

Driving Firm Value Through Sustainability: The Role of Carbon Emission Disclosure, Eco-Efficiency, and Green Innovation in Indonesian Energy Companies

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ABSTRACT: This study examines the effects of eco-efficiency, green innovation, and carbon emission disclosure on firm value among energy companies listed on the Indonesia Stock Exchange during 2020–2024. A quantitative panel data approach was employed using secondary data obtained from annual financial reports and sustainability reports. The final sample consisted of 16 energy companies with 5 years of observation, resulting in 80 company-year observations. Panel data regression analysis was applied to investigate the causal relationships among the study variables. Carbon emission disclosure was calculated using GRI 305. The empirical results indicate that green innovation has a positive and significant impact on firm value. Conversely, carbon emission disclosure has a negative impact on firm value. Meanwhile, ecological efficiency does not show a significant impact on firm value. Overall, the findings suggest that Indonesian investors place greater emphasis on innovation-oriented sustainability strategies rather than solely on efficiency- or compliance-based environmental measures when evaluating firm value in the energy sector.

Keywords: Carbon Emission Disclosure, Eco-efficiency, Green Innovation, Tobin's Q, Sector Energy.



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INTRODUCTION

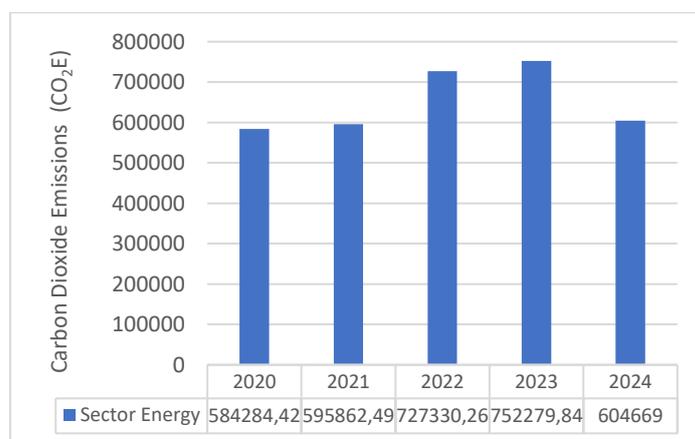
In recent decades, climate change and global warming have become serious concerns, making carbon emission reduction a key focus for governments, investors, and companies. The energy sector consistently accounts for the most greenhouse gas emissions globally and in Indonesia. When people burn fossil fuels, run factories, cut down forests, or change how land is used, they make it harder for nature to absorb carbon. This causes greenhouse gas levels to rise and disrupts the natural balance (Badan Meteorologi Klimatologi dan Geofisika, 2025; Low Carbon Development Indonesia, 2025).

In an effort to mitigate the growth of greenhouse gas emissions, the Kyoto Protocol was adopted in Kyoto, Japan, on December 11, 1997, under the United Nations Framework Convention on

Climate Change (UNFCCC). As a signatory country, Indonesia has translated these international commitments into national climate policies to reduce emissions and strengthen environmental governance and corporate accountability. These national policies are further operationalized through regulatory instruments in the financial sector that promote transparency and sustainability reporting. One of the key regulations is the Financial Services Authority Regulation No. 51/POJK.03/2017 on the implementation of sustainable finance. This regulation requires publicly listed companies, including energy sector firms, to prepare sustainability reports and disclose their environmental performance, including information on carbon emissions and environmental management practices. Therefore, POJK 51/2017 is directly relevant to this study because it shapes corporate disclosure behavior within the sample and provides a regulatory basis for examining carbon emission disclosure practices in the Indonesian capital market (Amira et al., 2024; Sari & Paramita, 2025).

Figure 1 shows that greenhouse gas emissions from Indonesia’s energy sector fluctuated during the 2020–2024 period. In 2020, economic activity in the energy sector declined sharply due to the COVID-19 pandemic. During the same period, the Indonesian Crude Oil Price (ICP) fell by US\$31.78 per barrel compared to 2019. The ICP serves as a benchmark for upstream energy revenues. Although domestic retail fuel prices remained relatively stable due to government price controls, the decline in ICP reduced revenue potential for energy companies. This effect was particularly notable for those engaged in oil and gas production. Revenue contraction weakened profitability and investor confidence, contributing to declines in stock prices and firm value. For instance, the average share price of energy sector companies decreased by 43.55% from 2019 to 2020. As economic conditions improved, emissions increased again from 2021 to 2023. This rise was in line with higher production and energy demand. Emissions then declined in 2024 due to the growing adoption of renewable and clean energy technologies (CNBC Indonesia, 2020; Kementerian Energi dan Sumber Daya Mineral, 2020; Petriella, 2025).

