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ABSTRACT

The mining industry is one of the industries that has caused environmental damage. It is not only deforestation, but pollution, groundwater, and air problems caused by the mining industry. Departing from the worsening ecological conditions due to development, the mining industry became environmentally friendly by adopting the so-called green mining. This article wants to examine the application of green mining in Indonesia to find out the main strategies they carry out by mining companies. Through descriptive analysis, this article finds that the green mining industry in Indonesia is organized through cooperation between the government, mining companies, investors, and researchers. The association is practiced through the so-called green policy, green management, green investment, and green technology.

Keywords: Green Investment, Green Mining, Green Management, Green Policy, Green Technology.

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I. INTRODUCTION

Indonesia is one of the four countries that caused 80 percent of tropical deforestation caused by large-scale mining in the last two decades; research states that Giljum *et al.* (2022) with 1,901 km² of deforested areas, Indonesia is by far the most affected country, accounting for 58.2% of direct forest loss by mining among 26 countries under investigation. The expansion of mines in East Kalimantan on the island of Kalimantan for coal production is a significant factor behind this development in Indonesia. The research also showed that Brazil and Indonesia have a high statistical significance for mining that encourages deforestation in surrounding areas up to 50 km outside the mining area. In Indonesia, the highest deforestation rate occurred from 2010 to 2014, a period marked by doubling the volume of coal production, mainly driven by demand from China and India. In addition, the mining industry is also an industry that contributes to damage to water quality around (Anggraeni *et al.*, 2019; Hernaningsih, 2022; Setiawan *et al.*, 2018), soil damage and air pollution and even (Shi'a, 2012) animal habitats (Wahana Lingkungan Hidup Indonesia, 2006).

Concerns over the environmental impact of mining activities have prompted the initiative to make plans for environmentally friendly industries, including mining. The green mining industry began to be introduced and practiced in several countries. Green Mining Industry is an effort to promote energy efficiency to reduce the environmental footprint of the life cycle of mineral-based products. The purpose of the new solution is to allow the recovery of all valuable minerals and by-products and to minimize the amount of waste. Solutions to reduce water and energy consumption are being developed (Huang *et al.*, 2021; Nurmi, 2017; Shi'a, 2012). Thus, it is mandatory to reduce energy and material mining, and mineral enrichment is compulsory so that mining can reduce the impact of mining at every stage of operation. Proper training, application of green technologies, sound environmental management tools, and forming sustainable partnerships help the mines improve performance and attain sustainability (Maddala *et al.*, 2021).

However, the implementation of the green mining industry is not easy. The challenges of the green

mining industry mainly come from the governance of state institutions in producing green mining industry policies. The conflict of interest between the central government, local governments, and metal mining companies often negatively affects the implementation of the green mining policy (Bebbington & Bury, 2019; Jiskani *et al.*, 2022; Zhao *et al.*, 2020). In addition to weak governance that causes conflicts, the lack of awareness of the environment and laws is another cause for implementing the green mining industry. Another challenge for the technical implementation of the green mining industry is that renewable energy has not been used in its operations. This is due, among others, to 1. Technically renewable energy is still challenging to produce 2. Renewable energy is not cheap, so finding investors is challenging. 3 Companies still see renewable energy as a compliment, not the company's main business (Barve & Muduli, 2013; Bebbington & Bury, 2019; Gangazhe, 2016). Referring to the condition of mining companies as a significant contributor to environmental damage and the high challenges of adopting a green mining industry, this article is intended to see how the adoption of the green mining industry by mining companies in Indonesia.

II. MATERIAL AND METHOD

Indonesia is one of the four countries that caused 80 percent of tropical deforestation caused by large-scale mining in the last two decades; research states that Giljum *et al.* (2022) with 1,901 km² of deforested areas, Indonesia is by far the most affected country, accounting for 58.2% of direct forest loss by mining among 26 countries under investigation. The expansion of mines in East Kalimantan on the island of Kalimantan for coal production is a significant factor behind this development in Indonesia. The research also showed that Brazil and Indonesia have a high statistical significance for mining that encourages deforestation in surrounding areas up to 50 km outside the mining area. In Indonesia, the highest deforestation rate occurred from 2010 to 2014, a period marked by doubling the volume of coal production, mainly driven by demand from China and India. In addition, the mining industry is also an industry that contributes to damage to water quality around (Anggraeni *et al.*, 2019; Hermaningsih, 2022; Setiawan *et al.*, 2018), soil damage and air pollution and even (Shi'a, 2012) animal habitats (Wahana Lingkungan Hidup Indonesia, 2006).

