Socio-environmental Life Cycle & Its Relevance to Long-term Sustainability: A Key Success of Jorong Barutama Greston Coal-mine Closure, South Borneo – Indonesia

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Abstract
Environmental management is currently a priority in various industrial activities, ranging from upstream activities such as mining and energy related to the manufacturing sector to various consumer products for daily activities to represent downstream activities. This paper discusses the closure of the mine managed by Jorong Barutama Greston (JBG) about a long-term social environment initiated with the principle of Life Cycle Thinking. It includes several essential activities in energy management aspects, such as the utilization of acid mine drainage as a source of electricity 3.57 GJ, which is associated with reducing CO2 emissions of 1.65 tons per year. In solid waste management, B3 waste is mostly reduced 0.7 tons from the source, non-B3 waste is mostly reused 1.66 tons. As for water management, water use efficiency effort is conducted by recycling. The main focus in wastewater is reducing a load of wastewater through the use of organic matter. To ensure the successful integration of biological resource conservation with community empowerment, a plantation activity for 1,625 plants as raw materials for organic dyeing for Sasirangan fabric products is a Banjar cultural excellence product. At least two groups of craftsmen have been empowered, consisting 20 members and community income stability per minimum wage during the COVID-19 pandemic. In the bigger picture, JBG performs a thorough optimization of the natural resources utilization and renewable and alternative resources to maintain the wellness of the surrounding environment. It is also culture as part of preparations for the mine closure period. It is hoped is that social services for the surrounding community will continue and provide good environmental management practices for the surrounding assisted groups.

Keywords: Life Cycle Thinking, Mine Closure, Environmental Management, Community Empowerment, Jorong Barutama Greston

Introduction

Priorities in the current era of industrialization focus not only on operational activities; the environmental balance and the surrounding social community also play an essential role. In upstream activities such as mining, especially coal mining, many mines have entered the mine closure period and diversified their core business to be more environmentally friendly. Environmental friendly activities and lower emissions resources optimization are also an integral part of life cycle thinking efforts in the operational journey of mining activities until the mine closes. Jorong Barutama Greston – JBG (see Figure 1), a subsidiary of Indo Tambangraya Megah Tbk, which operates in Tanah Laut Regency, South Kalimantan Province, is one of the coal mining industries that has prepared its reclamation and revegetation activities by managing energy resources and environment and its integration with community empowerment.

Figure 1: JBG Operational Area

This paper presents several programs about sustainability in environmentally sound activities that focus on social communities based on the life cycle principles of low emissions and waste reduction. The programs implemented are practical innovations based on the environmental management approach at JBG. It is competitively part of good mining practices and implements social-economic support and environmental sustainability in the Sustainable Development Goals (SDGs), where one of the tools is Life Cycle Thinking. For this reason, the low emission life cycle principle in coal product management will be presented. In addition, the integration between biodiversity protection and community empowerment also plays a vital role in the success of economic and environmental sustainability for the surrounding community.

Overview of Life Cycle Thinking in JBG

JBG has conducted a basic Life Cycle Assessment (LCA) data inventory since 2019 with the Cradle to Gate system. The focus is on land clearing activities, coal extraction activities,

transportation, product processing, and coal products shipping. The shipping process is intended for the coal-fueled mid-steam industry; it is the electricity generator in Java. The unit of product produced is per ton of coal, with a category focus on the impact of energy use and emissions. The picture of the LCA process that has been inventoried by JBG is shown in Figure 2.

