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APPLICATION OF MATERIAL FLOW COST ACCOUNTING AND GREEN ACCOUNTING TO ENVIRONMENTAL PERFORMANCE

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Abstract
Rapid economic growth and increased industrial activity have significantly impacted the environment. This issue demands greater responsibility from companies in the energy sector in managing the environmental impact of their business operations. This study aims to examine the application of Material Flow Cost Accounting (MFCA) and Green Accounting on Environmental Performance. The research uses a sample of energy sector companies during the 2022-2023 period. The sample was selected using the purposive sampling method, resulting in 47 energy sector companies over two years (2022-2023), yielding 94 observational data points. Hypothesis testing in this study employs Panel Data Regression Analysis using E-views software. The results demonstrate that Material Flow Cost Accounting (MFCA) has a positive effect on Environmental Performance, whereas Green Accounting does not significantly influence Environmental Performance.

Keywords: Material Flow Cost Accounting, Green Accounting, Environmental Performance

1. Introduction

Rapid economic growth and increased industrial activity have had a significant impact on the environment. Sustainability and environmental protection are increasingly a major concern among companies and the general public. In this context, accounting practices that focus on environmental aspects, such as Green Accounting and Material Flow Cost Accounting, become relevant to be integrated into the company's management system, in the Climate Transparency Report (2020), G20 countries are advised to carry out green recovery, where in the opinion of Langlois (2018), the existence of business processes will not only produce products, but also emissions that can have an impact on the environment, and according to Manik (2020), the main environmental impact of mining activities occurs during exploitation and use as energy.

This problem requires companies in the energy sector to be more responsible in managing the environmental impact of their business activities. Wang et al. (2022) stated that the company's relationship with the environment is non-reciprocal, meaning that the transaction does not lead to the achievement of reciprocal from the related parties. Amid increasing global attention to sustainability and environmental preservation, companies need to integrate strategies that not only pursue profitability, but also maintain a balance with social and environmental interests.

One of the approaches that is increasingly recognized in supporting the sustainability of companies is the application of Green Accounting, as explained by Lako (2016), green accounting is an accounting process that not only focuses on financial transactions but also pays attention to social and environmental transactions. The implementation of green accounting is expected to respond to the needs of corporate entities in recognizing and

measuring value, recording, summarizing, reporting and disclosing financial, social, and environmental accounting information in an integrated manner.

There is a management accounting method other than Green Accounting, namely Material Flow Cost Accounting which focuses on the efficiency of material flow in the production process. According to Craveiro (2017), Material Flow Cost Accounting is one of the approaches that is believed to contribute to reducing societal pressure because it provides harmony between sustainability and profitability Material Flow Cost Accounting helps companies to identify and reduce hidden costs associated with material and energy waste, which are often not seen in conventional accounting. In the context of energy sector companies, the application of Material Flow Cost Accounting is very relevant to reduce waste generated from the production process, while improving energy use efficiency.

Good environmental performance reflects the company's commitment to managing negative impacts on the environment through various sustainable efforts. This is becoming increasingly important considering the pressure from the community, the government, and other stakeholders who are increasingly concerned about the company's contribution in preserving the environment. In accordance with the principles of legitimacy theory, companies need to run operations in accordance with social expectations and applicable rules in order to continue to receive support from the surrounding community. By adopting Green Accounting and Material Flow Cost Accounting practices, the company is expected to improve environmental performance while meeting public expectations, which will ultimately create added value for the company in the long run.

Through this research, it is hoped that a deeper understanding of the importance of environmental accounting can be obtained in supporting corporate sustainability. In addition, this research is also expected to provide practical recommendations for companies in implementing Green Accounting and Material Flow Cost Accounting, so that they can achieve an optimal balance between economic, social, and environmental interests. Thus, this research not only contributes to the development of environmental accounting science, but also supports sustainable development goals in Indonesia, as well as encouraging the creation of a more environmentally friendly and highly competitive energy sector.

2. Theoretical Background

2.1 Stakeholder Theory

Stakeholder theory is a theory that describes the relationship between individuals or groups that are affected by a company's activities or can affect the activities of a company. Freeman (1984) also defines stakeholder theory as a theory that states and defines which party the company will be responsible for (Febrianty, 2020). Stakeholder Theory emphasizes that the company is not only accountable to shareholders, but also to all stakeholders, including employees, customers, society, and the environment. Stakeholders are any group or individual who can influence or be influenced by the achievement of organizational goals (Suripto, 2021). This not only helps companies meet stakeholder expectations, but also provides more transparent and accountable information regarding their environmental performance.

