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The Implementation of Environmental Cost Accounting in Waste Management in the Bioethanol Industry

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ABSTRACT

This research aims to measure the efficiency of waste management using the concept of Environmental Management Accounting (EMA) based on the Physical Environmental Management Accounting (PEMA) and Monetarily Environmental Management Accounting (MEMA) and analyzed the suitability of environmental cost accounting treatment based on the PSAK No. 201. This research is quantitative descriptive research. Data were collected through interviews and documentation. The data used were production quantities and waste management costs data collected in 2023. The research was conducted at bioethanol industry that processed waste into biogas and liquid organic fertilizer. The research findings revealed in the PEMA calculation there was an imbalance between input and output quantities because the company had not recorded Fusel Oil from the distillation stage. The MEMA calculation revealed the company can save costs incurred to buy gas from PT PGN if it adds two digesters. The highest expenditure in the environmental cost report is in the external failure cost category and presented it simultaneously with other accounts. Therefore, the company should implement environmental cost accounting to control and increase the efficiency of waste management costs.

Keywords: Environmental Cost Accounting, Waste Management Efficiency, Environmental Management Accounting (EMA), Accounting Treatment

ABSTRAK

Penelitian ini bertujuan mengukur efisiensi pengelolaan limbah menggunakan konsep Environmental Management Accounting (EMA) berdasarkan pendekatan Physical Environmental Management Accounting (PEMA) dan Monetarily Environmental Management Accounting (MEMA) serta menganalisis kesesuaian perlakuan akuntansi biaya lingkungan berdasarkan PSAK No. 201. Penelitian ini penelitian deskriptif kuantitatif. Pengumpulan data melalui wawancara dan dokumentasi. Data yang digunakan adalah kuantitas produksi dan biaya pengelolaan limbah tahun 2023. Penelitian dilaksanakan pada industri bioethanol yang mengolah limbah menjadi biogas dan pupuk organik cair. Temuan penelitian menunjukkan pada perhitungan PEMA terdapat ketidakseimbangan antara kuantitas input dan output karena perusahaan belum mencatat Fusel Oil dari tahap destilasi. Perhitungan MEMA menunjukkan perusahaan dapat menghemat biaya yang dikeluarkan untuk membeli gas dari PT PGN jika menambah dua digester. Pengeluaran tertinggi dalam laporan biaya lingkungan berada pada kategori biaya kegagalan eksternal dan disajikan secara bersamaan dengan akun-akun lainnya. Dengan demikian, perusahaan sebaiknya menerapkan akuntansi biaya lingkungan untuk mengendalikan dan meningkatkan efisiensi biaya pengelolaan limbah.

Kata kunci: *Akuntansi Biaya Lingkungan, Efisiensi Pengelolaan Limbah, Environmental Management Accounting (EMA), Perlakuan Akuntansi*

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INTRODUCTION

Over time, the industrial world has been confronted with increasingly complex and comprehensive challenges, particularly in aspects related to environmental issues. This has become a critical concern for corporate sustainability (Amelia & Sisdianto, 2024; Sales, 2019), as environmental considerations play a crucial role in maintaining a company's reputation and image in the eyes of stakeholders, ensuring its continued existence in the future (Arienata et al., 2024; Rahmawati et al., 2020; Sari et al., 2020). The growth of the industrial sector is accompanied by a corresponding increase in the environmental impact resulting from corporate operational activities (Nguyen, 2022; Qu et al., 2022; Nzama et al., 2022). A noteworthy phenomenon arising from these impacts is the growing pressure on companies to proactively manage the waste they generate (Latan et al., 2018; San et al., 2018).

Currently, many companies have begun to pay greater attention to environmental aspects as a means of preserving the environment, which in turn supports long-term business sustainability (Alwan & Maelah, 2024). The implementation of efficient and effective waste management practices has become a tangible demonstration of corporate commitment to environmental and social responsibility (Fuzi et al., 2019). In this context, environmental accounting can assist companies in enhancing the efficiency of their waste management efforts.