Figure 1. Contribution of GHG Emissions in Indonesia to the Energy Sector for the 2020-2024 Period



Sources: Ministry of Environment and Forestry (2024)

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Changes in the GHG emission contribution of Indonesia's energy industry affect not only the environment but also the performance and value of the enterprise. Increases indicate success for investors, and the firm's worth determines its long-term orientation. In this study, the worth of the firm was represented by Tobin's Q, a tool that incorporates a company's fundamental data with its market valuation as indicated by stock prices and reveals how investors evaluate the company's past and future prospects (Averio et al., 2024; Desmiza, 2023).

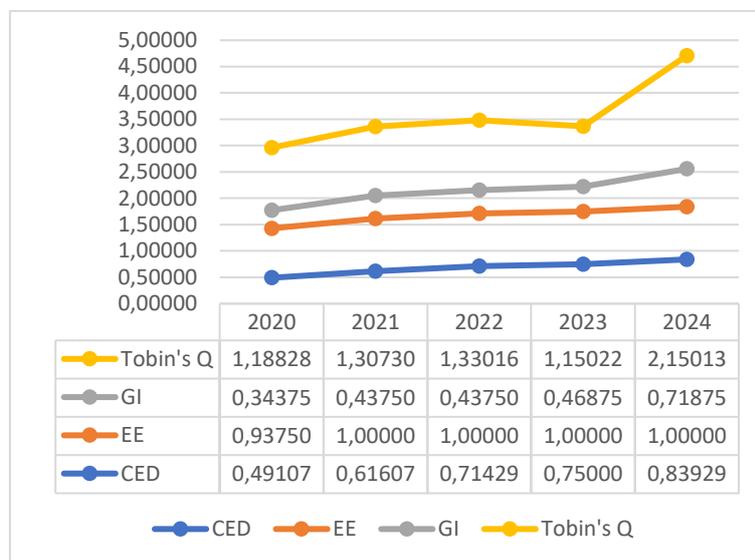
Businesses are expected to play a proactive role in addressing climate change by reducing emissions of greenhouse gases, including sharing their carbon footprint data. Carbon emission disclosure means reporting the emissions produced by a company's operations, which increases transparency and supports emission reduction (Pangestu & Nawirah, 2025; Soleha & Isnalita, 2022). The effects of carbon-emission disclosure on firm value have been the subject of conflicting research. Certain research, including Putri & Paramita (2025) and Ramdani & Nugraha (2024), find a positive effect, whereas others, such as Shafira (2024) and Sicard et al. (2023), find a negative effect. Meanwhile, research by Asyifa & Burhany, (2022), Rachmawati, (2021) and Ramadhan et al. (2023) shows no effect on firm value.

The concept of eco-efficiency is central to the company's strategy for environmental responsibility, as stated in these rules. conservation of natural resources, short for Ecological Economic Efficiency, is a strategy that blends sustainability-based natural resource management with economic efficiency concepts (Anjarsari et al., 2023). A number of studies by (Fanda & Dwijayanti (2024) and Noor et al., (2022) find that eco-efficiency positively affects a firm's value. However, Rahelliamelinda & Handoko, (2024) demonstrate how eco-efficiency lowers a company's worth. However, the findings of the study were carried out by Yuliandhari et al., (2023) demonstrate that the firm's worth is unaffected by eco-efficiency.

In addition, companies are required to achieve more sustainable breakthroughs, one of which is through environmentally based innovation, or Green Innovation. In implementing a sustainability strategy, the company seeks to replace conventional raw materials with sustainable alternatives to increase its appeal in consumers while reducing its carbon footprint (Dewi & Rahmianingsih, 2020; Husnaini & Tjahjadi, 2021). Prior empirical findings on the relationship between green innovation and firm value remain mixed. As an alternate point of view, Rahmasari & Irwansyah, (2024) and Yuniarti et al. (2022) show that Green Innovation positively influences a firm's value. Meanwhile, research by Hasan & Wijayanto, (2025) demonstrates how a firm's value is adversely affected by green innovation. The effects of green innovation, however, have not been studied. Additionally, there are differences in the value of the company. As an alternate point of view.

