Ecosystem Restoration as a Part of Energy & Environmental Life Cycle Contribution for Socio-Cultural Sustainability in Trubaindo Coal Mining, Indonesia

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Abstract
This paper discusses the ecosystem restoration efforts conducted by TCM, one of the coal mines operating in West Kutai, East Borneo. The activities conducted by TCM starting from initiatives in managing good mining practices and are based on the principles of sustainable environmental management. Restoration efforts start with a simple step, namely, replanting the post-mining area by adding value to the socio-cultural-economic environment of the local community. This principle is used for various activities of TCM, ranging from Life Cycle Assessment, Energy Efficiency, Emission Reduction, B3 and Non-B3 Waste Management, Water Efficiency and Wastewater Load Reduction, to Biodiversity Protection which is all Community Empowerment based. Some of the programs presented in this paper include life cycle inventory efforts with a cradle-to-grave system for the coal extraction cycle to its use as fuel in metal smelting until it becomes ready products and its post-use. Then in mining activities, energy efficiency related to hauling distances, also associated with emission reductions. In addition, efforts to reduce B3 waste through recycling used oil waste amounting to 5 tons and reusing non-B3 waste type conveyor belts from mining activities as well. In water efficiency, runoff water also functions for watering the mine road by 1000 m3. It directly reduces the amount of water flow in the settling pond, reducing the processing load. Then efforts were made to plant local endemic tree species in the reclamation area and developed in cultural-based community empowerment activities at the Lou Bentian Lamin House, inaugurated at 1st Semester of 2021.

Keywords: Ecosystem Restoration, Good Mining Practices, Socio-Cultural-Economic, Life Cycle Inventory, and Community Empowerment

Introduction

Management of the mining environment is closely related to the contribution to local social and cultural sustainability. From these activities, especially in developing countries, civilizations are formed, which together become a factor in changes in environmental quality. In line with the development of mining industrialization and population growth in the surrounding area, it is necessary to improve the environment's quality fundamentally. Trubaindo Coal Mining (TCM), a coal mining industry located in West Kutai (see Figure 1), East Kalimantan, a subsidiary of Indo Tambangraya Megah Tbk operating in Indonesia, is fully aware of this.

Figure 1: TCM Operational Area

Various TCM efforts in supporting ecosystem restoration in its concession regions, including community-based activities surrounding it as part of the good-mine closing efforts, are discussed in this paper. Implementing a program based on the life cycle of coal products to create the final post-manufacturing coal product is one of the initiatives. Then, in operational activities, energy-saving efforts are linked to indirectly reducing emissions. The main concern of operational activities is long mileage, requiring a proactive approach to fuel efficiency. TCM also makes an effort to conserve water by using rainfall to cleanse hauling roads, which results in a reduction in settling pond load in managing incoming runoff. Optimization is also taken in terms of waste management by utilizing operational waste, both B3 and Non-B3, to reduce waste generated. All of these initiatives are contributing aspects to long-term environmental management.

Green zones, woods, and regions that should be overgrown with plants are the main focus of the directly affected areas in the immediate context of ecosystem restoration. As a result, TCM has made efforts to manage post-mining sites by restoring vital plants, beginning with nursery activities in the Nursery area, as part of its active participation and implementation of good mining practice. Local workers were involved in plant management during these operations, and these activities were further developed during the construction of Lamin

House through cultural, socioeconomic, and environmental-based community empowerment programs. The Lamin House's sub-areas, which are based on the concept of ecologically friendly buildings, also reflect the representation of sustainable environmental management. The discussion below provides more information.

Overview of Life Cycle Assessment in TCM

A life cycle tracing of coal products from TCM's operating activities is one of the efforts to implement a sustainable environmental management program. The planned system boundary effort at this stage is Cradle to Grave, which covers coal mining and shipping activities as well as the production of fuel for metal processing activities. It is also a source of raw materials for electric motors, with this activity continuing until the product's estimated post-use cycle. However, in this paper, the system boundary in presented as Cradle to Gate as the following.

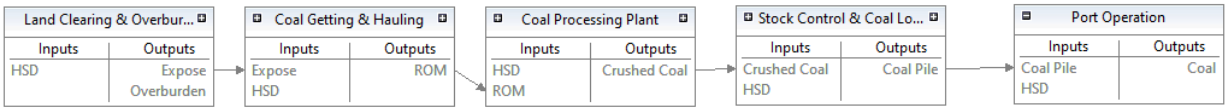

Figure 2: Scoping of the Cradle to Gate System in TCM

Primary data was collected from both TCM and contractors during the process, and it covered everything from fuel consumption to manufactured products, energy and mass balances, waste balances, and air emission cycles. The life cycle initiation approach in this study is mostly at the inventory data stage to identify hot spots, the impact of which would then be examined. At the very least, it is hoped that the inventory's hot spots are regions where improvements in energy management and its supporting environmental aspects have been implemented.