One relevant branch of environmental accounting for measuring the impact of waste is Environmental Management Accounting (EMA), which consists of two main approaches: Physical Environmental Management Accounting (PEMA) and Monetary Environmental Management Accounting (MEMA). If companies are able to implement EMA within their operational activities, the information generated can help control environmental costs as an effort to save expenses and generate revenue (Huseno, 2018). This view is supported by Nainggolan et al. (2018), who state that EMA can serve as a basis for companies to disclose the outcomes of their environmental impact efforts, thereby influencing stakeholders in their decision-making processes. Prakoso (2017) further suggests that EMA can function as a management tool for improving environmental performance. Thus, companies are expected to provide accurate and relevant information regarding environmental management so that it may serve as a metric for controlling environmental costs.

Before environmental cost information is presented in accounts related to waste management, companies must first undertake proper treatment of waste management costs. However, there is currently no specific standard that governs the accounting treatment of waste management costs. Some companies are not required to report financial information related to environmental matters. In cases where companies do implement environmental accounting and voluntarily report environmental information, such reports may become a source of competitive advantage (Wenda et al., 2021). This aligns with the Statement of Financial Accounting Standards (PSAK) No. 201 on the Presentation of Financial Statements, paragraph 14, which permits companies to present additional reports such as environmental reports and value-added statements (IAI, 2024). PSAK No. 201 can therefore serve as a reference for companies in presenting environmental cost information.

The bioethanol industry is one of the rapidly growing sectors, driven by the rising demand for renewable energy. Bioethanol, an environmentally friendly renewable fuel, has been increasingly promoted, resulting in growing demand. High levels of production processes inevitably generate significant amounts of waste. The waste generated from bioethanol production cannot be directly released into the environment, thus requiring proper treatment to convert it into something of added value. In practice, companies have managed such waste by converting it into biogas and liquid organic fertilizer. The biogas produced is utilized to operate boiler machines. However, the company faces limitations in production capacity, which restricts the optimal generation of biogas.

To address the gas shortfall, the company uses PGN gas. Consequently, if a surplus of biogas is produced, the excess gas used to operate the boiler exceeds requirements. This surplus biogas is flared due to the company's limited number of digester tanks. As a result, some of the biogas is wasted. Hence, EMA plays a vital role in managing corporate waste treatment efforts.

Some companies categorize environmental costs as part of production costs based on the assumption that waste management expenses are a natural consequence of the production process. However, this treatment is not entirely appropriate, as it may conceal various hidden costs, typically grouped under factory overhead costs (Mokhtar et al., 2016). This approach complicates management's ability to control environmental costs and limits external parties' ability to identify which costs are genuinely environmental in nature and represent the company's environmental responsibility.

Numerous studies have found that many companies have yet to fully implement proper environmental cost accounting practices. This conclusion is based on findings that many companies do not record, present, or disclose environmental costs in a distinct manner, resulting in such costs being integrated into the company's income statement (Ramadhani et al., 2024; Sukayat & Sonani, 2022; Ratu & Meiriasari, 2021). According to Nainggolan et al. (2018) and Prakoso (2017), although some companies have adopted EMA concepts, they have not yet specifically presented environmental cost reports. The focus of this study is on the importance of implementing environmental cost accounting to enhance waste management efficiency by integrating information from both management accounting and financial accounting, thereby producing a comprehensive environmental cost report. Based on this, further investigation is required into the application of environmental cost accounting in waste management, particularly in the bioethanol industry.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Environmental Accounting

Environmental accounting is an activity that plays a role in providing various relevant information related to the environment by identifying, recognizing, measuring, assessing, presenting, and disclosing all costs incurred by the company as an effort to improve environmental and social responsibility (Safitri & Sari, 2022).

Environmental Costs

According to Hansen & Mowen (2018), environmental costs are costs that are incurred due to the decline in environmental quality as a result of the company's operational activities. Environmental cost classification is divided into four categories, consisting of environmental prevention costs, environmental detection costs, internal environmental failure costs, and external environmental failure costs. Environmental prevention costs are related to preventing the production of waste or pollutants that have the potential to damage the environment. Environmental detection costs are related to determining whether the products, processes, and other activities carried out by the company are in accordance with applicable environmental standards or not. Internal environmental failure costs are related to waste that is generated but not yet released into the external environment. External environmental failure costs are related to operational activities carried out after the waste has been released into the external environment. Reporting environmental costs is one of the important things for companies that want to improve their environmental performance and control environmental costs. Therefore, a good environmental cost report is one that describes the breakdown of environmental costs based on their categories.

