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Implementation of Carbon Accouting and Green Innovation in Improving Environmental Performance Against the SDGs in Companies

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Abstract

Research Aims: Seeing the importance of carbon accounting and green innovation in the context of environmental performance and compliance with SDGs, this analysis is very relevant to provide new insights into how these two aspects can support each other. It is hoped that this analysis can provide practical recommendations for companies in implementing carbon accounting and green innovation effectively, as well as help them achieve the sustainability goals that have been set. The aim of this analysis is to find out and analyze how carbon emissions and green innovation impact the Sustainable Development Goals. In addition, this analysis also investigates how environmental performance impacts the relationship between the creation of carbon emissions and green innovation towards the SDGs. This analysis discusses energy and infrastructure companies listed on the Indonesia Stock Exchange from 2020 to 2022. A purposive sampling technique was employed for this investigation, and a sample of 14 businesses was selected. for this study, a sample of 14 businesses was selected. A total of 14 companies were selected as samples for this research using purposive sampling techniques. The PLS hypothesis testing system is used, and secondary data is the type of data used. The results of the analysis show that sustainable development goals are influenced by environmental performance and carbon accounting. On the other hand, green innovation has a significant impact regarding the environmental performance of companies working in the energy and infrastructure sectors.

Keywords: *Carbon Accounting, Green Innovation, Environmental Performance, Sustainable Development Goals.*

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1. Introduction

UN member countries adopted the Sustainable Development Goals (SDGs) in 2015 with the aim of overcoming various social, economic and environmental problems facing the world today. There are 17 interrelated targets, ranging from poverty alleviation to environmental protection. In the context of analysis, SDGs are often used as a Y variable to evaluate the impact of various factors regarding the achievement of these sustainable development goals. Recent analysis shows that companies that implement sustainable practices tend to perform better in achieving the SDGs, especially in terms of reducing greenhouse gas emissions and managing natural resources.

SDGs emphasize the importance of the involvement of all parties, including government, the private sector, civil society and individuals in achieving common goals. Focus on long-term sustainability in natural and social resource management. Recognize that achieving one goal can affect the achievement of other goals. Carbon accounting is increasingly becoming a concern throughout the world, especially in the context of sustainability and achieving Sustainable Development Goals (SDGs). In Indonesia, the carbon exchange will begin operating in September 2023, marking a significant step in managing greenhouse gas (GHG) emissions. A carbon tax policy is also planned to be implemented in 2025, which is expected to encourage businesses to be more transparent in reporting their emissions and contribute to reducing national emissions (CNBC Indonesia, 2024). Carbon accounting is a process that aims to measure and report greenhouse gas (GHG) emissions produced by business activities. With increasing awareness of climate change and its impact on the environment, companies are expected to be more transparent in reporting their emissions. This is not only important for regulatory compliance but also to meet the expectations of stakeholders who are increasingly concerned about sustainability issues.

The importance of carbon accounting to increase awareness of climate change, carbon accounting is an important tool for companies to report the environmental impact of their operations. This is not only important for regulatory compliance but also to meet the expectations of stakeholders who are increasingly concerned about sustainability issues. Green innovation is increasingly becoming the main focus in efforts to achieve Sustainable Development Goals (SDGs), especially in the context of climate change and sustainability. Many businesses in Indonesia are starting to implement green innovation practices to increase the efficiency of their operations and reduce the negative impacts they have on the environment. Companies in the energy sector

and manufacturing industry strive to implement environmentally friendly innovations because there are government policies that support the use of renewable energy and reducing greenhouse gas emissions. Recent analysis shows that green innovation not only helps companies meet environmental regulations but also improves their reputation and competitiveness in the global market. In an era of increasingly urgent climate change, companies are required to adapt to more sustainable business practices. Green innovation is key to achieving this target, because it helps the company reduce GHG emissions and maximize resource efficiency.

Carbon accounting and green innovation have an important role in improving the company's environmental performance. Carbon accounting allows companies to measure and report greenhouse gas (GHG) emissions resulting from their operational activities. By applying carbon accounting techniques, companies can calculate their carbon footprint and take steps to reduce these emissions. This is in line with SDG target 13, which focuses on action regarding climate change. Environmental performance focuses on measuring and evaluating the extent to which an organization is successful in managing and reducing its negative impacts regarding the environment. Aims to measure and improve environmental performance through effective and sustainable management. Environmental performance is the result of implementing green innovation and other environmentally friendly practices.