Concerns over the environmental impact of mining activities have prompted the initiative to make plans for environmentally friendly industries, including mining. The green mining industry began to be introduced and practiced in several countries. Green Mining Industry is an effort to promote energy efficiency to reduce the environmental footprint of the life cycle of mineral-based products. The purpose of the new solution is to allow the recovery of all valuable minerals and by-products and to minimize the amount of waste. Solutions to reduce water and energy consumption are being developed (Huang *et al.*, 2021; Nurmi, 2017; Shi'a, 2012). Thus, it is mandatory to reduce energy and material mining, and mineral enrichment is compulsory so that mining can reduce the impact of mining at every stage of operation. Proper training, application of green technologies, sound environmental management tools, and forming sustainable partnerships help the mines improve performance and attain sustainability (Maddala *et al.*, 2021).

However, the implementation of the green mining industry takes work. The challenges of the green mining industry mainly come from the governance of state institutions in producing green mining industry policies. The conflict of interest between the central government, local governments, and metal mining companies often negatively affects the implementation of the green mining policy (Bebbington & Bury, 2019; Jiskani *et al.*, 2022; Zhao *et al.*, 2020). In addition to weak governance that causes conflicts, the lack of awareness of the environment and laws is another cause for implementing the green mining industry. Another challenge for the technical implementation of the green mining industry is that renewable energy has yet to be used in its operations. This is due, among others, to 1. Technically renewable energy is still challenging to produce 2. Renewable energy is not cheap, so finding investors is challenging. 3 Companies still see renewable energy as a compliment, not the company's main business (Barve & Muduli, 2013; Bebbington & Bury, 2019; Gangazhe, 2016). Referring to the condition of mining companies as a significant contributor to environmental damage and the high challenges of adopting a green mining industry, this article is intended to see how the adoption of the green mining industry by mining companies in Indonesia.

III. RESULT AND DISCUSSION

A. Green Mining Policy in Indonesia

The main challenge of coal use today is the considerable international attention to the issue of global warming. The international agreement for global temperature reduction, documented as the Paris Agreement, was followed by almost all countries, including Indonesia. The decrease in energy sources that

produce carbon emissions, such as coal, and the shift to more environmentally friendly energy are efforts by countries to meet the deal. These global demands are putting pressure on the decreasing use of coal globally, including in Asia. To answer the challenges of coal use issues, the primary key is developing and utilizing coal in line with the carbon emission reduction target. Therefore, increasing national energy security and independence can be done through the optimization of national coal resources and reserves by: (1) maintaining the level of domestic use of coal; (2) conversion of coal for the substitution of imports of other energy and industrial raw materials; (3) extraction of coal content for industrial and agricultural needs; and (4) application of coal utilization technology that is more environmentally friendly (Direktorat Jenderal Mineral dan Batubara, 2021). The four points above can be achieved through the national coal development and utilization program that integrates the upstream and downstream sectors, so preparing a roadmap (road map) for the development and utilization of measurable and implementation coal is essential.

Green mining provides guidelines for the mining sector to achieve future sustainable development. The vital goal of green mining is to minimize adverse environmental and social impacts at all stages of operations and maximize local benefits. According to (Nurmi, 2010 to 7), the objectives of green mining include; 1. promoting materials and energy efficiency, which reduces the environmental footprint of mineral-based product life cycles, and 2. ensuring the availability of mineral resources for the future. Sustainable development requires that our current use of mineral resources does not endanger the ability of future generations to satisfy their needs. 3. To share fair benefits. All stakeholders must benefit from mining, and the industry should create a long-term positive impact on regional development. In line with this, the Ministry of Industry has compiled the concept of the green industry in Regulation of the Minister of Industry No. 05/M-IND/PER/1/2011, where the green industry is defined as an environmentally sound industry that aligns growth with environmental sustainability, prioritizing efficiency and effectiveness of the use of natural resources and benefiting the community.