Waste

Waste is all discharge or residual materials from production processes that no longer have economic benefit or environmental value, both in industrial and domestic (household) settings, and thus have a negative impact on the environment and society (Sartika et al., 2020).

Environmental Cost Accounting Treatment Based on PSAK No. 201 on the Presentation of Financial Statements

Companies must record all transactions that occur, especially those related to waste management activities. This is done because the costs incurred to manage waste are an important element in financial reporting. Currently, there is no specific standard that regulates how companies should treat environmental costs. This situation can cause discrepancies in allocating environmental costs if there is no basis for recognizing, measuring, presenting, and disclosing information related to the environment. Therefore, this study uses PSAK No. 201 as the basis for presenting environmental costs fairly. This is in

accordance with paragraph 17 of PSAK No. 201, which states that if there is no standard that regulates the accounting treatment of a certain issue, then the presentation can be carried out fairly by using accounting policies that are in line with actual business conditions so that companies can present relevant, reliable, comparable, and understandable information for users of financial statements. PSAK No. 201 paragraph 03 states that Indonesian Financial Accounting Standards (SAK) regulate the requirements regarding recognition, measurement, presentation, and disclosure of specific transactions or other events. Through proper treatment and allocation of environmental costs, companies can provide more accurate information related to all costs incurred as a result of environmental impacts.

Environmental Management Accounting (EMA)

According to Santoso (2024), EMA is an approach in environmental accounting that focuses on helping organizations to identify, measure, monitor, report financial and non-financial information, and manage costs and benefits related to environmental aspects. In applying the EMA concept, there are two things that need to be considered, namely Physical Environmental Management Accounting (PEMA) and Monetary Environmental Management Accounting (MEMA). PEMA is used to help management as a tool to control and handle environmental impacts that can be measured and expressed in physical units, for example, the use of materials measured in tons. MEMA is used to help management in identifying, finding, and managing environmental costs or revenues that are measured in monetary units.

METHOD

This research was conducted at a company engaged in the bioethanol industry by processing molasses into products such as Fuel Grade Ethanol and Extra Neutral Alcohol. Fuel Grade Ethanol can be used as a fuel additive. Extra Neutral Alcohol can be used as a mixture in the production of perfumes, cosmetics, and medical supplies. The product studied is Extra Neutral Alcohol 96% because it has the highest sales level.

The type of research used is descriptive research with a quantitative approach. The data sources used are primary and secondary data. Primary data was obtained through interviews with authorized personnel from the Production Department, Finance & Accounting Department, and Biogas & Fertilizer Plant Department. The interviews were conducted to obtain information related to the production process flow, the company's waste management practices, and the treatment of costs incurred in managing production waste. Secondary data was obtained through documentation, including production quantity data, raw material usage data, non-product output data, waste management activity cost data, and the 2023 Financial Statements. The analytical tools used are EMA and PSAK No. 201. EMA is used to measure the efficiency of waste utilization. PSAK No. 201 is used as a basis to analyze the accounting treatment of waste management costs carried out by the company.

The data analysis mechanism in this study begins by identifying and analyzing the company's waste management and its impacts through interviews and a site visit to the Biogas & Fertilizer Plant Department with the SPV of the Biogas & Fertilizer Plant Department. The next step is to conduct an analysis from the perspective of management accounting using the EMA concept. This process is divided into two steps. The first step is processing PEMA data by calculating input and output usage based on the material flow balance procedure concept. This step was carried out through interviews regarding the production process flow with the SPV of the Production Department. In addition, documentation was conducted by collecting data on production volume, raw material usage, and non-product output from the final fermentation and refinery shift reports for 2023.

The second step is processing MEMA data by preparing an Environmental Cost Report based on the theory of Hansen & Mowen. After the Environmental Cost Report is prepared, an analysis of the efficiency of waste management efforts is carried out. This step was conducted through interviews regarding the accounting treatment and waste management costs incurred by the company in 2023 with the SPV of the Finance & Accounting Department. In addition, documentation was conducted in the form of the 2023 Income Statement and Statement of Other Comprehensive Income, as well as Notes to the Financial Statements. Then, an analysis was conducted from the perspective of financial accounting, specifically

analyzing the accounting treatment of waste management costs based on PSAK No. 201, including recognition, measurement, presentation, and disclosure.