The company's environmental performance is an important indicator in achieving sustainable development targets. Environmental disclosure, carried out through sustainability reports, is also key in increasing company transparency and accountability regarding their environmental impacts. The Ministry of Environment and Forestry applies PROPER to measure environmental performance, while environmental disclosure is measured by the GRI 4.0 index from the Global Reporting Initiative. Compliance with the SDGs is becoming increasingly important in today's business context. Many companies are starting to realize that sustainability is not only a social responsibility but also a smart business strategy. In my observations, companies that are active in disclosing carbon emissions and implementing green innovation tend to get greater support from stakeholders, including investors and consumers. This shows that there is a positive relationship between environmental performance, carbon accounting, green innovation, and compliance with SDGs.

Although there are many benefits from implementing carbon accounting and green innovation, the author also observes that many companies face challenges in implementing it. Some of these challenges include a lack of understanding of carbon accounting, high initial costs for investment in green technology, and a lack of clear reporting standards on greenhouse gas emissions. These challenges can hinder companies' progress in achieving their sustainability goals. As a researcher in the field of accounting and sustainability, the author has seen how companies that implement carbon accounting and green innovation not only comply with regulations but also increase their operational efficiency. For example, several renewable energy companies have succeeded in reducing operational costs through investment in clean technology and better emissions management. From the author's observations regarding the renewable energy industry and infrastructure in Indonesia, there is increasing awareness of the importance of sustainability. However, many companies still face challenges in implementing carbon accounting practices effectively. The lack of clear reporting standards is often an obstacle for companies to disclose carbon emissions transparently. The author believes that this analysis will provide valuable insight into how the implementation of carbon accounting and green innovation can drive better environmental performance and support the achievement of SDGs in the renewable energy sector.

Seeing the importance of carbon accounting and green innovation in the context of environmental performance and compliance with SDGs, this analysis is very relevant to provide new insights into how these two aspects can support each other. This analysis is expected to provide practical recommendations for companies in implementing carbon accounting and green innovation effectively, as well as helping them achieve the sustainability goals that have been set.

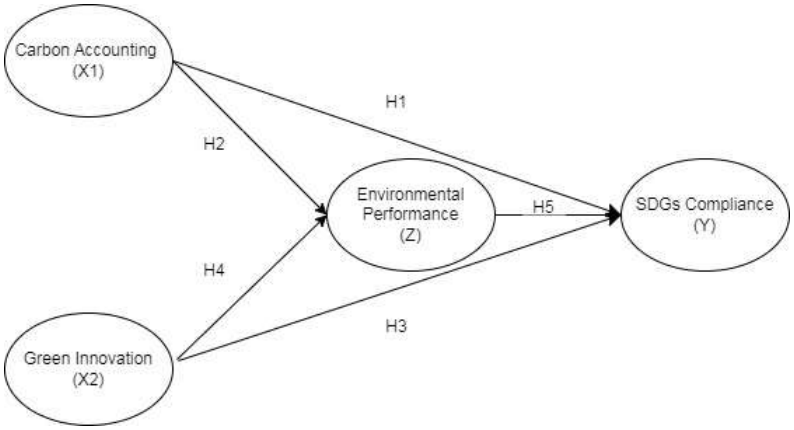
Formulation of the problem

a. How does carbon accounting affect Sustainable Development Goals compliance in companies in the renewable energy and infrastructure sectors?
b. How does carbon accounting affect the environmental performance of companies in the renewable energy and infrastructure sectors?
c. How does green innovation affect the environmental performance of companies in the renewable energy and infrastructure sectors?
d. How does green innovation affect Sustainable Development Goals in companies in the renewable energy and infrastructure sectors?
e. How does environmental performance affect the Sustainable Development Goals of companies in the renewable energy and infrastructure sectors?

Purpose of Analysis

a. To find out and analyze the influence of carbon accounting on Sustainable Development Goals compliance in companies in the renewable energy and infrastructure sectors.
b. To find out and analyze the influence of carbon accounting on environmental performance in companies in the renewable energy and infrastructure sectors.

c. To find out and analyze the influence of green innovation on environmental performance in companies in the renewable energy and infrastructure sectors.
d. To find out and analyze the influence of green innovation on Sustainable Development Goals in companies in the renewable energy and infrastructure sectors.
e. To find out and analyze environmental performance which influences Sustainable Development Goals in companies in the renewable energy and infrastructure sectors.



