et al., 2018; Sutomo et al., 2020). The use of very large amounts of water to control dust and wet coal to prevent burning is of great concern to many parties. Apart from that, the substantial consumption of both fossil fuels and other energy sources in the crushing process also contributes to greenhouse gas emissions. As global awareness of the importance of sustainability increases, the application of *Environmental*,

*Social, and Governance (ESG)* principles becomes increasingly crucial in the mining industry (Adebayo & Ackers, 2024; Fuadah et al., 2023; Husted & de Sousa-Filho, 2019; Mohammad & Wasiuzzaman, 2021; Nguyen & Ngo, 2022).

Currently, PT Borneo Indobara's *ESG* rating through its parent company, based on Sustainalytics, is 39.2, which means "High Risk." This figure shows that the company has made efforts to implement *ESG* principles, but there is still great opportunity for improvement. Several key improvements have been implemented at the Bunati crusher plant to enhance operational efficiency and environmental sustainability (Brogi et al., 2022; Cristea et al., 2022; Koroleva et al., 2020; Sharma et al., 2020). The plant underwent a significant redesign, transitioning from a system where coal from trucks required heavy equipment to push it into the crusher to a more streamlined process where trucks now dump coal directly into the hopper. This change has reduced reliance on heavy equipment and lowered fuel consumption. Additionally, the energy concept was revamped; in 2017, each crusher operated on a separate diesel generator, but this was later replaced with electricity sourced from PT PLN, significantly reducing emissions. Dust control measures were also introduced, including the use of dust suppressants to minimize airborne particles during crushing, thereby mitigating environmental and health risks for nearby communities. Furthermore, water management was optimized, with large volumes utilized for dust suppression, chemical dilution, and cleaning spillage and coal dust, ensuring better environmental compliance and operational hygiene. These efforts collectively aim to align the facility's operations with sustainability goals while improving efficiency.

Implementing several of the improvements described above requires commitment, effort, and costs. However, the effectiveness of many of the implemented measures has not been studied, so the extent and nature of the next improvements have not been well planned. The current handling of various *ESG* issues at Bunati Port can be said to be more influenced by "cost efficiency," especially those closely related to energy.

PT Borneo Indobara (*BIB*) is an affiliate of the coal mining company PT Golden Energy Mines, with the largest majority shareholder being the Sinarmas Mining group. The *BIB* mine location is in *Tanah Bumbu* district, South Kalimantan Province, approximately 180 km northeast of Banjarmasin. *BIB* holds mining rights through the *Perjanjian Karya Pertambangan Batubara (PKP2B, 2nd generation)* for a 24,100-hectare concession area, divided into four mining blocks: Girimulya, Batulaki, Kusan, and Sebamban, with the agreement valid until 2036. *BIB* coal production, both for export and domestic needs, uses Bunati Port, which is located around 8–30 km from the mine and is connected by a hauling road facility to the port, used as a coal terminal.



**Figure 1. PT Borneo Indobara Location**

**Source: Internal GIS data, PT Borneo Indobara (2024)**

**Vision:** To be the leading mining company in Indonesia by creating added value for customers and all stakeholders.

**Mission:** The mission is to build a corporate culture centered on managing human resource assets, focusing on superior operations and continuing to grow through the implementation of safety, occupational health, and operational safety standards, as well as the application of *Environmental, Social and Governance (ESG)* principles, namely environmental management and life protection, strengthening external relations, sustainable community empowerment, and continuous improvement processes within the company.

The vision and mission above demonstrate that the Company has a strong commitment to the sustainability program (*ESG*). Implementing this vision and mission, of course, needs to be based on several regulations and international agreements so that the Company's programs are aligned with policy or regulation.

Internationally, the issue of energy and emissions is very prominent because both are closely linked to global climate change. In the Paris Agreement, which Indonesia has also signed, the Indonesian government realizes these commitments through implemented regulations. One binding regulation in Indonesia is *PP No. 70 of 2009* concerning energy conservation. This regulation requires companies using more than 6,000 TOE (tonnes of oil equivalent) of energy to conduct an energy audit. Another relevant regulation is the *Regulation of the Minister of Energy and Mineral Resources No. 14 of 2012* concerning Energy Management. This regulation requires energy users consuming more than 6,000 TOE to do the following: a) appoint an energy manager; b) conduct periodic audits; c) prepare follow-up plans based on audit results; and d) report the results of energy management implementation to *ESDM*.

With these regulations, the Company must plan and follow up to improve its energy use. The consequences of this commitment will obviously have a significant impact on investment.

In addition to regulatory aspects, the Company continues to consistently expand production to meet the desires of its shareholders and stakeholders. To further build trust from all parties, especially consumers, this commitment to energy conservation can effectively demonstrate that mining operations can also be energy-efficient. This commitment must be carried out by carefully considering ongoing operations so as not to disrupt production. This is certainly very challenging, as it requires precise planning to avoid losses caused by incorrect steps. Up to 2024, the Company will consistently continue to carry out energy conservation projects aimed at contributing to reducing global warming rates, even as its operations continue to increase.