2.2 Legitimacy Theory

Legitimacy theory is a theory that was first proposed by Dowling and Pfeffer (1975) which focuses on the interaction between companies and society. Legitimacy Theory emphasizes that organizations must act in accordance with prevailing norms and values in society to gain legitimacy and support from stakeholders. This action shows that the company cares about the environment and strives to reduce the negative impact of its operations. Legitimacy theory focuses on the relationship between companies and society based on the social contract that occurs between companies and society (Adil & Winarsih, 2019).

2.3 Environmental Performance

Environmental performance is the measurable outcome of an environmental management system, which is related to the control of its environmental aspects, as well as the assessment of environmental performance based on environmental policies, environmental goals and environmental targets (ISO 14001). Environmental performance is a company's performance that focuses on the company's activities in preserving the environment and reducing the environmental impact arising from the company's activities (Septiani et al., 2019). In this study, environmental performance was measured using ISO 14001. This certificate is an international standard on environmental management systems (SML) designed to assist companies in identifying, prioritizing, and regulating risks related to the environment as part of their normal business practices.

2.4 Material Flow Cost Accounting

Flow Cost Accounting is derived from Flow Cost Accounting (FCA) originally from Augsburg in Germany, where this method was proposed by Bernd Wagner and his colleagues at the Institute of Management und Umwelt (IMU), and was subsequently introduced and adopted by Japan. Material Flow Cost Accounting according to (Katherine & Dahlia, 2019) is a management tool designed to support better environmental management, improve company competitiveness, and develop advanced manufacturing techniques. In this study, the proxies used are production costs. Production costs are costs related to the production of an item, namely the number of direct materials, direct wages and factory overhead costs (Dinar, et al., 2016).

2.5 Green Accounting

According to Loen (2018), Green Accounting is a concept where companies prioritize the efficiency and effectiveness of resources in their production process so that they are able to harmonize the development and development of the company with environmental functions and can benefit the community. This variable is measured using the main indicator, the Standard Index, where information disclosure is guided by the 2021 version of the Global Reporting Initiative (GRI) standard, which reflects the extent to which companies integrate sustainability principles in their reporting.

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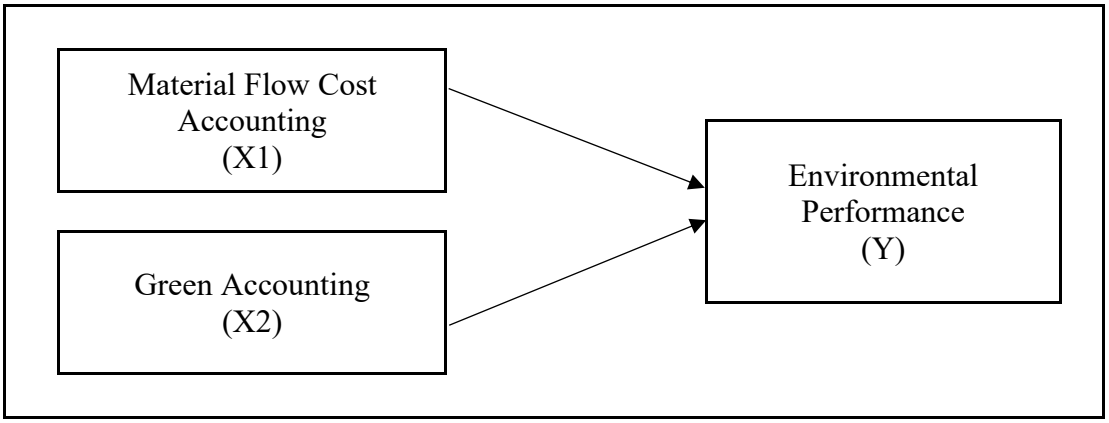
2.6 Hypothesis Formula

The variables that will be tested in this research will be developed in a conceptual framework which can be described as follows:



2.6.1 Material Flow Cost Accounting has a positive effect on Environmental Performance

Research by Hussam Salim Najaf et al. (2024) found that the application of Material Flow Cost Accounting (MFCA) in brick factories can efficiently manage the flow of materials and energy, reduce costs and waste, and improve the company's economic and environmental performance.

H1: Material Flow Cost Accounting has a positive effect on Environmental Performance

2.6.2 Green Accounting has a positive effect on Environmental Performance

Research by Dwi Ratmono et al (2024) where the results of the research reveal that green accounting has a positive effect on environmental performance.

H2: Green Accounting has a positive effect on Environmental Performance

2.6.3 The effect of the implementation of Green Accounting and Material Flow Cost Accounting on Environmental Performance

Asper a study by Shafira Selena Orlin & Muhammad Abdul Aris (2024), the results of the study report that Green Accounting, Material Flow Cost Accounting, and company size affect the Company's performance.

