6. Alternative Program From Life Cycle Assessments (LCA) in Sugar Cane to Reduce Environmental Impact

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Alternative Program From Life Cycle Assessments (LCA) in Sugar Cane to Reduce Environmental Impact

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ABSTRACT

The advantage of the LCA method is that it can comprehensively analyze the potential impacts that can occur on the environment. In this study, a study of the LCA of sugar production. In this study, a sugar factory produces an environmental impact on the gate to gate sugar production process (power plant, milling station, purification station, evaporation station, cooking/crystallization station, and spin) using the Eco-Indicator 99 (H) method. The most significant environmental impacts of the sugar production process are respiratory inorganics, land use, and fossil fuels. The cause of the impact of respiratory inorganics occurs due to air emissions such as particulate matter, nitrogen dioxide, and sulfur dioxide from the boiler. The cause of the effects of land use comes from sugarcane land used as raw material for cane cutter units. In comparison, the impact of fossil fuels occurs due to the use of diesel fuel in the sugarcane planting process and natural gas from the fertilizer production process. Alternative improvement programs can be carried out to reduce the environmental impact caused by the sugar factory production process include the procurement of air emission controllers that meet standards and periodic maintenance. Furthermore, reducing diesel fuel and replacing it with environmentally friendly fuels, paying attention to farmers. Related to increasing productivity based on land suitability assessment, reducing the use of chemical fertilizers, and replacing environmentally friendly fertilizers in the sugarcane planting process.

Keywords: Environmental impact, cleaner production, life cycle assessment, sugar industry

Introduction

The manufacturing process not only creates the desired product but also can create by-products. The manufacturing process not only creates the desired product but also can create by-products. Pollution and trash generated throughout the manufacturing process are undesirable by-products that can jeopardize the industry's survival. Clean production, or environmental management methods that are applied continually to every action from upstream to downstream connected to production processes, products, and services to improve quality, are required to prevent or limit these negative impacts. Based on the current situation, a strategy to lessen the burden of emissions coming from the manufacturing process is required (Iswara et al., 2020).

Cleaner production is a concept of industrial production activities by apply environmentally friendly ideas. One of the assessments of the environmental impacts caused by the production process is the Life Cycle Assessment (LCA) method (Renouf et al., 2018). The Life Cycle Assessment (LCA) approach is one of the environmental consequences generated by the manufacturing process. The LCA method has the advantage of being able to thoroughly examine the potential ecological repercussions (Farahdiba et al., 2021; Van Der Laan et al., 2015). The environmental effect can be evaluated using the LCA technique, which entails any environmental changes, whether harmful or good, that is entirely

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or partially driven by environmental factors. As a result, a Life Cycle Assessment based on the cradle to grave method is required to determine the size of the impact of the sugar manufacturing process to propose an alternative sugar fact.

State of the art

Sustainable development goals-cleaner production

Cleaner production is a proactive and comprehensive environmental management strategy that should be implemented in the manufacturing process and the product life cycle continues to reduce risks to humans and the environment (Duarte & Sánchez, 2015). Cleaner production, according to the Ministry of Environment (Kementrian Energi dan Sumber Daya Mineral, 2016), is an environmental management strategy that is preventive, integrated, and applied continuously in all activities from upstream to downstream related to production processes, products, and services. This program improves the efficiency of natural resource use, prevents pollution, and reduces waste formation. Furthermore, there is a process for repurposing and recycling production by-products as raw materials for the process. According to the understanding and flow chart relating to clean production, the terms utilized for environmental management are preventive, integration, efficiency enhancement, and risk minimization.

ISO 14044:2006

Life Cycle Analysis (LCA) or often also called Life Cycle Assessment is a cradle to the grave based method (analysis of the entire cycle from the production process to waste treatment) which is used to determine the amount of energy, costs, and environmental impacts caused by the stages of the product life cycle. The beginning of the process of taking raw materials until the product is finished being used by consumers (The International Standards Organization 2006). Based on the International standard (ISO 14040, 2006), the determination of the boundaries of the LCA system includes:

1. Cradle to grave, from raw material extraction, production process, and transportation to final product use in its life cycle.
2. Cradle to the gate, namely the process from extracting raw materials to the production stage (a process within the factory).
3. Gate to grave: the process from use after production to the end of its life cycle.
4. Gate to gate, covering the process from the stage of a process (production only).