The coal mining industry, particularly at the crushing stage, has long been scrutinized for its significant environmental impact, including energy consumption and emissions. Previous studies have highlighted key challenges and proposed solutions in this sector. For instance, BIAN et al. (2010) examined environmental issues from coal mining, emphasizing the need for sustainable practices to mitigate dust, waste, and emissions. Their findings underscore the importance of technological and operational improvements, yet they lack a detailed analysis of energy efficiency metrics in specific mining facilities. Similarly, Sun et al. (2018) focused on measuring emission-reduction and energy-conservation efficiency in urban contexts, providing a methodological framework that could be adapted to industrial settings. However, their study

did not address the unique operational dynamics of coal crushing plants, leaving a gap in practical, facility-specific recommendations.

This research fills these gaps by conducting a comprehensive, data-driven evaluation of energy and emission intensity at PT Borneo Indobara's Bunati Port crusher plant. By analyzing trends from 2017 to 2024, it quantifies the impact of specific interventions, such as the transition from diesel to PLN electricity and operational redesigns, which were not thoroughly explored in prior research. The findings will provide actionable insights for improving energy efficiency and reducing emissions, contributing to both operational sustainability and the company's *ESG* performance. Ultimately, this research aims to offer a replicable model for similar facilities, bridging the divide between theoretical frameworks and practical implementation in the coal mining industry.

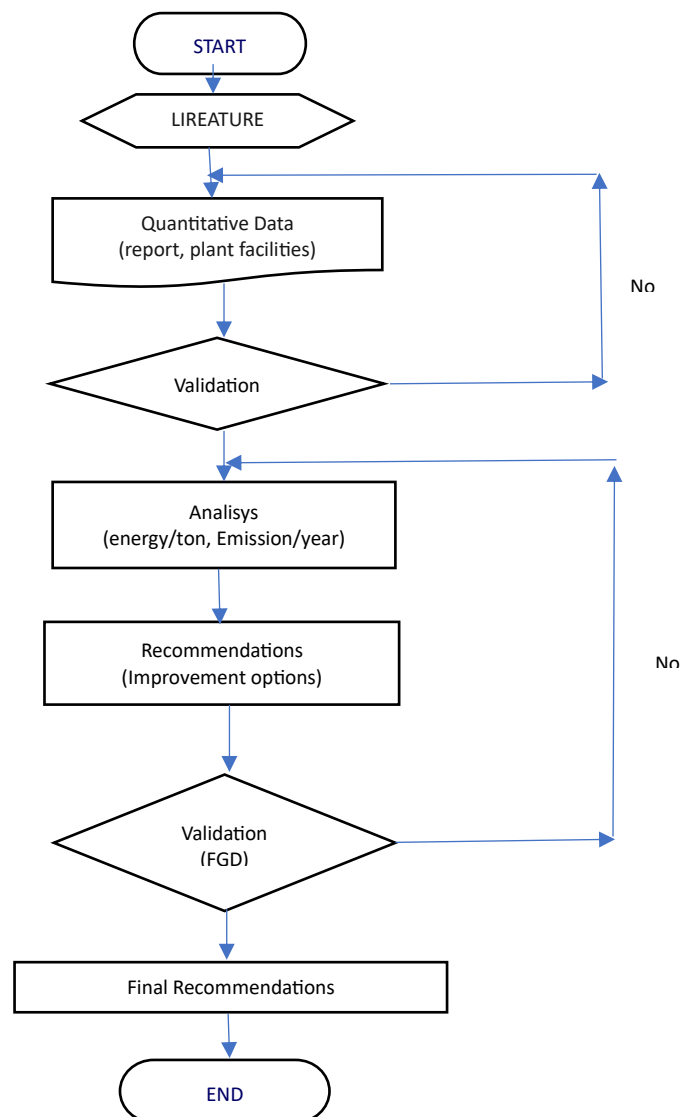
## **METHOD**

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This section outlines the methodology used to evaluate the implementation and improvement plan for energy management and emission control at PT Borneo Indobara Bunati Port, focusing on assessing the effectiveness of initiatives aimed at enhancing *ESG* performance. The methodology covers the research design, data collection methods, and data analysis techniques employed to systematically assess past actions and identify opportunities for further improvement. Specifically, the study examined the impact of key changes, such as the transition from diesel generators to PLN electricity and the redesign of the crusher plant's operations. It analyzed changes in energy intensity over time in relation to operational modifications to understand their effect on greenhouse gas emissions and the company's overall *ESG* contribution.

The research adopted a quantitative approach, relying on secondary data from operational reports and internal documents of PT Borneo Indobara, specifically from the OM contract holder, PT Bangun Arta Utama. The main dataset included direct energy consumption at the Bunati coal crusher facility from 2017 to 2024, comprising fuel usage, electricity consumption, and coal production volumes. Emission data were calculated based on diesel fuel and electricity usage, using standard emission factors. Data collection involved two key stages: gathering records of diesel fuel consumption prior to the energy transition and electricity usage after the shift to PLN electricity, sourced from daily contractor reports and PLN consumption records; and compiling emission data calculated from fuel usage, aligned with recognized emission standards.