In Indonesia, the recommendation to do *green mining* is contained in the Law of the Republic of Indonesia Number 3 of 2020 concerning Amendments to Law Number 4 of 2009 concerning Mineral and Coal Mining. The law has regulated several mining-related matters to control the behavior of mining companies from glorifying business licenses to reclamation. Every mining company must obtain a permit for every mining-related activity, from mining permits and transportation to sales. This is intended so that the investor can control the faithful stages of mining activities carried out by the company. The Law also stipulates the obligation of companies to carry out reclamation to improve the quality of the environment and ecosystem and community empowerment.

Government intervention in mining companies is also getting more prominent in this Act, as mentioned in article 6. In the article, the Central Government in the management of Mineral and Coal Mining has the authority, among others: to determine policy plans and direction of national Minerals and Coal, establish regulations, legislation and national guideline standards, conduct Mining Investigations and Research in all Mining Jurisdictions; issuing Business Regulations; conducting guidance and supervision on the implementation of Mineral and Coal Mining Business activities and post-mining reclamation, establishing production, marketing, utilization, and conservation policies, establishing policies of cooperation, partnership, and Community Empowerment (Undang-Undang No. 3, 2020, 2020).

In the laws and regulations of Law No. 3 of 2020, at least three critical points were found in mining management, including a. Licensing instruments, b. Utilization of exploitation areas and production operations and c. reclamation and post-mining. In its efforts, the control instrument through the coal mining business licensing policy is called the Mining Business Permit (Mining Business Permit / IUP). IUP is a license to carry out mining business. However, with the Local Government Law, the authority to provide IUP is the Provincial Government by its jurisdiction. The Omnibus Law and the Mineral and Coal Law in 2020 regulate the central mining business license with an electronically integrated licensing system. The principle of granting IUP is only allowed for one type of mine. One IUP is given for a kind of mineral or coal. The giving of IUP should not be more than one type of mine. These centralized joint rules make control over the first part more coordinated and integrative.

To control the behavior of companies that carry out development, the order also establishes control over the utilization of exploitation areas and production operations. Good mining business techniques include (a) environmental management efforts, Mineral and Coal conservation, and mining techniques by their fields of business; (b) the obligation to appoint a person in charge of operations in the field. The governance of the mining business includes: (a) the priority of domestic products, (b) the priority of local labor, and (c) the optimization of local spending on both mining goods and services (Yulianingrum, 2021).

Meanwhile, controlling the sustainability of coal mining management through reclamation and post-mining activities becomes the obligation of each mining company. Reclamation is an activity carried out throughout the stages of the mining business to organize, restore, and improve the quality of the environment and ecosystem so that it can function again according to its designation. Post-threshold activities are planned, systematic, and continued activities after the end of part or all of the mining business

activities to restore the functioning of the natural environment and social functions according to local conditions throughout the mining area (Candy No. 78, 2010).

The government has also prepared a law to tackle those who violate the environment, including mining companies through Law Number 4 of 1982 concerning Provisions for Basic Management Provisions Environment Law Number 23 of 1997 concerning Environmental Management (Undang-Undang Perlindungan dan Pemeliharaan Lingkungan / UUPPLH 1997), and Law Number 32 of 2009 concerning Environmental Protection and Management. The Act regulates what yang meant by environmental pollution, including industrial environmental pollution acts and the threat of humans to perpetrators of destruction of the environment. The Act applies to any violator of ecological collapse, including officials who do not exercise appropriate oversight of the activities intended by the law, as listed in Article 112 of the 2009 UUPPLH. The article states that any authorized official who deliberately does not supervise the compliance of the person in charge of the business and activities to the regulations, environmental legislation, and permits as referred to in Article 71 and Article 72, which results in pollution and environmental damage resulting in lost human lives will be sanctioned.