H3: The Effect of the Implementation of Green Accounting and Material Flow Cost Accounting on Environmental Performance

3. Methods

Method The type of data used in this study is secondary data consisting of annual reports and sustainability reports of energy sector companies listed on the Indonesia Stock Exchange for the 2022-2023 period. The data is obtained from the www.idx.go.id and the official website of each company. The sampling technique used is the purposive sampling method which means sampling based on certain considerations or criteria (Holiawati et al., 2024).

The criteria used in the selection of samples for this study are:

1) Energy sector companies listed on the Indonesia Stock Exchange (IDX) for the 2022-2023 period.
2) Companies that publish the complete Annual Report and Sustainability Report for the 2022-2023 period.

The sample consisted of 47 companies for 2 years so that a total of 94 observation data were obtained. The data analysis in this study will utilize computer technology, especially Econometric Views (EViews) version 13.

The data in this study will be tested using a regression method, namely Panel Data Regression. The regression model used is as follows:

$$Y = \alpha + \beta Xit1 + \beta X2it + \varepsilon$$

Information:

Y : Environmental Performance
α : constant
β1 – β6 : regression coefficient
X1 : Material Flow Cost Accounting
X2 : Green Accounting
ε : Error

4. Results and Discussion

4.1 Descriptive Statistics

The description in this study includes 5 variables, namely Green Intellectual Capital, Green Innovation and Carbon Emission Disclosure on Company Value with Environmental Performance as a Moderation Variable in Energy and Transportation Sector Companies 2021-2023.

Table 1. Descriptive Statistical Test Results

	EP	MFCA	GA
Mean	0.808511	11903206	0.307368
Median	1.000000	45747392	0.280992
Maximum	1.000000	61284247	0.925620
Minimum	0.000000	23305179	0.000000
Std. Dev.	0.395583	16017294	0.319223
Observations	94	94	94

Source: Secondary data processed through EViews 13, 2025

From the results of descriptive statistics, the analysis is as follows:

1) The average value for the Environmental Performance variable is 0.808511, which means that the Environmental Performance of the energy sector is relatively good. With a standard deviation value of 0.395583, the standard deviation value is smaller than the mean of 0.395583 > 0.808511, meaning that the data distribution is quite good. The maximum Environmental Performance value is 1.0000000 or companies that implement ISO 14001, which are as many as 39 energy sector companies, while the minimum value is 0.000000 owned by PT Astrindo Nusantara Infrastruktur Tbk, PT Sumber Energi Andalan Tbk, PT Capitalinc Investment Tbk, PT Trans Power Marine Tbk, PT Exploitasi Energi Indonesia Tbk, PT Dwi Guna Laksana Tbk, PT Petrindo Jaya Kreasi Tbk. and PT Golden Eagle Energy Tbk.
2) The average value for the disclosure of the Material Flow Cost Accounting variable proxied by production costs shows a figure of 11,903,205,897,686, with a standard deviation value of 16,017,294,291,176. The standard deviation value is greater than the mean, which is 16,017,294,291,176 > 11,903,205,897,686, which means that the data distribution is not good. The maximum value of production costs is 61,284,247,984,000 owned by PT Adaro Energy Tbk. in 2023 and the minimum value of production costs is 302,612,397,000 owned by PT Sumber Energi Andalan Tbk. in 2022.

3) The average value for the Green Accounting variable is 0.307368 or 30.73%, the 2021 GRI disclosure indicates that the sector shows less than optimal results in terms of Green Accounting disclosure because it is less than 50%, with a standard deviation value of 0.319223 greater than the mean of 0.307368, meaning that the data distribution is not good. The maximum value is 0.925620 owned by PT Golden Energy Mines Tbk. which means that this company disclosed 92.5% of GRI 2021 items for 2 consecutive years and a minimum value of 0.000000 owned by 18 companies, meaning that this company did not disclose GRI 2021 during the 2022-2023 period.

4.2 Panel Data Regression Analysis

The empirical analysis employs panel data regression using the Fixed Effects Model to examine the relationship between Material Flow Cost Accounting (MFCA), Green Accounting (GA), and Environmental Performance. The results of the estimation are presented in Table 2.

Table 2. Panel Data Regression Results (Fixed Effects Model)

Variable/ Statistic	Coefficient/ Value	Std. Error	t-Statistic	p-Value
Intercept	-0.983300	0.680012	-1.446	0.152
MFCA	0.061051**	0.024066	2.537	0.013
GA	0.108585	0.130989	0.829	0.409
R-squared	0.102			
Adjusted R-squared	0.083			
F-statistic	5.195			
Prob(F-statistic)	0.007			
Durbin-Watson stat	2.010			

Notes: ** denotes significance at the 5% level.
Source: Processed secondary data using EViews 13, 2025.