The methodology consisted of three analytical stages to evaluate and improve energy management and emission control. First, descriptive analysis identified trends in energy intensity and emission reductions over the study period, illustrated through tables and graphs to show impacts on *ESG* performance. Second, regression analysis assessed the influence of key changes—such as the switch to PLN electricity—on energy usage and emissions, identifying each improvement's contribution. Finally, results were interpreted by comparing data from before and after the implemented changes to assess effectiveness and generate recommendations for further improvements. This structured approach supported informed decision-making in the company's ongoing *ESG* efforts.



**Figure 2. Research Design**

Source: Adapted from operational analysis framework, PT Bangun Arta Utama (2024)

Quantitative methods were chosen because they allowed objective measurement of changes in energy consumption and emissions generated during the coal crushing process at the facility. This study analyzed data on energy use per ton of coal processed and calculated emissions from 2017 to 2024.

The focus was on measuring energy intensity per ton of coal produced at the Bunati crusher plant. Energy intensity data were compared across years to identify trends and assess the impact of improvements, such as the transition from diesel generators to PLN electricity. Carbon dioxide (CO<sub>2</sub>) emissions were the key exhaust gas analyzed.

Graphs were used to illustrate energy consumption and emission levels at the crusher plant before and after the improvements. These visualizations were analyzed to provide a clearer understanding of the effectiveness of the measures in supporting *ESG* performance enhancements.

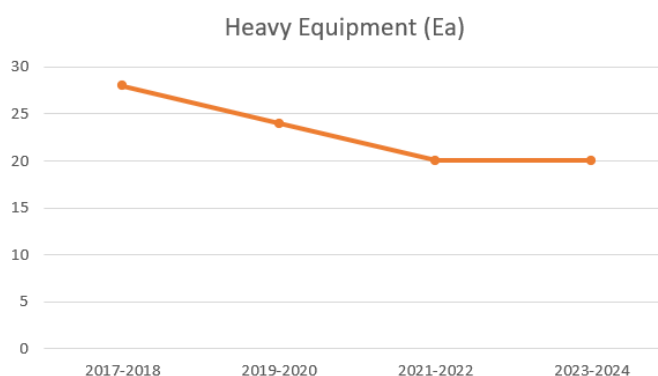
## RESULT AND DISCUSSION

### Energy Consumption and Crusher Plant Bunati Production

This section will discuss the trends in the consumption of primary energy used both fossil energy in the form of diesel and electricity from PLN, the volume of coal production, and the estimated greenhouse gas emissions generated by crusher plant activities at Bunati Port during the period 2017 to 2024. The trend analysis aims to understand the extent to which energy efficiency has been achieved following the implementation of several design and operational improvements, and how these changes affect the emissions intensity of each ton of coal produced. Data is reviewed on an annual basis to provide a comprehensive overview of energy and environmental development performance.

In addition to energy consumption and emissions, coal production trends are also analyzed as a basis for comparison of efficiency achieved. Increased production does not always mean efficiency is achieved, because there is also an increase in energy and if uncontrolled it can actually increase the intensity of emissions. Therefore, this sub-section serves as a basis for measuring the relationship between energy consumption, production amount, and emission level, so that it can be used as a base in developing appropriate and sustainable business solutions in the context of BIB's ESG.

From description, here is the graphical data of heavy equipment used from 2017-2024 to support bunati crusherplant operations.



**Figure 3. Heavy Equipment (HE) Quantity at BIB Crusher Plant**

Source: Internal operational reports, PT Borneo Indobara (2024)

From the graph above, it can be seen that from year to year the heavy equipment used by the BIB crusher plant has consistently decreased. This is due to a change in design concept from before 2017 where all crushers required heavy equipment to push coal into the crusher or loading point become a crusher plant that uses less heavy equipment.

**Table 1. Fuel Consumption crusher plant bunat**

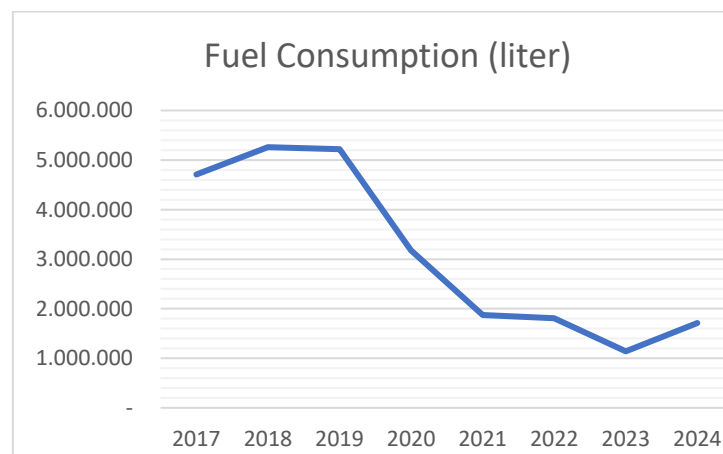
Month	Year							
	2017	2018	2019	2020	2021	2022	2023	2024
Januari	350.000	330.000	455.000	330.000	290.000	130.000	130.000	130.000
Februari	320.000	470.000	380.000	320.000	200.000	140.000	130.000	130.000