The government's efforts, which were carried out through the establishment of national standards regarding the implementation of the mining industry and laws and regulations, were also recognized by PT Adaro as a matter of encouragement for them to be more concerned about the green mining industry. From interviews conducted with Adaro representatives, it was revealed through what was conveyed as an external encouragement through the Ministry of Mineral Resources and the Ministry of Environment and Forestry:

So, if you look at the background, maybe we can divide it into two, namely External Factors and Internal Factors, so if we look at the fact that this external fact is quite massive from the government itself, especially if we in the mining industry are seen as an extractive industry, which is always viewed negatively, whether it changes about nature, especially if the method is open-pit mining. The government is very concerned if, from the government side, two institutions are responsible for operations or as the leading sector; the first is the Ministry of HR and the Ministry of Environment and Forestry. In this ministry, each of them applies operational standards related to environmental management, and an evaluation will be carried out related to good mining engineering rules, one of which is the aspect of environmental protection. So, with such external conditions, of course, from the inner side, it is necessary to respond to these challenges, including green investors and others. So, internally, you must respond with environmental protection programs and community development (PT Adaro Representatif, 2022).

The representative of PT Buma also conveyed the same by adding customers as external parties who indirectly encouraged them to comply with government regulations related to the green mining industry:

This BUMA is quite *concerned* related to compliance with regulations, both government regulations, and regulations in our customers so that it becomes a reference when talking about it; we speaking of the moment, how the heck is our application related to laws related to the environment? Indeed, at the moment, this is a *concern* for us. Secondly, we also commit as one of the contractors to the customer to meet some of the requirements that he has submitted to the government (PT Buma Representatif, 2022).

B. Green Mining Management

The challenge for mining companies today is that they must be able to promote material and energy efficiency, ensure that companies can sustainably minimize social and environmental impacts, and ensure that ex-mining land can still be helpful. This capacity is a requirement for every mining company to obtain a social license so that the company can operate.

This challenge is certainly not easy for company management. Green management is an obligation for every mining company to answer these challenges. The mining industry must develop a sustainable strategy that benefits the company. Of course, productivity and various stakeholders are essential in ensuring sustainability to avoid conflicts and reduce social and environmental problems. The implementation of green management in mining companies uses an international standard called ISO 50001. With ISO 50001 certification, companies and organizations can demonstrate their commitment to passing on sustainability relationships to their customers, employees, investors, and regulators. Thus, companies and organizations can gain a competitive advantage by proving themselves *good corporate citizens*. This can help boost their brand, which directly supports their marketing strategy.

ISO 50001 is an Energy Management standard that applies to mining companies. This standard is used to manage energy performance, including energy efficiency and consumption, using the Management System model with a Plan, do, check, and action cycle approach for continuous improvement. The standard aims to help organizations reduce energy use, greenhouse gas costs, and emissions. ISO 50001 is designed to help companies use their energy assets better, evaluate and prioritize energy-efficient technologies, and drive efficiencies throughout the supply chain.

The benefits of ISO 50001 include companies being able to develop policies for more efficient use of energy, set targets of energy efficiency and goals to meet guidelines, use data to better understand and make

decisions about energy consumption, measure the results of improvements from energy efficiency, support policy development and energy contribution to the structure of energy plans in achieving targets, creating awareness and commitment about energy (consumption, use, efficiency, renewable sources) in the organization and improving the organization's ability to manage energy risks regarding possible impacts as efficiently and effectively as possible (ISO, n.d.),

However, the successful implementation of ISO 50001 depends on the commitment of all levels and functions of the organization, especially the top management. Top management shall appoint a management representative who will ensure the management system complies with ISO 50001 requirements, determine methods to ensure effective system operation and control, and report to top management the performance and effectiveness of the energy management system (Proxsis Organizations, n.d.).