RESULTS AND DISCUSSION

Waste Management Conducted by the Company and Its Impact

The product produced by the bioethanol industry in this study is multigrade bioethanol. The production process is carried out through several stages consisting of propagation, fermentation, stripping, distillation, dehydration, and redistillation with a capacity of 100 kl/day. A high level of production activity will result in a high amount of waste, which can have a significant impact on the environment. The establishment of a bioethanol plant has positive impacts, such as providing an alternative for environmentally friendly fuel use and supporting efforts to reduce dependence on fossil fuels. In addition, bioethanol raw materials utilize waste generated from sugar production activities and convert it into renewable energy, which increases the market value of the agribusiness sector. On the other hand, the establishment of the bioethanol plant also contributes to creating job opportunities for the surrounding community.

The molasses used still contains chemical compounds, so if not managed properly, it can have negative impacts on the surrounding environment. Waste generated from bioethanol production activities includes liquid waste, hazardous and toxic (B3) waste, and air pollution. The liquid waste produced comes from discharge that is no longer contained in the bioethanol product. The company classifies liquid waste with the terms “spentwash” and “spentlees.”

Spentwash is waste generated from the stripping stage, while spentlees is waste generated from the distillation stage. Spentwash still contains high levels of organic chemical substances, so the company reprocesses it into biogas and liquid organic fertilizer. The biogas produced is used to operate the boiler machine, assisted by supply from PGN gas. The liquid organic fertilizer produced is used for the company’s estate land (HGU), distributed to the local community, and sold. Spentlees consists of fusel oil and water, which still contains other impurities. Fusel oil is not managed by the company but is handled by a transporter along with B3 waste. The water is reprocessed through the Water Treatment Plant (WTP) so that it can be reused in the fermentation stage for molasses dilution.

B3 waste is waste generated from supporting materials for the production process. B3 waste includes used oil, used chemical bottles, used ink bottles, used tubular lights, used batteries, used rags, expired chemicals, and residual laboratory reagent liquids. The management of B3 waste is handled by a third party (transporter) that is certified and has an operating permit from the Ministry of Environment and Forestry, so the handling of B3 waste is carried out by a responsible party. To store B3 waste before it is transported by the transporter, the company has a Temporary Storage Site (TPS) located near the Biogas & Fertilizer Plant Department. During the rainy season, the intensity of odors increases due to evaporation and higher air pressure, which causes unpleasant smells in the surrounding environment. The odor comes from gases contained in the materials used and the waste generated. To prevent the smell from disturbing the surrounding environment, the company tries to tightly close the areas that are the source of the odor. However, the company does not yet have an effective method to fully prevent odors because the influencing factor is air pressure, which cannot be predicted.

Law Number 32 of 2009 concerning Environmental Protection and Management Article 20 Paragraph (3) states that everyone is allowed to discharge waste into the environment as long as it meets environmental quality standards and obtains permission from the government. Research by Wijayanti et al. (2024) states that the liquid waste produced from bioethanol production still has dangerous characteristics, with a dark brown color and contains a Biological Oxygen Demand (BOD) of around 36,400 mg/L, Chemical Oxygen Demand (COD) ranging from 104,640–299,250 mg/L, and a pH of around 3.25. Based on this research, it is known that the waste produced from the bioethanol production process has very high levels and does not meet the wastewater quality standards that can be discharged into the environment (Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 concerning Wastewater Quality Standards, Appendix XXXVI (36)). The company applies a zero-waste principle by reprocessing the waste produced. This is part of the company's commitment to preserving the environment.

Implementation of Physical Environmental Management Accounting (PEMA)

The company cannot ensure that all inputs and outputs produced in the bioethanol production process have been calculated and recorded accurately, especially regarding the waste generated. This can cause discrepancies between the company's records and the established standards. The following is the PEMA calculation for each stage of bioethanol production:

Table 1. PEMA Calculation – Propagation Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Molasses*	5,864.887		5,864.887		0
Urea	5.374		5.374		0
Water	13,006.046		13,006.046		0
Activated Cell Mass**		18,876.307		18,876.307	0
Total	18,876.307	18,876.307	18,876.307	18,876.307	0

Source: Processed data (2024)

*Molasses: Sugarcane molasses.