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Maret	390.000	420.000	585.000	280.000	160.000	160.000	110.000	130.000
April	410.000	440.000	510.000	250.000	150.000	130.000	80.000	130.000
Mei	430.000	410.000	540.000	200.000	150.000	150.000	100.000	130.000
Juni	280.000	440.000	350.000	260.000	140.000	150.000	130.000	130.000
Juli	310.000	440.000	490.000	245.000	120.000	170.000	100.000	130.000
Agustus	370.000	445.000	435.000	250.000	120.000	170.000	120.000	120.000
September	450.000	400.000	425.000	200.000	100.000	130.000	130.000	130.000
Oktober	540.000	450.000	420.000	240.000	130.000	160.000	120.000	180.000
November	490.000	475.000	335.000	275.000	160.000	160.000	120.000	150.000
Desember	480.000	500.000	315.000	250.000	130.000	130.000	110.000	180.000
<b>TOTAL</b>	<b>4.710.000</b>	<b>5.260.000</b>	<b>5.220.000</b>	<b>3.180.000</b>	<b>1.870.000</b>	<b>1.810.000</b>	<b>1.320.000</b>	<b>1.710.000</b>

Source: Daily contractor reports and fuel logs, PT Borneo Indobara (2017–2024)

The energy source used in the bunati crusher plant is not only from diesel fuel, but also from electricity supplied by PLN. PLN electricity in bunati is currently the main source of energy to drive the entire fix plant. the use of PLN electricity at the bunati crusher plant for fix plant operations has reached 100% so that there are no more fix plant facilities that do not use PLN electricity.



**Figure 4. Fuel consumption crusher plant**

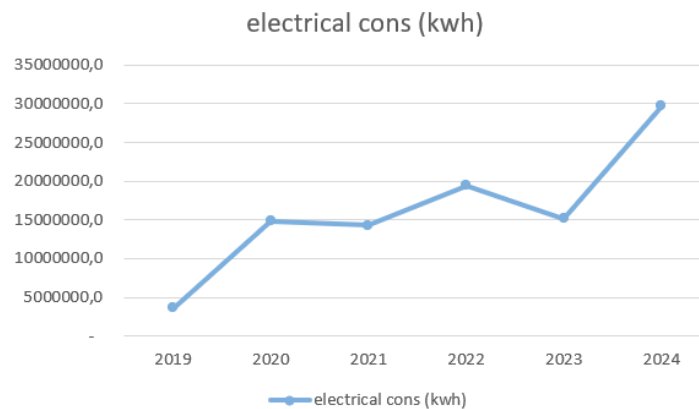
Source: Calculated from PT Borneo Indobara fuel usage data (2024)

The following is the data on electricity consumption at Bunati Port.

**Table 2. Electrical consumption crusher plant Bunati 2019-2024**

No	Bulan	2019	2020	2021	2022	2023	2024
1	January		1.238.700	1.535.940	1.142.220	1.262.940	2.367.240
2	February		1.262.940	1.379.880	1.352.580	1.075.500	2.267.280
3	March		1.075.150	1.358.100	1.377.540	1.351.500	2.509.320
4	April		1.351.500	1.361.160	1.274.880	1.332.840	2.508.960
5	May		1.332.840	1.252.740	1.661.340	1.328.580	2.551.464
6	June		1.328.580	1.084.740	1.727.120	1.181.460	2.450.840
7	July		1.181.460	1.066.440	1.797.960	1.054.800	2.185.380
8	August	287.340	1.054.800	999.060	1.853.280	1.224.960	2.489.508
9	September	696.060	1.224.960	731.100	1.808.760	1.228.160	2.070.048
10	October	645.660	1.188.180	1.158.060	1.799.400	1.225.860	3.049.176
11	November	825.360	1.225.860	1.189.260	1.994.040	1.421.580	2.943.360
12	December	1.194.600	1.421.580	1.172.640	1.592.040	1.510.500	2.410.620
	<b>Total</b>	<b>3.649.020</b>	<b>14.886.550</b>	<b>14.289.120</b>	<b>19.466.460</b>	<b>15.158.700</b>	<b>29.717.736</b>