In addition to ISO 5001, the environmental-based management assurance standard is ISO 14001. ISO 14001 is an internationally applicable standard regarding Environmental Management Systems (EMS). EMS is one part of standardization for organizations, agencies, or companies that specifically regulate the environment. In this case, what is meant is all the activities of the company and their impacts on the environment. The objectives of ISO 14001 are to suppress adverse effects on the environment that may arise due to the organization's operational activities, obey the applicable laws and regulations, and provisions related to environmental issues, and make improvements to the above actions on an ongoing basis. Through these primary goals, ISO 14001 EMS encourages companies to be active in improving their ecological role. This is done through a series of processes in a structured and continuous manner. The series of operations referred to in EMS include:

1) *Commitments and policies*

The company or organization is committed to increasing its participation in the environment. One of them is evidenced by formulating and establishing related policies.

2) *Planning policy will determine the next stage, which is Planning*

Here the organization initially identifies what environmental issues arise from its operational activities. At the same time, ascertaining how much negative impact may arise.

3) *Implementation*

The plan is applied factually by utilizing all the necessary resources. This could include counseling and training to increase employees' environmental awareness. Or it is supporting things, such as documentation, creation of operating procedures, creation of internal and external communication lines, and so on.

4) *Evaluation*

The intention of evaluation here is to review the plan's implementation to ensure the achievement of the previously set goals. If it is not achieved, the company will have to make improvements. If completed, it can be continued by determining new goals and targets.

5) *Reassessment*

Not enough companies engaged in extractive industries in Indonesia are still scarce to obtain ISO 50001 or 14001. From the Ministry of New Renewable Energy and Energy Conservation website, it is known that only Pertamina Hulu Mahakam, PT. PHE WMO, PT. Adaro Indonesia, PT. Rhinoceros NGL, PT. Indonesia Asahan Aluminium, PT. Kideco Jaya Agung, Pertamina Hulu Energi ONWJ, PT, and Pertamina Refinery Unit IV Cilacap are only recorded as ISO 5001 (EBTKE) certified. Meanwhile, those who obtained ISO 14001 include PT Pertamina EP Field Cepu, PT Krakatau Steel, Bukit Asam, PT Freeport Indonesia, PT Kaltim Prima coal, PT. Medco E&P Indonesia, PT Ceria Nugraha Indotama (CNI), PT Timah, PT ANTAM, PT Adaro Indonesia, PT Arutmin, PT Berau.

The government itself continues to encourage the improvement of the management of mining companies to care about the environment by organizing PROPER, namely the Company's Performance Rating Assessment Program. PROPER is an evaluation of compliance and performance exceeding the submission of the person in charge of the business and activity in the field of pollution control and environmental damage, as well as the management of hazardous and toxic waste (Ministerial Regulation LH No. 3 of 2014).

For PT Adaro, as the first mining company to receive gold PROPER, this award is an important recognition for the company's management, placing energy and environmental issues as an essential part of its performance. PT Adaro carries out efforts to improve the performance of its management by building management through IMS (Integrated Management System), which is a combination of: - Quality Management System (ISO 9001: 2015) - Environmental Management System (ISO 14001: 2015) - Energy Management System (ISO 50001: 2011) - Occupational Safety Health Management System (OHSAS 18001: 2007 and SMK3 Certification from the Ministry of Manpower) - Mining Safety Management System (Triwibowo, 2020), to help encourage the use of new and renewable energy, Adaro issued a green initiative. Green initiation is a new business pillar that PT Adaro will carry out through energy, namely

biomass and Tenaga Surya Power Plant (Pratiwi, 2022). In line with Zhou *et al.* (2021), Pun (2006), Mudgal *et al.* (2010), and Govindarajulu - Daily (2004), then top management plays a vital role in improving the quality of company management. This was also acknowledged in an interview conducted with PT Adaro: (...) for green initiative activities and so on, it does have full support from TOP Management, sir, especially from the owner, so the owner fully supports the green initiative activities, even in our pillars will be added with the green initiative activities themselves. So, it's supported by the direct owner" (PT Adaro Representative. Zoom Interview. June 24, 2022).