Define the Process of Sugar Refinery Production

Mill Station

Mill Station is a place where you can go to sugar cane obtained from farmers is weighed before entering the milling stage.

Refining station

The raw sap will be weighed and entered into the purification station after passing through the milling station. The purification station's job is to filter contaminants (not sugar) from raw sap so that clear sap can be produced (Kaab et al., 2019a).

Evaporation Station

This evaporation process aims to remove the water content contained in the sap so that it can thicken the sap

Crystallization Station

This process is used to convert the viscous juice into a crystal form of a size that has been determined by the industry

Rotary Station

This station serves to separate the sugar crystals from the crystal Stroop.

Packing station

The SHS sugar produced from the Puteran station will be dried using a sugar dryer.

Material and Methods

The stages of this research were compiled following the research objectives, which included determining the environmental impact of the manufacturing process and obtaining alternative improvement programs utilizing the Simapro 9.0.0.47 software

Goals and scope

The goal of this study is to figure out how the manufacturing process affects the environment. Meanwhile, the scope of the investigation is the gate to gate or the manufacturing process. The data used in this study was gathered from a sugar plant as secondary data. The Life Cycle Impact Assessment stage aims to evaluate and classify products based on their environmental impact.

The method was developed to identify the three main effect categories that can be seen using a normalization evaluation, as well as the amount of influence that emerges in the field. Hotspots, the size of each impact (characterization), and the largest impact are the outcomes of this step (normalization).

At Interpretation, the cause of the three most significant environmental consequences resulting from the sugar-producing process is being investigated. Hotspot analysis can be used to investigate the sources of environmental consequences.

Recommendations for a Development Program for sugar refinery

Obtain alternative improvement programs based on the interpretation results that the factory can implement. This alternate improvement program is taken into account when deciding whether measures are better than the ones made previously.

Results and Discussion

Interpretation from LCA analysis

Based on the output of data calculations performed with the SimaPro software, with the Eco-Indicator 99 (H) method. As can be observed, the cane cutter unit has the greatest influence on the environment. Following that, the Yoshimine 1 boiler, the Yoshimine 2 boiler, the Cheng Chen boiler, the defecator 2, and snowballing all contributed significantly.

After determining the sugar production process's environmental impact, the following stage determines the reason for the environmental impact. Then, at the interpretation step, the reasons of environmental consequences are determined. The environmental impacts evaluated in this study are the three greatest, namely respiratory inorganics, land usage, and fossil fuels.

Program recommendations

Based on the Life Cycle Impact Assessment (LCIA) results, it is known that the biggest impacts from the sugar factory production process are respiratory inorganics, land use, and fossil fuels. Meanwhile, the largest contributor units are the cane cutter unit, the Yoshimine 1 boiler, the Yoshimine 2 boiler, and the Cheng Chen boiler.

After understanding the environmental impact and the contributors to the environmental impact, then providing recommendations for improvement programs from the environmental impacts caused to become a sugar factory that is more environmentally friendly. The proposed program aims to reduce resource use, reduce energy consumption, improve process efficiency, reduce waste generation or emissions and utilize recoverable resources (ISO 14000 2004). Suggestions for improvement that can be given include:

Procurement of air emission controllers that meet standards and periodic maintenance.

Air emissions resulting from the burning process of sugarcane bagasse are nitrogen dioxide, sulfur dioxide, and particulate matter. In the industrial sector, it is required to take an inventory of the type, the volume of emissions, air control devices, and operating time for industries that cause air pollution (Regulation of the State Minister of the Environment No. 12 of 2010). The inventory is used to maintain air quality. Furthermore, in dealing with air emissions arising from the Sugar Factory power plant process in the boiler unit, it is necessary to have an air emission control unit with periodic maintenance (Gunawan et al., 2019).