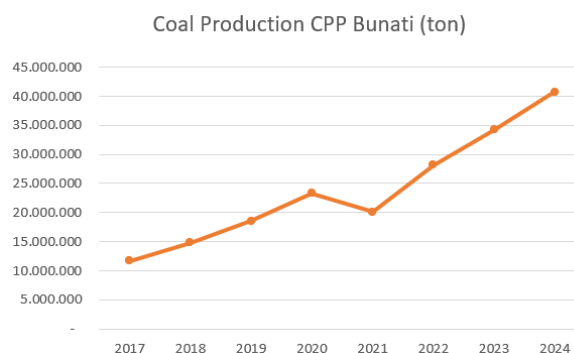
Source: PLN electricity billing records and internal audits (2024)



**Figure 5. Electrical consumption chart crusher plant Bunati 2019-2024**

Source: Processed from PLN consumption data, PT Borneo Indobara (2024)

Since 2017, PT Borneo Indobara has expanded massively from the mine to the Bunati crusher plant. The expansion is carried out to achieve targets that continue to increase from year to year. The latest achievement in 2024 is 46.8 Mt where 40.7 Mt can be delivered through the Bunati crusher plant. The following is the production data from 2017 to 2024;



**Figure 6. Coal Production Crusher Plant Bunati 2017-2024**

Source: Annual production reports, PT Borneo Indobara (2024)

From the graph above, it can be seen that every year BIB coal production continues to increase along with the increase in expansion carried out. There was a decrease in production in 2021 where at that time the Covid 19 pandemic occurred. The pandemic has an impact on all sectors including the production of PT Borneo Indobara Coal.

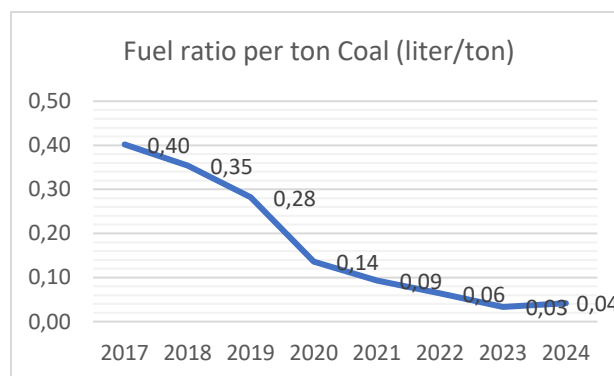
### Energy Ratio and Emission to Production

The ratio of energy consumption and emissions to coal production is an important indicator in assessing the operational efficiency of industrial facilities. One of the mining facilities at PT Borneo Indobara is the Bunati crusher plant. This ratio illustrates how much energy from both fossil fuels and electricity and emissions are produced for each ton of coal produced. By calculating this ratio periodically, the company can compare the effectiveness of its use of energy resources and the success of the pollution control program that has been implemented. The ratio can also serve as a benchmark for its efficiency achievements.

The importance of analyzing this ratio is not only for technical operations, but also for its contribution to BIB's commitments in the Environmental, Social, and Governance context. Ratios that show a downward trend over time reflect improvements in energy efficiency and emissions reduction. A downward trend also has a positive impact on the company's reputation, compliance with environmental regulations, as well as potential cost savings. Therefore, the ratio of energy consumption and emissions per ton of production is one of the main parameters in the evaluation of environmental performance that is based on data and focused on continuous improvement.

**a. Ratio of Fuel and Electricity to production at Bunati crushing plant**

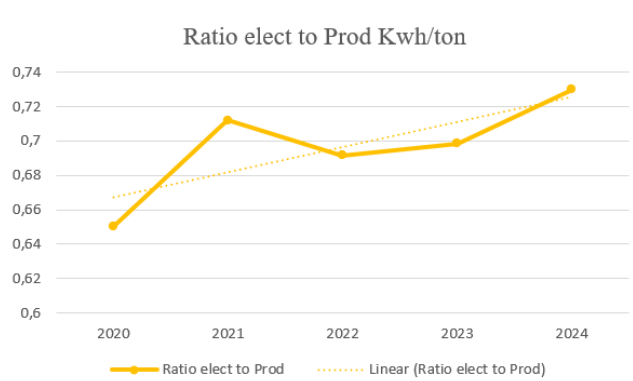
Fuel, electricity and energy consumption ratios at Bunati's crushing plant are important indicators to measure operational efficiency for every ton of coal produced. By calculating the total energy consumption both in the form of diesel fuel for heavy equipment and electricity for equipment operation and dividing it by the total coal production. Pt BIB can find out how much energy is needed to produce one ton of coal. This ratio is the main reference to determine the effectiveness of various improvements that have been made, such as switching from diesel generators to PLN electricity and simplifying the process at the Bunati crushing plant. The following is data on the ratio of various energy to coal production at Bunati.