C. Green Mining Investment

Decision-making concerning exploration investments is never based solely on geological potential but considers many other issues. Access to Tanah and legal framework are essential factors for the mineral industry. Competition with other land uses (such as agriculture, nature conservation or landscape history, and infrastructure buildings) leads to increasing barriers to mineral exploration. The development of mines is also becoming increasingly difficult for communities and the environment because mining interests must compete with other interests in society, such as biological diversity, tourism, and recreation. Laws and regulations will make mining in the future more difficult in many countries (Nurmi, 2017).

To compete with other sectors, mining companies increasingly consider Environmental Social Governance (ESG) as a company standard in their investment practices. It consists of three concepts or criteria: Environmental, Social, and Governance. Companies that carry out the idea and implementation of ESG criteria have become a primary consideration for investors in deciding whether to invest in a business or company. In addition to considering economic benefits, the balance between social and environmental aspects is a consideration for investors to invest. Therefore, the sustainability study of the mining industry has always focused on aspects of a clean environment, such as waste management (González & Onederra, 2022). It also found that established industrial companies have placed ESG as critical consideration, including mining. The company's value is closely related to the implementation of ESG in its company (Pandu, 2021).

Green investment strengthened in the 90s with a focus on governance issues but generally included environmental factors. In the 2000s, sustainability and long-term investment became popular. Some green funds have been around since the 1980s and 1990s. Still, climate change and growing concerns about the depletion of natural resources and resource efficiency have brought a considerable impetus to green investment in recent years. Lately, the concepts of impact investing, universal ownership, and sustainable capitalism have been introduced (Senses - Ch. Stewart, 2012). The transition to green energy is increasingly attracting investors. In 2020, it will be the most critical number for financing mining that has carried out a transportation strategy in the green mining industry (de Jong *et al.*, 2021).

The increasing number of green investments is stated in Nababan & Hasyir's (2019) research that environmental performance significantly influences financial performance (Return on Asset/ROA), where the higher the PROPER ranking will have an impact on the higher the ROA value. This is in line with the resulting concept), that (Ezejiophore, 2016 environmental performance can increase goodwill, which creates economic benefits and improves the company's reputation in the community to support the company's higher financial performance.

Changes in investors' considerations in investing are increasingly encouraging companies to engage in social and environmental concerns. The influence of investors' tendency on their ESG is also recognized by mining companies, who mention that an investor and stakeholder is an external factor that encourages mining companies to adopt the green mining industry.

So, indeed, investors' concern for practices in the environmental field has increased. Ada green investor who is only willing to invest in companies whose environmental record is good, which is reflected in that, especially what is seen is PROPER, yes, what ratings, it is usually like that. Well, indeed, coal, some see as an industry that produces dirty energy because of its high emissions because its nature is like that, however. The point is that in operational practice, it is what we strive for, and always investors who come are concerned, in addition to the quality of the product, how is the safety, how is the environment, how is the development of the community, now because PROPER is known nationally and internationally. The main consideration is what the proper rating is; if it is red, of course, this is not environmentally compliant; if he invests there, it can be criminal or something, but if it is green or gold, it has been proven that his company is already concerned" (PT Adaro Representative, 2022).

To support green investment, the Indonesian government has also issued a law related to this matter, namely through Article 2 of Presidential Regulation 16 of 2012, which states that the policy direction is an investment, which consists of 1) Improving the Investment Climate; 2) Investment Distribution; 3) Focus on Food, Infrastructure, and Energy Development; 4) Green Investment Investment; 5) Empowerment of Micro, Small, Medium Enterprises, and Cooperatives; 6) Provision of Investment Facilities, Facilities, and Incentives; and 7) Investment Promotion.

D. Green Technology

Law No. 39 of 1999 on Human Rights in article 9, paragraph (3) states that "everyone has the right to a good and healthy living environment." The Act allows superiors, including mining companies, to maintain a good and healthy environment. To fulfill this obligation, Rahmat Makassau, Chairman of the Indonesia Mining Association (IMA), made a fuss that companies must start thinking about developing mines using technology and where power or generation could be gained. The thought must be carried out because, inevitably, mining products will be linked to be produced green or not (Indrawan, 2022). Recognition of the use of technology in the green mining industry can be seen, for example, in Clean Coal Technology Vision 2045. The Coal Road Map is prepared to refer to the target of downstream coal products, which are a priority for import substitution and meeting domestic energy and industrial needs for the development and utilization of national coal with the application of environmentally friendly technology (Direktorat Jenderal Mineral dan Batubara, 2021).