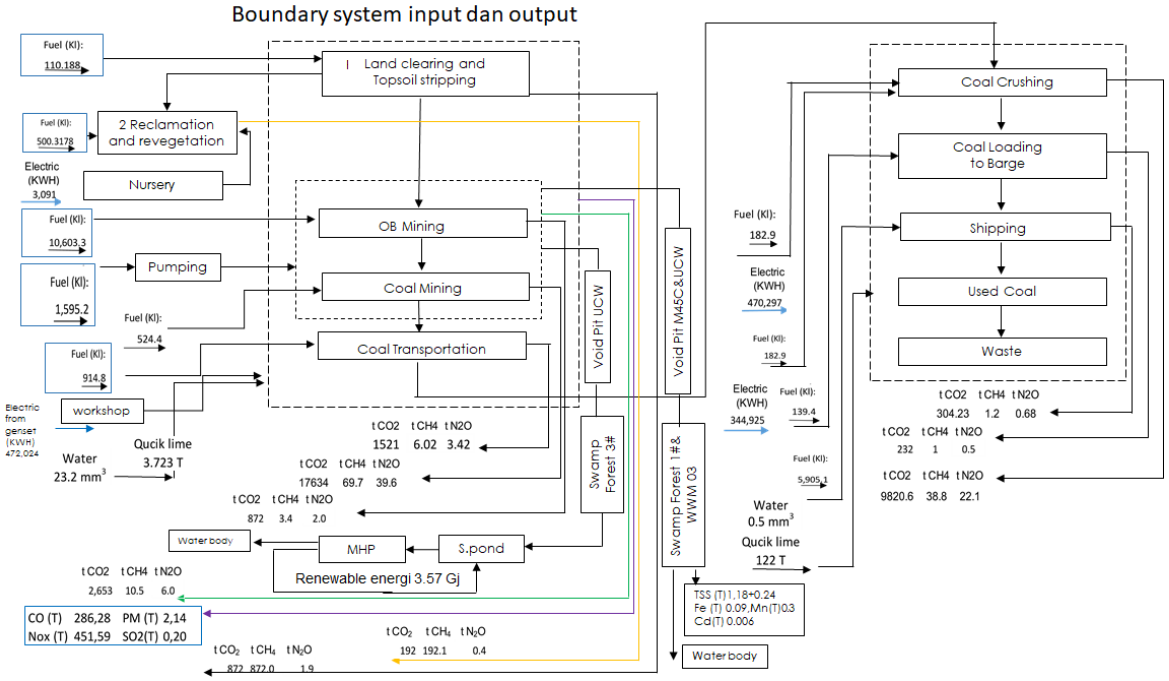

Figure 2: Limitations of the Cradle to Gate System at JBG

In 2021, a more detailed inventory will be carried out using the Cradle to Grave scheme, and it is planned to be published after calculating the resulting impact. Furthermore, the presentation of superior programs based on environmental management and sustainable livelihoods is presented as follows.

Energy Use Efficiency: Acid Mine Drainage Utilization As a Power Source with Additional Voltage (Ph) for Corrosion Control and Efficiency

One of the main aspects of the life cycle inventory effort is energy use, especially in operational and supporting activities at JBG. The electricity source is from the State-Owned-Electricity Company (PLN) with coal as a fuel source and isolated connection system. For this reason, one energy conservation effort is by using acid mine drainage as a source of electricity by adding voltage for energy efficiency and controlling corrosion at the same time. This program is an innovation that undergoes a simple trial process at JBG. The activity scheme is shown in Figure 3.

Figure 3: The schema of Acid Mine Water Utilization with Voltage Addition

This program is estimated to utilize electrical energy from acid mine water of 3.57 GJ based on initial calculations. Previously, the water in the settling pond has been used for electricity in the Micro Hydro Power Plant (PLTMH) program and several other integrated energy efficiency activities and efforts in the JBG area. These activities as a whole are a process to improve energy efficiency in supporting more efficient environmental sustainability.

Reducing Life Cycle-Based GHG Emissions by Stabilizing PLTMH current by utilizing Acid Mining Water

Aside from the energy efficiency factor, LCA also focuses on emission impacts that have relatively high relevance to mining activities, especially coal. The emission reduction program is an innovation, namely the current stabilization by utilizing acid mine water in the Micro-Hydro Power Plant (PLTMH) scheme. This activity utilizes electrical energy from environmentally friendly sources, which can reduce greenhouse gas emissions by 1.65 ton per year. The documentation of the utilization activities is shown in Figure 4.