Design criteria in planning a wet scrubber include particle size and discharge, flue gas flowrate, gas velocity, liquid gas ratio, droplet size, and residence time (Pryor et al., 2017). Treatment of air emissions can be seen from the efficiency of a unit. In the wet scrubber removal efficiency of particulate matter reaches 70-90%. Meanwhile, the inorganic gas can reach 95-99% and SO2 80-99% (U.S. Environmental Protection Agency 2003). The efficiency of the cyclone control unit reaches 70-90% PM (Particulate Matter), 30-90% PM10, and 0-40% PM 2.5 (Nieder-Heitmann et al., 2019). The existence of air control following standards and periodic maintenance is expected to reduce the impact of respiratory inorganics.

Reduce diesel fuel and replace it with renewable (biodiesel) fuels.

Reducing diesel fuel used for energy in the sugarcane planting process is replaced by biodiesel. The biodiesel which can be applied is B100. B100 is a fuel made from natural / Crude Palm Oil (CPO) which is used directly in diesel engines without any mixture of fossil fuels. In 2020, the minimum mandatory use of biodiesel (B100) in the agricultural sector is 30% of the total energy demand (Government Regulation No. 12 of 2015). This obligation is used to reduce imports of fuel oil and save foreign exchange. The use of biodiesel is more efficient than the use of diesel. For car transportation, based on test results by the Agricultural Research and Development Agency, 1 liter of biodiesel can cover a distance of 13.1 km, while diesel is only 9.6 km (Kaab et al., 2019b). Therefore, the reduction and replacement of diesel fuel are expected to reduce the impact of fossil fuels.

There is a concern for farmers related to increasing productivity based on land suitability assessments.

Land suitability is the suitability of land for certain uses such as suitable for irrigated rice fields, annual crops, or food crops. The suitability of the land can be seen based on land suitability assessments such as drainage, soil texture, soil depth, peat maturity, soil CEC, base saturation, soil pH, C organics, total N, P_2O_5, K_2O, and salinity (Farahdiba et al., 2021; Sahu, 2018). The suitability of the land will make it easier to make land improvements to create a sustainable use of agricultural land and be accompanied by an increase in productivity (Minister of Agriculture Regulation No. 79 of 2013). If there is a land with low P_2O_5 content and low organic C content, needs the addition of manure or compost and the application of P_2O_5 fertilizer. These improvements are expected to increase productivity and prevent the impact of land use.

Reducing the use of chemical fertilizers and replacing them with organic fertilizers in the sugarcane planting process.

The biggest impact contributor lies in the cane cutter unit which comes from the process material, namely sugar cane. The cane cutter unit becomes the biggest impact due to the emergence of the impact of carcinogens. The impact of carcinogens occurs because of the cadmium content in fertilizers. The content of cadmium in fertilizers occurs due to chemical phosphate fertilizers. The content of cadmium found in sugarcane roots was 57.52 mg/kg, bagasse 8.25 mg/kg, sugarcane leaves 8.24

mg/kg, and sap 0.24 mg/kg (Nieder-Heitmann et al., 2019). To reduce this impact, it is necessary to reduce and substitute with organic fertilizers. The maximum tolerance limit for heavy metal content in inorganic fertilizers is 100 ppm arsenic, 10 ppm mercury, 100 ppm cadmium, and 500 ppm copper (Decree of the Minister of Agriculture Number 238 of 2003). Meanwhile, the tolerance limit for metal content in organic fertilizers is 10 ppm arsenic, 1 ppm mercury, 2 ppm cadmium, and 50 ppm copper. The content of heavy metals in organic fertilizers is lower than the content of fertilizers in inorganic fertilizers. An example of replacing fertilizers such as chemical phosphate fertilizers (inorganic) can be replaced with organic fertilizers derived from bat droppings (guano). Guano fertilizer has a high phosphorus and nitrogen content. In practice, a single guano fertilizer dose of 400 kg/ha with an R/C ratio of 2.06 gave a yield of 6.72 tons/ha of GKP. Meanwhile, the use of 200 kg Guano fertilizer plus 200 kg urea and 100 kg KCl/ha yielded 6.79 tons/ha GKP. The application of a single guano fertilizer is more profitable than a mixture of 200 kg Guano fertilizer plus 200 kg urea and 100 kg KCl/ha (Van Der Laan et al., 2015). Reducing the use of chemical fertilizers and replacing them with natural fertilizers is expected to reduce the impact of carcinogens.

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