Several companies have used technology in exploration, management, or post-mining in green mining practices. Zijian's research suggests that the choice of tailings reprocessing technology can create significant value and reduce costs for the environment. Likewise, the emission purification technology system is optimized before it is released. Choosing the right technology for the mining industry is much more efficient than overhauling the entire management. This includes, for example, the use of up-down good drainage technology that can solve the threat of water shortage hazards resulting from the mineral mining process. (Bai *et al.*, 2022)

Meanwhile, blasting efforts in the exploitation of minerals that can potentially destroy the environment can be reduced by the risk of using Biocompatible green Blasting. Green Biocompatible Blasting provides a safer working space and environment for personnel and the ecosystem. The concentrations of dust and toxic gases produced in the tests were much lower than the traditional blasting method. Green Biocompatible Blasting can reduce the high concentrations of dust and poisonous gases caused by conventional blasting in surface mining with proper attention (Sozai *et al.*, 2017). Meanwhile, the use of Biodegradation for clean-up cyanide as an alternative to physical and chemicals treatment processes in the mining industry (Luque-Almagro *et al.*, 2016) and the use of technology of paste and thickened tailings (P&TT) to reduce pollution due to acid and metalliferous drainage or AMD (also commonly known as acid mine drainage) (Mudd, 2011).

In Indonesia, the use of technology in the mining industry, for example, has been used by PT Adaro in developing coal processes. To reduce energy use, CPBL/Cool Processing and Bars Loading is supported by a power source with solar power. CPBL is an effort to reduce the size of coal to customer demand. This CPBL is usually in the Port because it will be raised to the ship after the coal is crushed. PT Adaro has built CPBL with solar energy in several of Kelani's ports. Two solar power plants are owned, namely rooftop solar power plants with a power of 130 KwP, and operating in 2019. The second is a floating solar power plant. This Solar Power Plant can reduce the use of power generators during operations only; unfortunately, the Solar Power Plant used today does not use batteries, so it can only operate when there is sunlight. The use of batteries is still considered because the batteries also enter P3 waste.

In addition to utilizing solar energy, mining companies are encouraged to utilize biodiesel. This initiative has been promoted since 2018 by using the B10 formula. PT Adaro has embarked on this biodiesel technology initiative to replace fossil energy gradually. One of the biodiesels used by PT Adaro is jatropa. The content of jatropa used is 20% energy, and the other is still in the form of diesel, as much as 80%. This transition was not easy and cheap because PT Adaro also had to adjust the use of machines that could utilize mixed energy. PT Adaro claimed that United Tractors and Komatsu had supported this kind of energy transition (Agency Manager Plantation Fund Coconut Palm (BPDPKS), 2018).

The use of technology at PT ANTAM is intended to process slag. Slag is a residual material resulting from the pyrometallurgy process of separating metals from their ores. To reduce slag waste, ANTAM innovates to utilize the slag produced by the UBP Nikel Southeast Sulawesi ferronickel processing plant by utilizing slag for concrete construction materials named POTON or Pomalaa Concrete. POTON is currently still used internally in the Company, including as a road base, yard base, and construction purposes that require concrete materials, namely employee sports facilities, parks, lodging guests and employee service houses, pedestrians, and other maintenance projects of the Company. The use of slag material in value-added products has received permission from the Ministry of Environment & forestry based on the Decree of the Minister of Environment Number SK 127/MenLHK/Setjen/PLB.3/2/2019 dated February 11, 2019, concerning Amendments to the Decree of the Minister of Environment and Forestry Number SK.610/MenLHK/Setjen/PLB.3/8/2016 concerning B3 Waste Management Permits. In 2020, precast concrete products made from slag were used in two forms, namely 108,385 bricks and 585,329 paving blocks. In addition, it is also used as a substitute for aggregates (sand and gravel). Currently, ANTAM also uses a combination of slag utilization and Fly Ash Bottom Ash (FABA) for utilization as construction material (PT Aneka Tambang Tbk., 2020).