H1 = Carbon accounting disclosure has a positive and significant effect on Sustainable Development Goals (SDGs).
H2 = Carbon accounting disclosure has a positive and significant effect on the company's environmental performance
H3 = Disclosure of green innovation has a positive and significant effect on Sustainable Development Goals (SDGs).
H4 = Disclosure of green innovation has a positive and significant effect on the company's environmental performance.
H5 = Disclosure of environmental performance has a positive and significant effect on Sustainable Development Goals (SDGs).

2. Empirical Literature Review

Management applies management accounting data to process financial data to monitor its business activities. This report is then used as a decision making tool (Adistianingsih & Pandin, 2024).

The stakeholder approach began to emerge in the mid-1980s as a response to the problems faced by managers at that time, especially those related to environmental change. This system shows the desire to create a structure that can solve this problem (Rokhlinasari, 2016).

Consisting of 17 globally agreed goals to address the social, economic and environmental challenges facing the world, Sustainable Development Goals (SDGs) cover things such as quality education, gender equality, poverty eradication and climate action. Until 2030, the SDGs are intended to be a comprehensive and inclusive framework that can be used by every country to achieve sustainable development.

In the Sustainable Development Goals (SDGs) there are five dimensions in achieving desires, which are included in the 17 main targets of the SDGs, namely:
a) People aim to eradicate poverty and hunger in all forms of life and social welfare.
b) Earth, or earth, has the goal of protecting natural resources and climate for future generations. This includes targets for clean and affordable energy, targets for responsible consumption and production, targets for addressing climate change, targets for marine ecosystems and targets for terrestrial ecosystems.
c) Prosperity, or prosperity, with the goal of ensuring that people have decent jobs and that the economy develops.
d) Peace, which aims to build a peaceful, just and inclusive society. Peace includes 16 goals—peace, justice, and resilient institutions; And
e) Partnership, or partnership, which aims to implement the agenda through a strong global partnership. The partnership covers 17 goals.

In the Carbon Emission Disclosure Checklist there are 6 categories and 18 indicators, as follows:

Category	Item	Information
Climate Change: Risks and Opportunities	CC1	Assessment/description of risks (both specific and general rules/regulations) related to climate change and the actions taken to manage these risks.
	CC2	Current (and future) assessment/description of the financial, business and opportunity implications of climate change
Greenhouse Gas Emissions	GHG1	Description of the methodology used to calculate greenhouse gas emissions (e.g. GHG or ISO protocol)
	GHG2	Existence of external verification of GHG emission quantity calculations by whom and on what basis
	GHG3	Total greenhouse gas emissions (metric tons of C02 produced)
	GHG4	Disclosure of scope 1 and 2, or 3 GHG emissions
	GHG5	Disclosure of GHG emissions based on origin or source (example: coal, electricity, etc.).
	GHG6	Disclosure of GHG emissions by facility or segment level
	GHG7	Comparison of GHG emissions with previous years.
Energy Consumption	EC1	The amount of energy consumed
	EC2	Calculation of energy used from renewable resources
	EC3	Disclosure by type, facility or segment.
Greenhouse Gas and Cost Reduction	RC1	Details of the plan or strategy to reduce GHG emissions.
	RC2	Details of current GHG emission containment target levels and emission reduction targets.
	RC3	Emission reductions and costs or savings achieved to date as a result of emissions reduction plans
	RC4	Future emission costs are taken into account in capital expenditure planning.
Carbon Emission Accountability	ACC1	An indication that the board committee (or other executive body) has responsibility for action related to climate change.

The concept of desirability and environmental protection is now known as green innovation. The following is an explanation of the concepts and theories underlying green innovation, and how they relate to environmental performance and fulfillment of the Sustainable Development Goals (SDGs). Innovations that aim to reduce negative environmental impacts through the development of environmentally friendly products and processes are known as green innovations.