**Activated Cell Mass: Cultivated yeast.

Table 1. PEMA Calculation – Fermentation Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Activated Cell Mass	21,876.307		21,876.307		0
Molasses	7,168.195		7,168.195		0
Sulfuric Acid	0.075		0.075		0
Defoamer	0.420		0.420		0
Urea	8.061		8.061		0
$MgSO_4$	0.338		0.338		0
Caustic Soda	7.471		7.471		0
Water	30,461.416		30,461.416		0
Fermented Wash 9%*		59,522.283		59,522.283	0
Total	59,522.283	59,522.283	59,522.283	59,522.283	0

Source: Processed data (2024)

*Fermented Wash 9%: Ethanol with less than 9% alcohol content.

Table 3. PEMA Calculation – Stripping Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Fermented Wash 9%	59,522.283		59,522.283		0
Spentwash		44,212.580		44,212.580	0
Ethanol 35%		15,305.730		15,305.730	0
Technical Alcohol*		3.973		3.973	0
Total	59,522.283	59,522.283	59,522.283	59,522.283	0

Source: Processed data (2024)

*Technical Alcohol: Low-quality alcohol that still contains impurities.

Table 4. PEMA Calculation – Distillation Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Ethanol 35%	15,305.730		15,305.730		0
Spentlees		6,376.984		6,376.984	0
Ethanol 90%		5,787.758		5,787.758	0
Fusel Oil*		0		3,134.618	3,134.618
Technical Alcohol		6.370		6.370	0
Total	15,305.730	12,171.112	15,305.730	15,305.730	3,134.618

Source: Processed data (2024)

*Fusel Oil: An oily liquid that contains a mixture of impurities.

Table 5. PEMA Calculation – Dehydration Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Ethanol 90%	5,787.758		5,787.758		0
Ethanol 99.5%		5,787.758		5,787.758	0
Total	5,787.758	5,787.758	5,787.758	5,787.758	0

Source: Processed data (2024)

Table 6. PEMA Calculation – Redistillation Stage of Extra Neutral Alcohol 96%

Description	Company Record		PEMA		Difference
	Input (1)	Output (2)	Input (3)	Output (4)	
Ethanol 99.5%	5,787.758		5,787.758		0
Water	128.499		128.499		0
Ethanol 96% (ENA Grade)		5,655.721		5,655.721	0
Technical Alcohol		260.536		260.536	0
Total	5,916.257	5,916.257	5,916.257	5,916.257	0

Source: Processed data (2024)

In this analysis, it is assumed that the company's recorded inputs are used as the basis for data accuracy. The reason behind this assumption is that the company consistently records every type of raw material and supporting material used. In addition, the company also records the amount of output produced because it will be used in the next (continuous) process. Based on the results of the PEMA calculation analysis carried out at each stage of production, it can be concluded that the company's management has done a fairly good job in recording the amount of input used and output produced. This is proven by the absence of discrepancies between input and output in the propagation, fermentation, stripping, dehydration, and redistillation stages. However, in the distillation stage, there is a difference between the company's records and the PEMA calculation regarding the amount of input and output. In the distillation stage, the company produces waste in the form of Fusel Oil, but the company does not record the amount of Fusel Oil generated. This is because the company assumes that the Fusel Oil does not have a significant impact. If Fusel Oil is detected during the distillation stage, it is immediately removed from the process without specific calculation or recording. Therefore, it is assumed that the discrepancy comes from the unrecorded Fusel Oil.

Implementation of Monetary Environmental Management Accounting (MEMA)

MEMA focuses on managing financial (monetary) information related to potential savings from waste utilization. Therefore, the focus in this section related to the company's finances includes the impact of the imbalance in input and output in the PEMA calculation, preparing the Environmental Cost Report, and identifying efficiency efforts in waste management.

Impact of Input and Output Imbalance in the PEMA Calculation

Based on the analysis of the PEMA calculation shown in Table 4, there is an imbalance between input and output in the distillation stage because the company did not record the Fusel Oil produced. Fusel Oil still contains chemical substances that can be reused for specific needs. The company could utilize the Fusel Oil by selling it to other industries, such as paint, lubricant, or solvent industries. This would allow the company to gain profit from selling the Fusel Oil and provide added value. Additionally, all waste produced can be used efficiently without being wasted.

The company has not yet considered the potential benefits that can be obtained from Fusel Oil. The Fusel Oil is transported and managed by a transporter together with other B3 waste. This leads to costs included in transporter fees. Since the B3 waste transport costs are combined into a single charge, the specific cost related to Fusel Oil cannot be explicitly identified.