**Figure 6. Fuel Ratio per ton crushed coal**

*Source:* Energy intensity analysis, PT Borneo Indobara (2024)

Dari From the above graph, it can be understood that there is a consistent decrease in the ratio of fuel consumption to production at the Bunati Crushing Plant. This indicates an increase in energy efficiency in the company's operations. This indicates that for every ton of coal produced, less energy is required from year to year. This data does not yet provide a comprehensive picture of Bunati's energy consumption, so other data is needed because as explained in 4.2 that in 2020 the entire Bunati crusher plant is already using electricity. Below is data on the ratio of electricity consumption to production:



**Figure 7. Electrical Ratio per ton crushed coal**

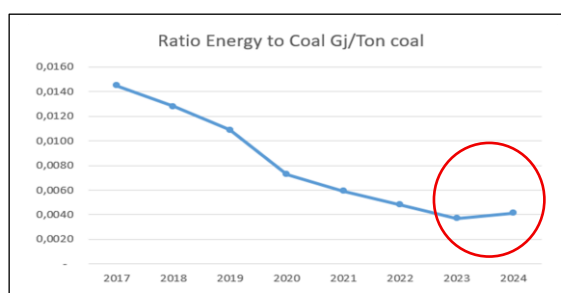
Source: Derived from PLN consumption and production data (2024)

From the graph above, the data shows that every year there is an increase in electricity consumption per ton of coal produced. The increase if traced there are several reasons:

1. In 2021 is the worst ratio of electricity usage to production. This can happen because there is little coal production in that year due to the constraints of the covid pandemic. On the other hand, fix plant operations still have a minimum consumption of electricity.
2. There are additional facilities as improvements that use large amounts of electricity while it is not directly related to increasing production. In 2023, 4 magnet separators were installed, each of which uses more than 25 KW of electricity. In addition, there are also 2 Sampler units that have a load of more than 200 KW each.
3. Increased electricity consumption can also indicate inefficiency in the use of electricity. For example, the crushing plant operates far from its installed capacity, which can be caused by various things such as late supply of coal from the mine.
4. The continuous expansion of bunati has forced some equipment beyond the BEP (best efficiency point) to increase their productivity without investing in new machines.

**b. Emissions to production ratio at Bunati crushing plant**

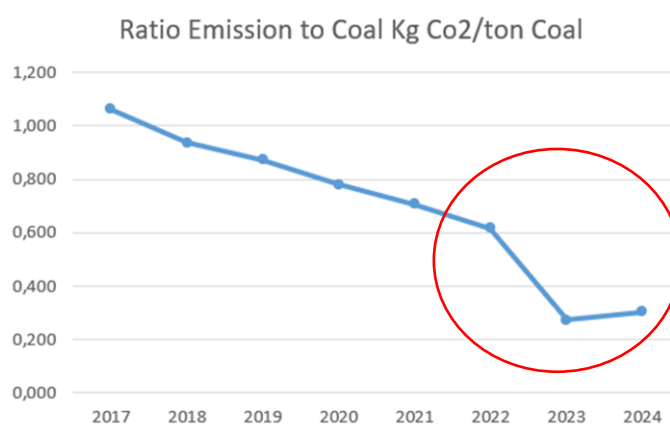
The energy and emissions to production ratio is an important indicator to determine the extent to which crushing plant operations consume energy and generate greenhouse gas emissions relative to the volume of coal produced. This ratio reflects environmental efficiency, with lower values of both ratios resulting in lower energy and emissions per ton of coal. At Bunati, this ratio includes energy and emissions from heavy equipment fuel consumption and electricity use which contributes to total equivalent CO<sub>2</sub> emissions. Below is the data energy per ton of coal produced at Bunati's crusher plant;



**Figure 7. Total Energy Ratio per ton crushed coal**

Source: Integrated analysis of diesel and electricity use, PT Borneo Indobara (2024)

Based on the graph above, in general, the energy consumption ratio at the bunati crushing plant shows a good decrease and this is a very good result. The data above also shows that in 2024 there is an increase in overall energy consumption at the bunati crushing plant. At the beginning of that year there was an increase in activity, namely the operation of the north stockpile and EV charging. North stockpile still uses conventional heavy equipment so this will increase diesel fuel consumption. For EV charging, there is currently an EV truck pilot project running which uses electricity from Bunati to recharge the truck. There are 2 EV truck battery charging points of 400 KW each.



**Figure 8. Total Emission Ratio per ton crushed coal**

Source: Calculated using IPCC emission factors and operational data (2024)

The decrease of the emission ratio at bunati crusher plant is quite good from year to year. This shows the decrease in CO<sub>2</sub> released into the air from each ton of coal produced. There is interesting data from the emission ratio graph, namely a very drastic decrease in the emission ratio in 2023 and a slight increase in 2024. From the data obtained in 2023 there was a significant decrease in emissions due to changes in the source of electricity used. Where in the previous year BIB used energy sourced from fossil energy to energy sourced from new renewable energy from PLN. PLN provides these services in the form of REC (renewable energy certificate). All electricity consumed at the bunati crusher plant has been in REC.

### **Solution and Proposed Implementations Plan**

From the data and analysis above, the following are some recommended solutions that can potentially be implemented to reduce the rate of increase in energy and emission ratios that increase in 2024 and do not increase in future years.