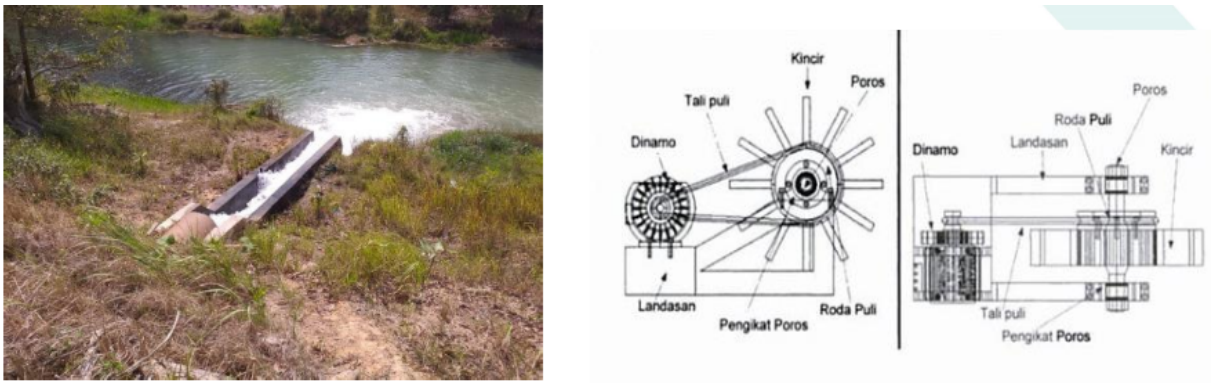

Figure 4: GHG Emission Reduction with PLTMH Optimization

Not only reduce emissions directly by reducing non-renewable electricity consumption, but this program also provides a competitive advantage for coal products produced by JBG. The coal fuel use of transport vehicles is among the lowest in mining activities because the

hauling road route at JBG is one of the closest. It means that overall, JBG's operational activities strongly support LCA efforts, as evidenced by the conserved energy usage optimization in the process.

Water Use Efficiency: Processed Water Utilization for Domestic Needs (bath and lavatory)

Still related to energy and emissions, the water efficiency activities in the MHP program are beneficial for reducing electricity consumption and optimizing water usage in the settling pond. The electricity generated from the MHP is used for lighting mining operations on the night shift. This activity is also integrated with Sparing Online, a continuous wastewater monitoring platform applied to coal mining activities. Previously, the power source was a battery; now, it has been substituted for micro-hydropower.

In water utilization, MHP can provide electricity supply to pump processed water by settling ponds; previously, it was discharged directly into water bodies. The water is used for domestic needs (bath and lavatory) in the WWM-16 area. The water utilization activities at MHP are shown in Figure 5.

Figure 5: Processed Water Utilization from MHP for Domestic Needs

This program can utilize water 18,000.00 m3, previously it was directly channeled into water bodies. This program also reduces a load of processed wastewater to the environment by reusing it. It means that these conservation efforts can integrate interrelated aspects in supporting the Sustainable Development Goals (SDGs).

Mining Wastewater Management: Reduction of Suspended Solids Load by Utilizing Grass as Organic Partition in Settling Pond Flows

As described in the water efficiency program, the processed wastewater is utilized for domestic activities in the mining area. It includes efforts to reduce a load of wastewater in water bodies around the mining areas. In addition, innovations were also made to manage

acid mine water by using grass as an organic partition in the settling pond flow. The documentation of the innovation scheme is shown in Figure 6.

Figure 6: Organic Partition in Settling Pond Flow

This program aims to reduce the suspended solids load in acid mine water. Based on the calculations, the program can reduce the TSS load by 300 tons per year by adding distributed grass resembling organic partition in the stabilization pond.

Domestic Waste Reduction: Utilization of Used Cooking Oil into Bar Soap

JBG is doing much innovation and developing solutions for practical problems in the field, one of them is domestic canteen activities where one of the wastes is the used cooking oil. In general, used cooking oil is a problem in all aspects of domestic activities, from local community activities to office canteen activities. For this reason, an innovation was made in recycling used cooking oil into bar soap within the scope of domestic use. The documentation is shown in Figure 7.

Figure 7: The Process of Making Used Cooking Oil Into Bar Soap

Based on the results of calculations and basic trials, this program will provide competitive benefits in utilizing non-B3 waste cooking oil of 0.25 tons per year. This initiative is still on a pilot scale in the scope of domestic canteen activities at JBG and is in further testing in 2021. In the future, it is hoped that product development integrated with community empowerment programs would also consider the administrative, technical, and institutional aspects.