1 Seeing the potential of slag that can be utilized more widely, the Government has a discourse to remove slag from the B3 waste category. ANTAM welcomes the address and has explored the potential use of slag with local governments as a construction material to reduce natural exploitation. As for non-B3 waste, management standards are carried out through waste separation, composting organic waste, reuse, and recycling. If it is not recyclable, non-B3 waste is placed into a Landfill.

PT Freeport did the same thing to reprocess the tailings. The rest of this mining is claimed to be a non-hazardous material (B3 waste) and can be used for agriculture, forestry, livestock, or fish activities. Rigorous testing proves that the metal intake contained in the plant meets national and international quality standards so that it can be used to grow legumes; casuarina and matoa; pineapple, melon, banana; vegetables; chilies, cucumbers, tomatoes, rice, chickpeas, and pumpkins. Tailings can also be developed into concrete-forming materials with Portland cement clamps and polymers (PTFI, 2015). In addition to PT Freeport Indonesia which uses tailings from gold mining, PT Timah Tbk and PT Bulutumbang also use tailings from tin mining to make concrete (Riogilang & Masloman, 2009). Concrete made of these tailings has gone through several tests. From the research conducted by tailings, it has noble - Sari (2018), the advantages of SiO₂, Fe₂O₃, and Al₂O₃ more than 60% so that it has the potential to be a cement-based building material, such as concrete and mortar. Tailings also have a gradation that meets the requirements of a fine aggregate. Physical characteristics, in particular, the sludge content of the tailings, meet the needs for use as a mortar raw material.

The stockpile technology developed by PT Bukit Asam is one of the efforts to minimize coal waste produced as liquid waste. Liquid waste can come from the coal mining process, coal stockpiling in *stockpiles* or the coal washing process. Pollutants in coal liquid waste can be temperature, pH value, metal content, and total suspended solids. As long as coal is stockpiled in the *stockpile*, acid mine water can form. Acid mine water can be caused by coal *stockpiles*, especially when the sulfur content is high. Thus, technology is needed to manage coal liquid waste formed in the store. The technology developed by PT Bukit Asam is the construction of *stockpiles* and the building of sludge deposit ponds (KPL), KPL drainage systems, and the process of processing coal liquid waste in KPL. Research shows that the basement stockpile Sons and Handayani (2017) design and drainage channels around the stockpile basement prevent standing water at the *stockpile site*. Likewise, with the dimensions of KPL and the location and dimensions of drainage Caltrans. The technology in this stockpile is building significantly.

IV. CONCLUSION AND RECOMMENDATIONS

The practice of the green mining industry in Indonesia began when the government adopted this in 2011 through Regulation of the Industrial Ministry No. 05/M-IND/PER/1/2011. The regulation defines a green industry as an environmentally sound industry that aligns growth with environmental sustainability, prioritizing efficiency and effectiveness of resource use in nature and benefiting society. Moving on from this, mining companies began redesigning themselves to pay attention to environmental impacts. Previously, environmental protection and management had been regulated in Law Number 23 of 1997 concerning Environmental Management and Law Number 32 of 2009 On Environmental Protection and Management.

In addition to government regulations that force mining companies to minimize environmental impacts, mining companies also strive to implement green management. This is related to the Asian investors who are also starting to shift by preferring environmentally friendly companies. Several companies that successfully comply with the Quality Management System (ISO 9001:2015) and the Environmental Management System (ISO 14001:2015) are more able to attract investors to join the management of mining companies.

Technology is inevitable for mining companies to be able to reduce adverse impacts on the environment. The use of fuels derived from new renewable energy, such as diesel energy and biomass, is becoming increasingly practiced thing by mining companies. Likewise, technology can help them suppress environmental pollution and process the remaining mining material into materials that can be reused. However, for some mining companies, environmentally friendly technology, both production process technology and the technology used in post-mining, is not cheap. The government must design access to technology that can massively support the green mining industry in Indonesia.

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CONFLICT OF INTEREST

We declare that we do not have any conflict of interest.

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