Environmental Cost Report

The company has allocated and incurred costs for waste management. However, the company only classifies waste management costs in a simple way based on activities. The following is the environmental cost report presented for the company:

Table 7. Environmental Cost Report

Description	% by Category	% of Operational Costs
Environmental Prevention Costs	3.71%	3.79%
Environmental Detection Costs	0.25%	0.26%
Internal Environmental Failure Costs	4.74%	4.84%
External Environmental Failure Costs	91.30%	93.17%
Total	100%	102.06%

Source: Processed data (2024)

The environmental cost report is presented based on Hansen & Mowen's theory. Environmental prevention costs include employee training costs, licensing fees, and certification fees. Environmental detection costs include water body analysis fees, hazardous waste (B3) analysis fees, stack emission analysis fees, and air quality testing fees. Internal environmental failure costs include expenses for purchasing materials used to reprocess spentlees into sterilized process water and transporter costs. External environmental failure costs include environmental sanitation fees, CSR expenses, and fertilizer transportation costs.

Based on Table 7, the highest cost is found in the category of external environmental failure costs. The main factor contributing to this being the highest category is the fertilizer transportation cost due to the distribution process of liquid organic fertilizer to HGU land, which is located at a considerable distance and distributed through a third party. The fertilizer transportation cost is higher than the revenue from the sale of liquid organic fertilizer. This imbalance exists because the company's goal in producing liquid organic fertilizer is not to gain high profit, but rather to implement a zero-waste principle. Since waste cannot be completely avoided, the company can make savings. Savings can be achieved by increasing income from the sale of liquid organic fertilizer to reduce the high fertilizer transportation cost. This step is aimed at minimizing waste management costs while also creating added value from an additional source of income.

Table 7 also shows that there is a percentage that exceeds the proportion of operational costs. This is because the company does not yet have a specific allocation for waste management costs, and instead combines it with other expenses. This is proven by the Income Statement and Statement of Other Comprehensive Income. The costs used for waste management are partly allocated to Cost of Goods Sold and General and Administrative Expenses. The company does not yet have a specific environmental cost report, so the costs incurred for waste management activities cannot be specifically identified. The existence of an environmental cost report can serve as a tool for the company to control costs and identify savings opportunities.

Savings on Waste Management

The company has made savings from the waste generated by utilizing it as biogas and liquid organic fertilizer. The biogas produced is used by the company to operate the boiler. Currently, the company is experiencing problems that hinder the biogas production process because the digester is not functioning properly. This issue causes a decrease in the efficiency of waste processing, which means the company cannot supply biogas. For the time being, the company continues to use PGN gas to operate the boiler.

The use of PGN gas results in fairly high costs. The cost of purchasing PGN gas can still be made more efficient by producing a greater amount of biogas. Therefore, it is necessary to analyze the opportunities that the company can utilize to reduce these costs. The discussion of opportunity analysis is divided into two alternatives. The first alternative is to produce biogas and purchase gas from PGN to make up for the shortfall, while the second alternative is to plan the purchase of a new digester.

Alternative One: Producing Biogas and Purchasing Gas from PT PGN

Currently, the company is optimistic about producing bioethanol continuously at maximum capacity due to increasing market demand. If the company produces bioethanol at full capacity of 100 kl/day or 36,500 kl/year, more waste will be produced, allowing for maximum biogas production. Table 8 in the appendix provides information on the gas required to operate the boiler if the company uses the old digester system. The company has two digesters with a height of approximately 20 meters and a width of around 30 meters. Based on the calculation, the gas shortfall is 153,188.97 MMBTU/year.

The gas shortfall is met by PGN gas, so a conversion must be made to equate the content of biogas with PGN gas. The factor that determines gas quality is the methane (CH4) content. Methane content in PGN gas is 90%, while in the company's biogas it is 65%. The volume of methane in the biogas is 99,572.83 MMBTU/year (153,188.97 x 65%). Therefore, after converting biogas to PGN gas, the actual gas shortfall is 110,636.48 MMBTU/year (99,572.83 ÷ 90%). This gas shortfall causes the company to incur costs from purchasing gas from PT PGN. These costs can be reduced if the company is able to produce more biogas.