Chen et al. (2006) distinguish two main types of green innovation, the first is environmentally friendly product innovation, namely goods that reduce waste and do not have a negative impact on the environment. The second is green process innovation, which means more efficient use of resources and energy, thereby reducing pollution emissions.
Green innovation can be described by four signs:
1) The latest technology is used in the production process to reduce energy, air and waste usage;
2) The product uses materials that do not cause pollution or are dangerous (environmentally friendly materials);
3) Applying environmentally friendly packaging, such as plastic and paper that can be recycled; And
4) It is possiblerecycle or recondition materials or components used in the production process to recycle or recondition materials or components used in the production process .

Environmental performance is the measurable result of an environmental management system, which is involved in controlling each environmental element. Environmental policy determines environmental performance analysis (Hidayati & Wardhani, 2023).
Environmental performance measurement can be done through various indicators, including:

Color	Category	Score
Gold	Very good	5
Green	Good	4
Blue	Enough	3
Red	Bad	2
Black	Very bad	1

Analysis shows that environmental performance contributes to achieving the Sustainable Development Goals (SDGs). Studies show that good environmental performance can increase satisfaction with global desires. However, not many p-analyses have found a direct relationship between the two.

3. Method, Data, and Analysis

The objective of this research is to characterize and test the relationship between variables and current variables, this research is included in the descriptive research category. This research aims to characterize and test the relationship between current variables, this research is included in the descriptive research category, namely carbon accounting, green innovation, environmental performance, and compliance with SDGs. The population in this analysis are companies operating in the renewable energy and infrastructure sectors listed on the Indonesian Stock Exchange. Samples can be taken through a purposive sampling system, where the analysis selects companies based on certain criteria, for example companies that have made sustainability reports and are registered in PROPER. There are 156 companies in the renewable energy and infrastructure sectors that make up the population for this analysis. The criteria for this analysis are:

1) Energy and infrastructure corporations listed on the Indonesia Stock Exchange (BEI) in 2020-2022.

2) Energy and infrastructure corporations that publish sustainability reports consecutively in 2020-2022.

3) Energy and infrastructure corporations registered in the 2020-2022 Company Performance Assessment Program (PROPER).

Information	Amount
Energy and infrastructure sector companies listed on the Indonesia Stock Exchange (BEI) in 2020-2022.	156
Minus: 1) Energy and infrastructure sector companies that do not publish complete and consecutive sustainability reports for 2020-2022 2) Energy and infrastructure sector companies that are not registered in the 2020-2022 Company Performance Assessment Program (PROPER)	 (32) (110)
Data on companies that meet the sample criteria	14

The Company's criteria for the Energy and Infrastructure sector are as follows:

No	Code	Name of Energy and Infrastructure Sector Company
1	ADRO	Adaro Energy Indonesia Tbk.
2	DSSA	Dian Swastatika Sentosa Tbk
3	HRUM	Harum Energy Tbk.
4	ITMG	Indo Tambangraya Megah Tbk.
5	MEDC	Medco Energi Internasional Tbk
6	PGAS	Perusahaan Gas Negara Tbk.
7	PTBA	Bukit Asam Tbk.
8	SMMT	Golden Eagle Energy Tbk.
9	ADHI	Adhi Karya (Persero) Tbk.
10	CMNP	Citra Marga Nusaphala Persada
11	JSMR	Jasa Marga (Persero) Tbk.
12	META	Nusantara Infrastructure Tbk.
13	PTPP	PP (Persero) Tbk.
14	WIKA	Wijaya Karya (Persero) Tbk.

The variables and operations that will be used in this analysis are explained in the following table:

Variable	Operational Definition	Indicator	Formula	Scale
Carbon Accounting	The process of measuring and reporting carbon emissions produced by company activities.	Categories on CED	CED = Total score / Maximum total score	Pan-Disclosure Score
Green Innovation	Implementation of new technologies and practices aimed at reducing negative environmental impacts.	Number of Green Innovation Projects	GIN = Total items disclosed /Total	Pan-Disclosure Score
SDGs Compliance	The degree to which companies meet the targets set in the SDGs, especially those related to the environment.	Percentage of SDGs Targets Fulfilled	Measured based on program evaluation and achievement of SDGs.	Pan-Disclosure Score
Environmental Performance	A measure of a company's effectiveness in managing the environmental impact of its operational activities.	PROPER Score	*SKORPROPER*	Score (0-5)

To find out whether there is a significant influence between the independent variables carbon accounting and green innovation, the dependent variables are SDGs coverage compliance and environmental performance. Hypothesis testing is carried out:

1) Measurement Model (Outer Model):

a. Convergent Validity: a measure of how well an indicator measures a particular construct.

b. Discriminant Validity: ensuring that certain constructs have greater numbers than other constructs. The total holding factor is expected to be more than 0.7. This is achieved through a comparison of the number of cross-loadings.

c. Reliability: Composite reliability is measured by Cronbach's Alpha and any number above 0.7 is considered to be good reliability.