4.3 Hypothesis Testing

4.3.1 F-Test for Overall Significance

The F-test examines the joint significance of all independent variables. The results indicate an F-statistic of 5.195 with a p-value of 0.007, which is below the 0.05 significance level. Thus, the null hypothesis is rejected, confirming that Material Flow Cost Accounting and Green Accounting collectively exert a statistically significant influence on Environmental Performance.

4.3.2 t-Test for Partial Significance

The t-test evaluates the individual impact of each independent variable on Environmental Performance.

1) Material Flow Cost Accounting (MFCA)
   The coefficient for MFCA is 0.061 with a p-value of 0.013, which is statistically significant at the 5% level. This result supports H1, indicating that MFCA positively and significantly enhances Environmental Performance.
2) Green Accounting (GA)
   The coefficient for GA is 0.109 with a p-value of 0.409, which exceeds the 0.05 significance threshold. Thus, H2 is rejected, suggesting that GA does not exhibit a statistically significant effect on Environmental Performance.

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4.3.3. Model Interpretation

The regression equation derived from the analysis is:

$$Environmental\ Performance = -0.983 + 0.061 \cdot MFCA + 0.109 \cdot GA$$

The model demonstrates that MFCA is a significant driver of Environmental Performance, while GA does not contribute meaningfully within this empirical context. The adjusted R-squared value of 0.083 indicates that approximately 8.3% of the variance in Environmental Performance is explained by the independent variables, suggesting the potential influence of other unobserved factors. The Durbin-Watson statistic of 2.010 confirms the absence of autocorrelation in the residuals, affirming the robustness of the model.

4.4 Discussion

The results of the study show that the Material Flow Cost Accounting affects Environmental Performance. By reducing production costs through resource efficiency, waste reduction, and process innovation, MFCA not only increases the company's profitability but also reduces environmental impact. Although the increase in production costs may be due to meeting higher environmental standards (such as ISO 14001) may require additional costs, it improves the company's environmental performance and reputation. This is in line with expectations Squirrel who care about sustainability, thereby creating added value for the company and the environment at the same time. The results of this study are supported by previous research conducted by São Paulo et al., (2024) that Material Flow Cost Accounting (MFCA) can help companies reduce waste and improve environmental performance. MFCA helps identify material waste and improve efficiency. Case studies show positive results in textile companies.

The results in this study show that the Green Accounting has no effect on Environmental Performance. GRI disclosures are voluntary and non-binding. Companies may only disclose positive information or ignore unfavorable data about their environmental impact. Some companies may use GRI disclosures as a tool for "greenwashing," i.e., creating an eco-friendly image without making any real changes to their operations. In this case, green accounting does not contribute to the actual improvement of environmental performance. These results are in line with research conducted by Amaliyah & others, (2022) which states that recycled materials, renewable energy and the allocation of corporate social responsibility funds have no effect on environmental performance.

The results of the study show that the variables of Material Flow, Cost Accounting, and Green Accounting have an effect on Environmental Performance. The implementation of MFCA and Green Accounting helps companies comply with applicable environmental regulations. This compliance not only avoids companies from legal sanctions but also strengthens their legitimacy in the eyes of stakeholders.

5. Conclusion

This study examines the application of Material Flow Cost Accounting and Green Accounting to Environmental Performance in companies in the Energy and Transportation Sector 2022-2023. The analysis used in this study is a panel data regression test using the EViews 13 program. Based on the sequence of the research process that has been carried out, starting from data collection, data grouping, data testing and discussion of the results of data testing that has been carried out in the previous chapter. So, it can be concluded as follows:

1) The results of this study found that Material Flow Cost Accounting has an effect on Environmental Performance. This means that the increase in production costs does not always have a negative impact on environmental performance. If the increase in costs is due to investments in environmentally friendly technology, improved operational standards, or regulatory compliance, this can actually improve environmental performance.
2) The results of this study found that Green Accounting has no effect on Environmental Performance. This means that the Company may use GRI disclosures only to meet stakeholder expectations and maintain their legitimacy, without making any tangible changes in operations. In this case, green accounting functions as a tool of legitimacy, not as a driver of improving environmental performance.
3) The results of this study found that Material Flow Cost Accounting and Green Accounting have an effect together on Environmental Performance. This means that the implementation of MFCA and Green Accounting helps companies comply with applicable environmental regulations. This compliance not only avoids the company from legal sanctions but also strengthens their legitimacy in the eyes of stakeholders.

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