Alternative Two: Planning to Purchase a New Digester

The company currently only has two digesters, which are not operating efficiently. This hampers the biogas production and storage process. If this continues, it may cause unnecessary expenses. Therefore, the addition of biogas digester tanks is necessary. Table 9 in the appendix shows the potential biogas output from two new digesters at normal capacity is 5,475,000 m^3. Based on this calculation, one digester produces 2,737,500 m^3/year, while the company's biogas requirement to operate the boiler is 8,760,000 m^3/year (Table 8). The company can add two new digester units to meet the boiler's needs, eliminating the need to purchase PGN gas. Using biogas entirely to operate the boiler can help the company improve cost efficiency for energy needs. If the company adds two new digesters, it will save on PGN gas purchase costs by Rp 17,837,377,215.69 ($9.98 x Rp 16,154.82 x 110,636.48 MMBTU).

Accounting Treatment of Environmental Costs in Waste Management

The final stage of this research is to analyze whether the company has treated waste management costs in accordance with accounting principles, as analyzed based on PSAK No. 201. PSAK No. 201 is used as a reference to analyze the accounting treatment of waste management costs because there is currently no specific standard that regulates it. To analyze how the company treats environmental costs in waste management, an interview was conducted with the SPV of the Finance & Accounting Department. The company recognizes waste management costs using the accrual basis method. This is based on the information obtained during the interview, where it was stated, "The company has a Waste Management Cost account, which is part of the Cost of Goods Sold. These costs are recognized when the transaction occurs." The company has recognized waste management costs in accordance with PSAK No. 201 paragraph 27, which states that an entity prepares financial statements using the accrual basis, except for the statement of cash flows.

The company measures waste management costs in monetary units (Rupiah), using the historical cost method. Based on the interview, "The costs incurred for waste management are recorded based on historical values, and the unit used for measurement is Rupiah." This measurement process is in accordance with PSAK Conceptual Framework paragraph 6.1, which states that information presented in financial statements is measured in monetary units using historical cost or current value.

The company presents waste management costs in the Income Statement and Statement of Other Comprehensive Income under the Cost of Goods Sold account in the Manufacturing Expenses sub-section. According to the interview, "The costs incurred for waste management are presented in the Income Statement under the Cost of Goods Sold account." The company still presents waste management costs under Cost of Goods Sold and General and Administrative Expenses. It can be concluded that the company does not yet have a specific environmental cost report. This is not fully in line with PSAK No. 201 paragraph 14, which states that companies may present additional reports, such as environmental reports, separately from financial statements, especially for industrial companies where environmental factors are significant to sustainability. The company should prepare a specific environmental cost report to better control the costs incurred. The company can present these transactions under a separate account specifically for waste management activities, so the information presented is not biased.

The company discloses waste management costs in the Notes to Financial Statements (CALK) in a simple manner under the label "Waste Management." According to the interview, "The costs incurred for waste management have not yet been disclosed in detail in the CALK." The company has disclosed waste management costs in the CALK. However, the information presented is only the total amount, without a breakdown of the specific costs incurred for each waste management activity. As a result, users of the financial statements do not get detailed information, which can lead to misunderstandings when using the financial statements. This does not align with PSAK No. 201 paragraph 113, which states that if presentation is made systematically, it should consider the impact on the understandability of the financial statements. The company should disclose information related to waste management in a more comprehensive manner.

CONCLUSION

The results of the study show several findings from both management accounting and financial accounting perspectives. From the management accounting perspective, the company has managed the waste produced, but there are still shortcomings in managing the odor generated from the production process. Based on the analysis using the EMA concept, the PEMA analysis indicates an imbalance between the amount of input and output in the distillation stage because the company has not recorded the amount of Fusel Oil produced. The MEMA analysis is divided into two aspects. The first aspect is seen from the environmental cost report, which shows that the highest cost is in the category of external environmental failure costs due to the distribution of liquid organic fertilizer. The second aspect relates to efforts to save costs from waste produced, namely if the company is able to supply biogas at maximum capacity, it can reduce the cost of purchasing gas from PT PGN.

From the financial accounting perspective regarding the accounting treatment of environmental costs, it is found that the company still presents waste management costs together with other accounts. In addition, the company does not yet have a specific Environmental Cost Report. These findings indicate that the company has not yet comprehensively applied environmental cost accounting in managing waste, so it cannot be ensured that the implementation of the zero-waste principle is truly effective within the company.