#### **1. Optimization of the north stock pile operation and loading and unloading system without additional heavy equipment.**

The main solution is minimizing the use of the North stockpile and prioritize direct unloading into hoppers as had been successfully done during the normal operating situation at bunati. By limiting the use of conventional heavy equipment, fuel consumption and emissions

can be further reduced. This can be implemented gradually at the North Stockpile which currently relies on conventional heavy equipment.

The implementation plan is to conduct technical studies on logistics lines, especially fleet management and north stockpile operation design so that heavy equipment there is not operated continuously. This is a quick step that does not cost much but requires an in-depth study so that it can be accepted by the contractor holding the north stockpile work contact as one of the parties that will be disadvantaged due to the reduced working hours of the heavy equipment provided. This step could be implemented within the next half year, due to that it does not require direct investment. The north stockpile stake holders should agree on the scheme and include it in the contract addendum.

## **2. Converting conventional Heavy Equipment to electric or hybrid**

The challenge of first solution above is that heavy equipment will often not work and only wait, this is the cause of the operational management of the north stockpile being unattractive to prospective contractors holding the operation contract. As an improvement first solution, if the north stockpile is operated it must use electric or hybrid-based heavy equipment units. This solution allows for a reduction in direct diesel emissions and improves energy efficiency in the long term. It will still be increasing the energy ratio, but it will not be increasing emission ratio. Currently the coal hauling department has conducted implementation research with 6 DT EV units operated to transport coal from the mine to the Bunati CPP, this can also be applied to the north stock pile.

The implementation plan includes mapping the needs of active heavy equipment, analyzing investment costs, and piloting one to two units of Electric or hybrid based for heavy equipment. conventional heavy equipment is then compared on a capex and opex basis within a certain time span according to the economic life of the machine. For dump trucks, if the investment review analysis is favorable then this can be implemented immediately with reference to research in the coal hauling department. If the trial is successful, then full conversion can be planned in phases over maximum the next 2 years. this has the greatest opportunity considering that for DT, BIB has already started the implementation research and also it will not has impact to production capacity.

## **3. Independently and gradually utilization of renewable energy.**

To reduce dependence on electricity from PLN which is not fully sourced from clean energy, Bunati can start using renewable energy such as solar panels for some of the plant's needs. BIB has already planned for 2 MW of solar panels and an MOU with a partner was signed last year. Regulatory constraints are become obstacle to the process; BIB continues to communicate with PLN and encourage the government to make it easier and provide greater opportunities so that the plan can be realized.

The first step begins with a feasibility study of the installation location and an estimate of the energy capacity that can be generated. This has already been done in 2024 and needs to be encouraged so that some regulatory issues can be resolved. If these regulatory hurdles can be resolved, within 1.5 years 2 MW of solar PV can be operational and this can compensate for some of the heavy equipment that cannot be converted to EV or hybrid that is still in use in bunati.

## **4. Re-engineering operations at the north stockpile with specialized equipments.**

The North Stockpile is a critical point that remains energy and emissions inefficient due to the use of conventional heavy equipment. Solution options include re-engineering the operational flow in this area to replicate the success of the main system at East and West Bunati.

The implementation plan includes a redesign of coal material flow, an integrated conveyor system, and the possible use of a fully electric stacker-reclaimer. The initial phase involves a thorough technical audit, feasibility study especially considering the remaining duration of PT BIB's contract with the government which is only until 2036, followed by a gradual adjustment of the supporting infrastructure. This is the solution with the biggest challenge which is that it requires a very expensive investment cost while PT BIB will expire its concession period in 11 years and the negative issue of coal as a dirty energy source makes the chances of this solution option even harder because it has an impact on coal prices which continue to be depressed.

### **Justification of Implementation Plan**

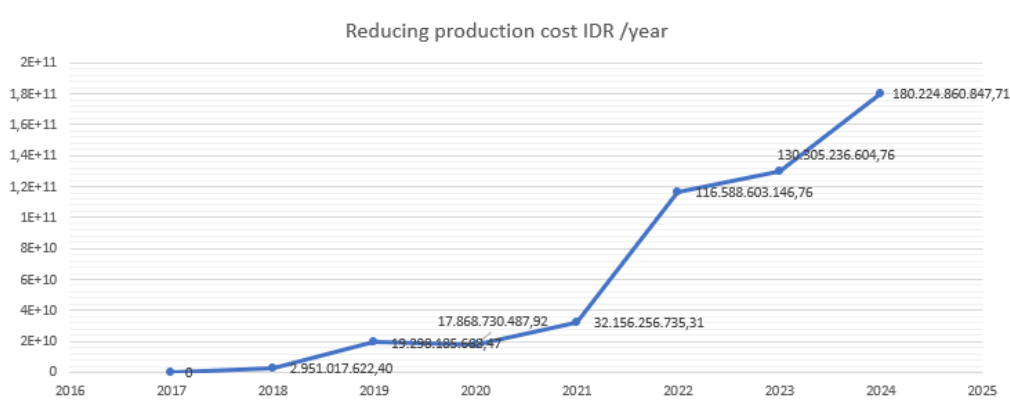
The implementation of the proposed solutions to improve energy efficiency and emission control in Bunati's operational areas, especially at the North Stockpile, needs to be based on robust and data-driven considerations. Over the period 2017 to 2024, PT Borneo Indobara has proven that operational design changes that reduce reliance on heavy equipment and fossil energy have significantly reduced fuel consumption and resulted in substantial production cost savings. This positive trend not only demonstrates the success of the previous strategy, but also provides a strong basis for developing further solutions such as stockpile optimization and conversion of heavy equipment to more environmentally friendly systems. The following justifications are the reasons why it is feasible and relevant to continue improving ESG implementation at the Bunati plant.