2) Structural Model (Inner Model):

a. R-Square: Calculates the percentage of variance in the dependent variable that can be explained by the independent variable. The variance in the dependent variable that can be explained by the independent variable. A strong model is indicated by an R-Square value greater than 0.67. It is indicated by an R-Square value greater than 0.67.

b. F-Square: Quantifies the size effect in structural models. Numbers above 0.35 show a large influence.

c. Hypothesis Testing: Applying a bootstrapping system to calculate the T-statistic and P-value for each relationship between variables.If the P value value is less than 0.05 and 0.05 and the T-statistic is higher than the T-table (usually 1.96 for α = 0.05), the hypothesis is accepted. The T-statistic is higher than the T-table (usually 1, 96 for α = 0.05), the hypothesis is accepted.

The following steps were used to analyze the data:

1) Data collection: Questionnaires are issued to companies in the renewable energy and infrastructure sector to collect data.

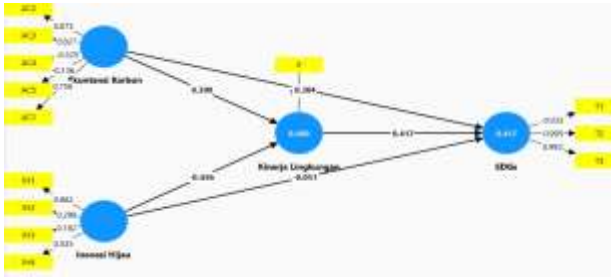
2) Input data to SmartPLS: This data is imported into SmartPLS in CSV format, and the model context is built by determining the relationships between variables. PLS Algorithm Analysis: Once the model is built, analysis is performed by selecting the PLS Algorithm option to obtain initial results from the model.

3) Bootstrapping: To test the significance of the hypothesis, this analysis applies bootstrapping and finds the number of T-statistics and P-values for each relationship between variables.

4) Interpretation of Results: The results of the analysis are displayed in the form of graphs and tables to make it easier to understand the relationship between variables. Indirect Effect Test: If there are intervening variables, such as environmental performance, analysis is carried out to determine the indirect effect. A bootstrapping system was used to carry out this analysis.

4. Result and Discussion

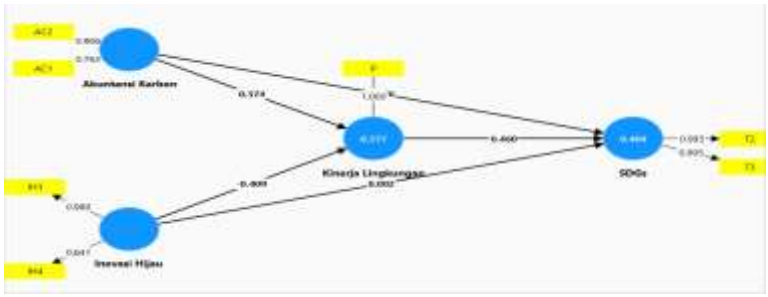
PLS reliability and validity indicators are assessed in the outer model and validity indicators are assessed in the outer model. While composite reliability can be used to measure reliability indicators, convergent validity and discriminant validity are examples of validity indicators. Can be used to measure reliability indicators, convergent validity and discriminant validity are examples of indicators.



Here, we can see the convergent validity of the output produced by the SmartPLS software because the indicators for each variable have a filling factor of more than 0.5, which shows that the model can be continued without modification.

	Carbon Accounting	Green Innovation	Environmental Performance	SDGs
AC1	0,763			
AC2	0,906			
IH1		0,980		
IH4		0,641		
P			1,000	
T2				0,995
T3				0,995

The table above shows that indicators with a number of external models lower than 0.7 are not suitable for use. Therefore, indicators with a number of outliers lower than 0.7 should be removed from the model.