Based on the findings obtained, the following suggestions are proposed for the company's consideration. The company should consider selling Fusel Oil to other industries to increase revenue and immediately find an effective way to address the odor caused by the production process. In addition, it is important for the company to implement the EMA concept to create efficiency in waste management. This is intended to ensure that the company is applying the zero-waste principle in optimizing the resources used. To enable the company to present waste management costs according to their categories, it is recommended that the company create a specific waste management cost account and prepare a dedicated Environmental Cost Report to control the expenses incurred.

This study focuses on the application of environmental cost accounting in waste management within the bioethanol production process from the perspectives of management accounting and financial accounting. Therefore, there are limitations in the theories, concepts, and methods used, especially regarding the lack of established standards. Due to these limitations, future research is recommended to be more complex in discussing the application of environmental cost accounting in waste management from various aspects. The lack of discussion related to environmental cost accounting has resulted in limited information, making it difficult to compare with other research objects. Thus, future researchers should conduct a more in-depth study and expand the research objects.

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APPENDIX

Table 8. Gas Requirement Calculation for Operating Boiler Machine – Two Existing Digester Units

Description	Calculation Basis	Amount
a. Calculating Biogas Requirement to Operate the Boiler Machine		
Biogas required to operate the boiler/day	1,000 m^3 x 24 hours	24,000 m^3
Biogas required to operate the boiler/year	24,000 m^3 x 365 days	8,760,000 m^3
1 MMBTU = 27.3192 m^3	—	—
Biogas required to operate the boiler/year	8,760,000 m^3 ÷ 27.3192 m^3/MMBTU	320,653.61 MMBTU
b. Calculating Potential Biogas Produced by 2 Existing Digesters at Full Capacity		
Waste generated/day for 2 digesters	—	1,000 m^3
Waste generated/year for 2 digesters	1,000 m^3 x 365 days	365,000 m^3
Potential biogas generated/day (2 digesters)	—	15,000 m^3
Potential biogas generated/year (2 digesters)	15,000 m^3 x 365 days	5,475,000 m^3
1 MMBTU = 27.3192 m^3	—	—
Biogas availability/year (2 digesters)	5,475,000 m^3 ÷ 27.3192 m^3/MMBTU	200,408.50 MMBTU
c. Biogas Potential Produced/Year (2 Digesters) After Capacity Reduction Due to Digester Malfunction		
Estimated biogas loss due to digester malfunction	15,000 m^3 x 60 days	900,000 m^3
1 MMBTU = 27.3192 m^3	—	—
Estimated biogas loss (in MMBTU)	900,000 m^3 ÷ 27.3192 m^3/MMBTU	32,943.86 MMBTU
Biogas potential/year (after malfunction)	5,475,000 m^3 – 900,000 m^3	4,575,000 m^3
1 MMBTU = 27.3192 m^3	—	—
Biogas potential/year after malfunction (in MMBTU)	200,408.50 MMBTU – 32,943.86 MMBTU	167,464.64 MMBTU
d. Gas Deficit Required to Operate Boiler (to be Purchased from PGN)		
Gas deficit (before conversion)	320,653.61 MMBTU – 167,464.64 MMBTU	153,188.97 MMBTU
Gas deficit (after conversion)	(153,188.97 x 65%) ÷ 90%	110,636.48 MMBTU

Source: Processed data (2024)

Table 9. Calculation of Potential Additional Biogas from New Digesters in 2025

Description	Calculation Basis	Amount
a. Calculating Potential Biogas Generated by 2 New Digesters at Full Capacity		
Waste generated/day for 2 digesters	—	1,000 m^3
Waste generated/year for 2 digesters	1,000 m^3 x 365 days	365,000 m^3
Potential biogas generated/day (2 digesters)	—	15,000 m^3
Potential biogas generated/year (2 digesters)	15,000 m^3 x 365 days	5,475,000 m^3
b. Total Potential Biogas Generated from Old and New Digesters (4,575,000 + b)		
Biogas potential from old digesters (2 units)	Based on Table 8	4,575,000 m^3
Total biogas potential (4 digesters)	4,575,000 m^3 + 5,475,000 m^3	10,050,000 m^3

Source: Processed data (2024)