#### **1. Optimization of north stockpile operations and unloading system without additional heavy equipment**

The North Stockpile currently relies on conventional heavy equipment for the coal loading process, which requires large amounts of diesel fuel consumption. Data from 2017 to 2024 shows that the reorganization of the operational system at the Bunati crusher plant that reduces reliance on heavy equipment has significantly reduced diesel consumption from 4.7 million liters to only 1.7 million liters per year. This is also followed by significantly improved production cost efficiency, achieving savings of more than 180 billion by 2024 as shown in figure 9. Optimization of the North Stockpile can be done by applying a similar method, namely using a coal flow system directly from the hauling truck to the hopper without support of heavy equipment as the main driver. This means that the use of the north stock pile should be minimized in normal operating situations. This solution will also support the improvement of ESG aspects by reducing emissions and environmental impacts in the surrounding area.

#### **2. Converting conventional heavy equipment to electric or hybrid**

Data shows that diesel fuel consumption has decreased dramatically along with the reduction in the number of heavy equipment, but at the North Stockpile the use of conventional heavy equipment is still quite dominant. To further reduce costs and emissions, converting the machines from diesel-based to electric or hybrid is the next strategic step. Electric-powered machines have higher energy efficiency and much lower emissions than diesel versions, and can reduce long-term operational costs such as maintenance and fuel.



**Figure 9. Production cost reduction by energy efficiency**

Source: Financial and operational reports, PT Borneo Indobaras (2024)

This conversion can be started gradually, starting with units that operate in a fixed and repetitive area such as wheel loaders for coal retrieval in stockpiles. Another advantage is that the operation of electric machines tends to be quieter and environmentally friendly, which will have a positive impact on working conditions in the field as well as the company's image in ESG practices. In addition, with the increasing trend of more efficient electricity consumption per ton of coal, this solution will be in line with the direction of energy transition and support the target ratio of emission reduction per ton of coal produced.

DT EV technology is now available, EV machines such as Komatsu's PC200-class wheel loaders and excavators from Chinese manufacturers. These machines are still in the development stage and require research to prove their reliability. PT BIB will actively cooperate in the research and implementation of these machines so that BIB will be the pioneer of their use in mining.

The following are the cost savings from energy savings and efficiency that have been carried out at the bunati crushing plant.

### 3. Gradual Utilization of Renewable Energy

As part of a long-term strategy, the utilization of renewable energy such as solar panels is very relevant. As electricity consumption continues to increase, utilizing renewable energy can be an environmentally friendly and sustainable alternative. In addition to helping stabilize energy costs in the future, this step will have a positive impact on the company's ESG score and demonstrate a commitment to sustainability that will improve PT BIB's image

### 4. Re-engineering Operations at the North Stockpile with Specialized Equipment

The use of conventional heavy equipment that still dominates operations at the North Stockpile is a real challenge today. They are not specifically designed for efficiency in a working environment such as a stockpile. Therefore, the implementation of specialized equipment such as stacker-reclaimers or auto-stackers can significantly improve work efficiency, reduce energy intensity, and reduce emissions.

While these solutions require a relatively large initial investment, historical data shows that sustainable operational savings recoup the investment in the medium term. This justification is supported by the increasing trend of cost savings, proving that operational

efficiency goes hand in hand with financial efficiency. this solution has more potential when coal prices are high or government contract extensions are obtained early.

## CONCLUSIONS

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Between 2017 and 2024, PT Borneo Indobara (BIB) significantly reduced diesel fuel consumption from 4.7 million liters to 1.7 million liters annually while increasing coal production from 12 million tons to over 40 million tons. This led to a decrease in energy intensity from 0.0145 GJ/ton to 0.0041 GJ/ton and a reduction in CO<sub>2</sub> emissions from 1.06 kg/ton to 0.3 kg/ton, resulting in operational cost savings exceeding Rp180 billion by 2024. However, a slight increase in energy and emission ratios was observed in 2024, mainly due to the activation of the north stockpile, which still relies on conventional heavy equipment, with 20 such units operating at the Bunati crusher plant. To address this, adopting proposed solutions one and two—likely involving modernization or electrification of equipment—holds strong potential for further improvements. Future research should focus on evaluating the implementation and impact of these solutions on energy efficiency and emission reductions to sustain and enhance BIB's environmental performance.

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