Furthermore, the presentation of superior programs based on environmental management and sustainable livelihoods is presented as follows.

Energy Efficiency: Using B30 for Vehicle Fuel Savings

TCM's operational activities significantly concern transportation distance from one location to another, which is quite challenging. For this reason, the focus on the management consumption of natural resources, such as fuel, is also carried out efficiently by modifying the transport distance. In addition, more environmentally friendly diesel fuel type B30 is set to replace all operational vehicles based on the laws and regulations. The activities of vehicles using B30 are shown in Figure 3.

Figure 3: Activities of Using B30 on Operational Vehicles

Through the initiative to use environmentally friendly fuels, energy efficiency increases 16.77 GJ throughout 2020. This program is part of a sustainable effort, which will continuously be developed in line with the development of environmentally-friendly fuel technology.

GHG Emissions and Conventional Reduction in Modification of Distance and Road Gradient during Hauling Activities

The most of GHG emissions are linked to energy efficiency activities in emission reduction initiatives. Meanwhile, conventional pollutants like SOx, NOx, particulates, and others are not typically linked to energy consumption. Since an increase in GHG emissions dispersed into the atmosphere is one of the global warming triggers, efforts to reduce emissions are an essential part of ecosystem restoration. As a result, modifications of distance and road grades in hauling operations are carried out in order to improve the performance of air quality control based on local concerns in TCM activities. Figure 4 shows an illustration of this program.

Figure 4: Modification of Distance and Road Gradient

This fuel use has proven to be very effective and can reduce GHG emissions by 82.56 tons of CO2 and 101.49 tons of NOx throughout 2020. This initiative includes activities based on LCA and continues to increase along with the development of mining activities.

Water Efficiency: Rejuvenation of Water Supply System Facilities in Non-Mining Activities

Regarding water efficiency, the main focus to support ecosystem restoration is preventing water leakage from the source. For this reason, in several locations, the clean water supply system facilities have been renovated, especially for non-mining activities. The activities include repairing water faucets to minimize leakage and replacing Galvanized pipes with HDPE to reduce the risk of corrosion. The documentation of the water supply system rejuvenation for supporting activities in TCM is shown in Figure 5.

Figure 5: Water Supply System Rejuvenation Activities

This activity is based on field conditions where potential leaks are often found. From this program, water usage is reduced up to 75 % compared to the previous year. This is probably due to the prevention of water leakage and the efficient use of water under the same operational and non-operational conditions. For this reason, starting in 2021, a pilot water audit will also be conducted, which focuses on inventorying the water supply system to be more efficient in minimizing potential leaks and optimizing the use of water resources.

Mining Wastewater Management: of Acid Mining Water Management Effectivity with Combination of Activated Lime and pH Adjuster based on Life Cycle Thinking

Acid mine drainage, which is normally managed using a sedimentation pond system known as a settling pond, is one of the necessary environmental aspects of coal mining activities. This pool uses gravity in a specific area to reduce levels of iron (Fe) and manganese (Mn), as well as physical water quality indicators like pH and total suspended solids (TSS). Figure 6 shows the documentation of TCM's settling pond management activities.

Figure 6: Settlement pond management activities

For settling pond management, besides managing acid mine drainage, there is also the management of rainwater or runoff that flows into channels around mining activities. For this reason, improvements are needed for the effectiveness and quality of water and wastewater management to reduce the potential load of wastewater to the environment, in this case, water bodies. Through this combination program of activated lime and pH adjuster, the principle of Life Cycle Thinking is used where the optimum combination will significantly support the efforts to improve environmental management sustainably. From the start, it is found that the effectiveness of reducing the wastewater load is possible to be increased with a target of reducing the pH adjuster by 50%.

3R of Hazardous Waste: Contaminated Water Management using Oil Trap with recycling system

There are routine vehicle checks and repairs in the housekeeping workshop area such as DT HD 785, LD Scania, Support Units for Fuel Trucks, Crane Trucks, and many other. One of the activities is also washing equipment that produces oil-contaminated water, which is included in B3, with the initial management of an oil trap separator unit. In this improvement, the effluent oil-contaminated water is recycled to replace surface water and water in the voids to wash light vehicles (LV). The description of vehicle washing activities using recycled water is shown in Figure 7.