Based on data from 2020 to 2024, Figure 2 illustrates the gap between theory and practice. Despite improvements in stability, eco-efficiency, green innovation, and carbon emission disclosure, firm value did not rise in 2023. Since theories like legitimacy and signaling generally imply a favorable association between sustainable practices and business value, further study is required to close this research gap (Fanda & Dwijayanti, 2024; Hardiyansah et al., 2021).

Figure 2. Development of Carbon Emission Disclosure, Eco-Efficiency, Green Innovation, and Firm Value in the Energy Sector 2020-2024



Source: IDX, data processed 2025

Although studies with similar titles have been conducted by Fanda & Dwijayanti (2024) and Yuliandhari et al. (2023), this study has novelty.

This study contributes new empirical evidence by focusing on Indonesian energy companies during the post-pandemic period (2020–2024) and applying the GRI 305 standard as a more comprehensive proxy for carbon emission disclosure.

Prior empirical studies report mixed evidence regarding the effects of carbon emission disclosure, eco-efficiency, and green innovation on firm value. Given that the energy sector is a major contributor to environmental pollution, examining these relationships remains particularly relevant. This study contributes to the theoretical literature by extending the sustainability and firm value literature through a comprehensive examination of how these three sustainability dimensions influence firm value. Methodologically, this study employs the Global Reporting Initiative (GRI) 305 index as a consistent and comprehensive proxy to measure carbon emission disclosure. Empirically, this study provides evidence from energy sector firms listed on the Indonesia Stock Exchange during the 2020–2024 period, thereby enriching the accounting and sustainability management literature in the Indonesian context.

Signalling Theory

Signalling theory is that communication carried out by a company as a sender of signals (information) shows the company's situation, which is useful to other parties (investors) in decision-making and is used to reduce information asymmetry (Connelly et al., 2025; Nur et al., 2024; Sion, 2024).

Stakeholder Theory

Companies, according to stakeholder theory, shouldn't only look out for themselves when making decisions; they should also do what's best for their stakeholders (Beckman et al., 2016; Mahajan et al., 2023).

Legitimacy Theory

Legitimacy theory is a theory on how a company and society interact, and managers use it to grow their firm by boosting public trust so that the company's operations align with societal norms, values, and beliefs (Mousa & Hassan, 2015; Ogunode, 2022; Suchman, 1995).

Firm Value

Firm value is how investors see a company's current performance and its chances for future growth (Hasanah & Paramita, 2025; Paramita & Ali, 2023). Tobin's Q is applied because it combines a company's fundamental information with a market valuation reflected in its stock price. As a result, this ratio not only indicates the worth of the company's assets but also how investors see its performance and future possibilities (Yuliusman & Kusuma, 2023). Referring to research conducted by Sari & Paramita (2025), the firm's values are formulated as follows:

$$\text{Tobins' Q} = \frac{\text{MVE} + \text{TL}}{\text{TA}}$$

Carbon Emission Disclosure

How much data a business makes public on its carbon emissions is called carbon emission disclosure. The business's sustainability report details its carbon emissions (Apriandi & Lastanti, 2023; Irwhantoko & Basuki, 2016). Since GRI-305 is a crucial indicator for businesses reporting carbon emissions, it is used in measurement indicators for carbon emission disclosure., including in Indonesia, and can be used in all sectors (Budiman et al., 2024). Referring to research conducted by Alfayerds & Setiawan, (2021), carbon emission disclosure was formulated through:

$$CED = \frac{(\text{Number of items disclosed})}{(\text{Number of disclosure items})}$$

According to signal theory, carbon emission disclosure reflects a firm's commitment to environmental responsibility and reduces information asymmetry for investors. According to stakeholder theory, the business releases its carbon emissions in response to requests from stakeholders and to foster positive connections with the public and investors, who increasingly demand openness and accountability regarding carbon emissions. This encourages investor interest in investing, which will push the stock price higher, thereby increasing the firm's value

(Apriandi & Lastanti, 2023; Hardiyansah et al., 2021). Research by (Hardianti & M., 2023) indicates that the firm's worth is much enhanced when it discloses its carbon emissions in its sustainability report on a regular basis.

H1: Carbon Emission Disclosure has a positive effect on the firm's value

Eco-Efficiency

Eco-efficiency emphasizes integrating economic efficiency with the efficient and sustainable use of resources. With this approach, the company can maximize production while minimizing environmental impacts (Anjarsari et al., 2023). Variable Eco-efficiency. In this study, the scale is nominal, so it cannot be included directly in the linear regression model. Refers to Gujarati & Porter, (2009) in the book Basic Econometrics. Qualitative variables can be analyzed in regression by converting them into dummy variables. namely 1 and 0. Measurement indicators Eco-efficiency according to Damas et al. (2021), namely by using ISO 14001 ownership, because it is in line with the eco-efficiency.