3R of Hazardous Waste: Replacement of B3 Ink with Sasirangan Organic Dyes

In one of the community empowerment efforts during the COVID-19 pandemic, the Sasirangan handicraft products have been developed, one of which is a 3-layer cloth mask. In the process, the coloring of the sasirangan cloth uses synthetic ink, which contains Hazardous and Toxic Materials (B3). For this reason, an improvement program was carried out using replacing the coloring process using organic materials extracted from plants. The coloring activities of Sasirangan cloth are shown in Figure 8.

Figure 8: Sasirangan Coloring

This program is currently in the development stage and undergoes several trials for coloring techniques and organic materials. Based on calculations, this program can reduce the use of non-organic ink materials by 0.7 tons per year. This initiative is also integrated with aspects of liver protection and community empowerment, as discussed below.

Biodiversity: Eco-Printing Sasirangan with Mahogany Coloring Plants Produced by JBG

As previously explained, the integration of inter-sectoral programs is one of JBG's efforts to support good mining practices and sustainable environmental management. All of them are

based on life cycle thinking in energy management, the environment, and inter-aspect community empowerment. The main activities are reclamation and revegetation in protecting biodiversity, where seedlings occurred in particular nursery areas. In integrating biodiversity activities and community empowerment, the Mahogany tree nursery and conservation program can further extract to obtain organic dyes. These dyes are the essential ingredients and a mixture of eco-printing in making Sasirangan cloth. The Mahogany plant conservation activities are shown in Figure 9.

Figure 9: Mahogany Tree Conservation in JBG Nursery Area

JBG has been conserving Mahogany since 2021 with a total of 3,500 trees. Mahogany trees are included in the plantation with conservation status of **Vulnerable (VU)** and have been planted in several JBG reclamation areas as planned. Since this plant can provide natural coloring, it is further utilized in Sasirangan eco-printing products.

Community Development and Social Sustainability: Eco-Printing Sasirangan

As a form of environmental management programs and community empowerment integration, Eco-Printing Sasirangan is an innovation in developing product excellence. Moreover, in this innovation, natural organic coloring is made from self-cultivated plants for reclamation and revegetation activities at JBG. The environmental benefits are the reduction of synthetic dyes and the increase in Mahogany plants utilization which have been developed since the nursery phase. The documentation of the Sasirangan fabric coloring activity is shown in Figure 10.

Figure 10: Sasirangan Fabric Dyeing Process in Karang Rejo Village

The economic benefits of this program include savings in operational costs from purchasing synthetic dyes of up to 50 %, increasing the selling value as well as the income of community groups amidst the COVID-19 pandemic by 80% from the minimum wage of South Kalimantan. The social benefit is increasing knowledge about organic materials in developing the quality of Sasirangan fabric products. This program is expected to continue and develop further to the institutional stage. Also, the independent skill of the assisted communities is expected to provide a sustainable impact during the mine closure period.

Conclusions & Recommendations

The initiatives carried out by JBG specifically show integrated efforts to improve social, economic, and environmental sustainability through the Life Cycle Thinking approach since the operational period of mining activities. We conclude that there are at least some benefits from the activities as follows.

- The utilization of acid mine water as a power source by 3.57 GJ
- Emission reduction resulting from MHP by 1.65 ton CO2-eq
- Reduction of B3 waste from the use of Sasirangan organic dye by 0.7 ton
- The amount of used cooking oil turned into bars of soap by 0.25 ton
- Water conservation by reusing processed water for domestics' purposes by 18,000.00 m3
- Reduced wastewater load from the use of organic bulkheads in acid mine water treatment units by 300 ton.
- The total number of mahogany trees planted in the nursery activity is 3,500.00 tree.

- The total community empowered from the development of the Sasirangan Eco-Printing program is 20 people with economic, environmental, and social benefits that support each other during the COVID-19 pandemic until 2021.

Acknowledgments

We thank the management and work team of Jorong Barutama Greston for their consistency and enthusiasm in innovating from time to time. We also thank the management of ITMG Jakarta and all stakeholders involved in each program implementation. We realize that of all the programs that have been delivered, it is not easy to prepare for mine closure based on good mining practices and their integration into sustainability in the post-mining economy, society, and environment, especially to the surrounding community.

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