Apart from measuring convergent validity and discriminant validity, outside the model can also be measured by measuring the reliability of the construct or latent variable by applying a composite reliability number. If the composite reliability result is 0.7, the variable is considered reliable. The results of measuring composite validity and discriminant validity in this analysis are presented in the following table:

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Carbon Accounting	0,589	0,823	0,701
Green Innovation	0,646	0,807	0,686
SDGs	0,99	0,995	0,99

Testing within the model, or structural model, is carried out after testing outside the model has met the requirements. The sum of the r-rectangle for the dependent construct, which is an indicator of reliability, and the sum of the t-statistics of the test coefficients of the path coefficients, which are the path coefficients, are necessary to understand the internals of the model. A larger number of r-rectangle shows that the prediction

model of the resulting analysis model is better, and the number of path coefficients shows the significance level of the hypothesis test. The number of R-Square constructs is as follows:

	R-square	R-square adjusted
Environmental Performance	0,377	0,345
SDGs	0,404	0,357

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Results
Carbon Accounting -> SDGs	-0,409	-0,406	0,165	4,277	0,037	Negative/Significant
Carbon Accounting -> Environmental Performance	0,374	0.356	0,136	1,988	0,185	Positive/Insignificant
Green Innovation -> SDGs	0,002	0,013	0,193	0,02	0,185	Positive/Insignificant
Green Innovation -> Environmental Performance	0,276	0,285	0,154	1,976	0,031	Positive/Significant
Environmental Performance -> SDGs	0,46	0,433	0,215	1,174	0,027	Positive/Significant

Path coefficient describes the level of significance and relationship between analysis variables. with the following requirements: The hypothesis is accepted if t is greater than t table, namely more than 1.96, and rejected if t is less than t table, namely less than 1.96.

Thus the path coefficients give the following results:

1. Influence relationship (X1) Carbon Accounting (Y) Sustainable Development Goals

Based on the path coefficient table above, we can see that the path coefficient or initial sample estimate is -0.409 with a total T statistic of 4.277. Because the standard t-table sum is less than 1.960, we can assume that (X1) regarding (Y) has a significant negative influence, and this result shows that H1 is accepted.

2. Relationship of influence (X1) Carbon Accounting (Z) Environmental Performance

Based on the path coefficient table above, the influence relationship (X1) with respect to (Z) shows the results of the path coefficient or initial sample estimate of -0.374 with a T-statistic of 1.988. Because the standard t-table sum is less than 1.960, it can be concluded that (X1) regarding (Z) has a positive and insignificant effect; as a result, H2 is rejected.

3. Influence relationship (X2) Green Innovation (Y) Sustainable Development Goals

Based on the path coefficient table above, there is a path coefficient result or initial sample estimate of 0.002 with a total T statistic of 0.185. This shows that (X2) regarding (Y) has a positive and insignificant effect, and these results show that H3 is rejected.

4. Relationship of influence (X2) Green Innovation (Z) Environmental Performance

The path coefficient table above shows the results of the path coefficient or initial sample estimate of 0.276 with a total T statistic of 0.031. This shows that the influence relationship (X2) t with respect to (Z) is positive and significant, and this shows that H4 is accepted.

5. Relationship of influence (Z) Environmental Performance (Y) Sustainable Development Goals

The relationship of influence (Z) with respect to (Y) is presented in the path coefficient table above with the result of the path coefficient or initial sample estimate of 0.46 with a total T statistic of 0.027. Because the standard t-table sum is less than 1.960, it can be concluded that (Z) regarding (Y) has a positive and significant effect, which means H5 is accepted.

5. Conclusion and Implications

The results of the analysis carried out on 14 energy and infrastructure companies listed on the Indonesia Stock Exchange (BEI) during the 2020–2022 period aim to find out and analyze how disclosure of carbon emissions and green innovation impacts SDGs compliance with environmental performance as an intervening variable. It is hoped that the results of this analysis can help investors in making investment decisions by considering the performance of the company owner.

The research results show that environmental performance and carbon accounting have an influence on the Sustainable Development Goals, while green innovation has a significant impact on environmental performance on businesses in the energy and infrastructure sectors.

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