Table 1. Eco-Efficiency Indicator

Eco-Efficiency Indicator	
Grade 1	Eco-efficient company (ISO 14001 Certification Holder)
Value 0	Non-eco-efficient companies (Not ISO 14001 Certified)

Utilizing eco-efficiency shows the business's dedication to environmental and social responsibility, as evidenced by its ISO 14001 certification, which serves as proof of its Eco-efficient practices (Damas et al., 2021). Utilization eco-efficiency. According to signal theory, this is a good indication to investors that the business is concerned about environmental concerns and has a standardized environmental management system. The stock price will rise as a result. According to Fanda and Dwijayanti (2024), a high stock price indicates a bigger value for the company (Tobin's Q) if the total assets remain constant. This is because investors see the stock price as a reflection of the firm's performance. Safitri & Nani, (2021) provide empirical evidence that eco-efficiency has a beneficial effect on a company's value. Therefore, by combining Eco-efficiency with ISO 14001 certification, a company can increase its value by being more legitimate, transparent, and attentive to its stakeholders.

H2: Eco-Efficiency has a positive effect on firm value

Green Innovation

Green Innovation is an effort to implement environmentally friendly operational activities across a company's products, processes, technology, and packaging (Dewi & Rahmianingsih, 2020).

Green innovation (GI) in this study is measured using a disclosure-based index following Agustia et al. (2019). The following are indicators for measuring green innovation:

Tabel 2. Green Innovation Indicator

No	Green Innovation Indicator
1	The production process uses new technologies to reduce energy, water, and waste
2	The product uses fewer polluting or hazardous substances (environmentally friendly).
3	Using an eco-friendly product package (e.g., paper and plastic),
4	Components or materials in the production process can be recycled or reconditioned.

Specifically, GI is calculated as the ratio between the number of green innovation items disclosed by a company and the maximum number of disclosure items that can be reported, as expressed in the following formula:

$$GI = \frac{\text{Number of Items that the Company can Disclose}}{\text{Maximum Number of Items that can be Disclosed}}$$

A company's active participation in green innovation is seen as an indication of its preparedness for changes in the market, sustainability demands of stakeholders, and recognition from the public in order to create a positive reputation. This positive perception can increase investor confidence, thereby encouraging investor interest in investing. This will push the stock price up. If the company's total assets stay the same, a high stock price signals a better value for the business (Tobin's Q). Sunarto et al., (2024) found that green innovation has a considerable and positive impact on business value, which supports this.

H3: Green Innovation has a positive effect on firm value.

METHOD

The relationship between the independent and dependent variables is examined in this study through the use of a causal-descriptive quantitative approach. For this panel, the firm relied on its yearly financial accounts and sustainability reports. There are 91 companies that make up the research population. Using a purposive sample technique, the researcher chose energy businesses listed on the Indonesia Stock Exchange (IDX) from 2020 to 2024. In order to choose the sample, the investigator established specific criteria.

Table 2. Sample Criteria

Yes	Description	Violate the Criteria	Quantity
1	Companies in the energy industry that were listed between 2020 and 2024 on the Indonesia Stock Exchange (IDX)	-	91
2	Energy sector companies that reported complete financial statements for the 2020-2024 period	-	91
3	Energy sector companies that did not report complete sustainability reports during the 2020-2024 period	75	16
Total Sample			16
multiplied by 5 years of observation (16 x 5)			80

Source: Secondary Data processed, 2025

This study is limited by its relatively small sample size of 16 energy sector companies. This limitation stems from the limited number of companies consistently publishing sustainability reports during the observation period.

The program Eviews 13 is used for data processing and analysis.