Figure 7: Recycle Oil Trap for Washing Vehicles

This program has been implemented since 2017, with the results of reusing B3 waste of 4 tons per year. This activity also succeeded in supporting Life Cycle Thinking efforts by reducing water use in related operational activities.

Reduction of Solid Waste: Installation of a rubber conveyor to replace materials use

In the operational area, efforts have been made to reuse worn rubber conveyors to replace the use of materials in numerous places when processing non-B3 solid waste. As illustrated in Figure 8, one of them is in sports facilities.

Figure 8: The Utilization of Used Rubber Conveyors in Sports Facilities

It reduces the utilization of used rubber conveyors by 21.6 tons per year. This effort includes supporting Life Cycle Thinking which also supports Ecosystem Restoration by not adding new materials in the mining activity area.

Biodiversity: Conservation of local endemic plants of West Kutai and Local Fruit Plants

Biodiversity aspects have a critical role in sustainable environmental management, particularly post-mining activities, as the most significant contribution of ecosystem restoration efforts. As a result, conservation of native endemic plants in West Kutai, such as Jelutung, Duabanga, Meranti, Ulin, Kapur, and Kahoy, has been planted in the reclamation area as part of good mining practices. In addition, in West Kutai, there is a native Durian and Rambutan fruit plantation. Figure 9 shows the documentation of nursery activities at TCM.

Figure 9: Nursery activities for local endemic plants and local fruit trees in West Kutai

This program has succeeded in planting over 250,000.00 trees that grow and develop in the reclamation and revegetation areas. In this case, every tree plantation activity will contribute to ecosystem restoration in the future and reduce the potential for global warming. Every successful effort to rebuild this natural treasure requires consistent efforts and joint commitment in achieving sustainable development goals.

Community Development and Social Sustainability: Increasing Tourism through Lamin House Development

Most program contexts are only implemented on an internal scale of all the activities discussed in the previous section. Meanwhile, the Lamin House initiative in Dilang Puti – Bentian Besar, West Kutai, reflects environmental restoration efforts in the context of community empowerment. This program is part of a long-term plan to close the mine and replace it with a cultural and tourism system centered on community social welfare. The Lamin House is managed by the community, which is the main activity of the empowerment. It is a traditional house of West Kutai, and it functions as a tourism place to increase the rate of tourism, which is expected to be effective after the COVID-19 pandemic is appropriately resolved. The appearance of Lou Bentian's Lamin House is shown in Figure 10.

Figure 10: Lou Bentian's Lamin House Landscape

At the time of initiation, this program involved 500 communities and will continue to develop as local tourism conditions improve. As level-up participation in ecosystem restoration, Lamin House has a representation of environmental management aspects. The source of electricity for lighting and water pumps uses Solar Panels and uses rain-fed water primarily. There are also waste disposal facilities separated by type (B3 and Non-B3). In addition, the Lamin House, which is built from Kalimantan endemic wood, namely Bengkirai, Ulin, and Meranti Merah, is represented in the Lamin House garden by planting these wood trees. The integrated Lamin House program is based on the concept of Eco-Friendly Building, which is currently under review for the value of Social Return on Investment (SROI).

Conclusions & Recommendations

Of all the activities at TCM, the programs are based on direct or indirect ecosystem restoration efforts. We conclude that there are at least some benefits from the activities as follows.

- The use of B30 biodiesel fuel can increase energy efficiency by 16.77 GJ.
- Emission reduction resulting from modification of hauling distance and hauling road gradient is obtained by 82.56 tons of CO2 and 101.49 tons of NOx.
- Reduction of B3 waste from recycled oil-contaminated water by 4 tons.
- Reuse of rubber conveyor by 21.6 tons.
- Water conservation from the rejuvenation of water supply system facilities of 75%.
- The effectiveness of wastewater load from chemical optimization can save pH adjuster by up to 50%.
- The total numbers of local endemic plants planted in nursery activities are 100,000.00 trees, and local fruit trees are 150,000.00 trees.
- The total number of people who were empowered from the initiation of the Lamin Lou Bentian House program was 500 people involved and supported the activities.

There are many challenges and obstacles in conducting the programs and activities, notably during the COVID-19 pandemic, which is still happening today. Regardless of the challenges, it is hoped that the initiative will continue and help the community and

environment. Furthermore, all TCM entities, as well as public health concerns, are critical to the successful implementation of these ecosystem restoration operations.

Acknowledgment

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