RESULT AND DISCUSSION

Descriptive Statistical Analysis

Table 3. Descriptive Statistical Analysis Results of Ratio Scale Variables

	X1	X3	Y
Mean	0.682143	0.481250	1.425218
Median	0.857143	0.500000	0.946060
Maximum	1.000000	1.000000	20.98533
Minimum	0.000000	0.000000	0.457330
Std. Dev.	0.347687	0.181306	2.373832
Skewness	-0.918236	-0.087413	7.230476
Kurtosis	2.448604	3.512966	59.25629
Jarque-Bera	12.25556	0.978992	11246.30
Probability	0.002181	0.612935	0.000000
Sum	54.57143	38.50000	114.0174
Sum Sq. Dev.	9.550000	2.596875	445.1713
Observations	80	80	80

Source: Secondary Data processed (2025)

Based on the table above, the following explanation is obtained:

1. The number of data points for each of the variables under study is 80, according to the descriptive analysis. According to Tobin's Q, the Y variable has an average of 1.425218, a median of 0.946060, a maximum of 20.98533, a minimum of 0.457330, and a standard deviation of 2.373832.
2. The CED variable exhibits a range of values: 0.000000 at the lowest, 1.000000 at the highest, 0.857143 in the median, and 0.347687 as the standard deviation.
3. The mean, median, maximum, and standard deviation values for the GI variable are 0.481250, 0.500000, 1.000000, 0.000000, and 0.181306, respectively.

Table 4. Results of Descriptive Statistical Analysis of Nominal Scale Variables

Remarks	Year					Total	Percentage
	2020	2021	2022	2023	2024		
Has ISO 14001 Certification	15	16	16	16	16	79	98,75%
Does not have ISO 14001 Certification	1	0	0	0	0	1	1,25%
Total Observations						80	100%

Source: Secondary Data processed (2025)

Based on the table, there has been stability in energy sector companies that have ISO 14001 certification during the 2020-2024 period. From 2020 to 2024, 79 observations (98.75%) of energy sector companies had ISO 14001 certification, and 1 observation (1.25%) did not.

Panel Data Regression Model Selection Test

The following is the presentation of the model selection test results:

Panel Data Regression Model Selection Test

Here are the results of the model selection test:

Chow Test

Table 5. Chow Test Results

Effects Test	Statistic	d.f.	Prob.
Cross-section F	2.031667	(15,61)	0.0271
Cross-section Chi-square	32.415354	15	0.0056

Source: Data processed using Eviews 13

The p-value for the Chow test is 0.0056, as shown in Table 5, which is lower than the significance level of 0.05. Due to Ha's authorization, the Fixed-Effects Model (FEM) is the optimal choice.

Hausman Test

Table 6. Hausman Test Results

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	2.608788	3	0.4560

Source: Data processed using Eviews 13

The third test produced a p-value of 0.4560, which is more than 0.05, as seen in Table 6. Therefore, H_a was ignored, and the Random Effect Model (REM) was determined to be the most appropriate model.

Lagrange Multiplier Test

Table 7. Lagrange Multiplier Test Results

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	2.863553 (0.0906)	1.580997 (0.2086)	4.444550 (0.0350)

Source: Data processed using Eviews 13

The p-value for the LM test is 0.0350, as shown in Table 7, which is lower than the significance level of 0.05. This study employs the Random Effect Model (REM) since H_a is deemed appropriate. As far as the Chow, Hausman, and LM tests are concerned, the REM is the most appropriate fit.

Classic Assumption Test

According to Ghazali, (2021), testing for normalcy, heteroscedasticity, multicollinearity, and autocorrelation is unnecessary since the Random Effect Model (REM) estimate using Generalized Least Squares (GLS) meets the Best Linear Unbiased Estimator (BLUE) criterion.

Regression Data Panel

Hypothesis Testing

Table 8. Panel Data Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.273033	2.098145	0.606742	0.5458
X1_CED	-3.016807	0.835730	-3.609788	0.0005
X2_EE	0.453523	2.041232	0.222181	0.8248
X3_GI	3.661764	1.353387	2.705629	0.0084

Source: Data processed using Eviews 13

The following is the regression equation derived from Table 8's output findings:

$$\text{Tobin's } Q = 1,273033 - 3,016807\text{CED} + 0,453523\text{EE} + 3,661764\text{GI} + \epsilon$$

1. First, the firm has a Tobin's Q value of 1.2730 if eco-efficiency, green innovation, and carbon emission disclosure are considered constants or zero.
2. The CED variable's coefficient is -3.0168. Thus, Tobin's Q will fall by 3.0168 units for every unit rise in the carbon emission disclosure index, if all other parameters remain constant.
3. The value of the variable coefficient EE is 0.4535. This suggests that companies with eco-efficiency (ISO 14001 certification) have a higher Tobin's Q of 0.4535 than companies without ISO 14001 certification, provided all other parameters stay the same.
4. The GI variable coefficient has a value of 3.6618. This indicates that, if all other factors remain the same, a one-unit rise in the green innovation index will result in a 3.6618-unit increase in Tobin's Q.

Partial Test (T-Test)

The following are the results of the one-way test for hypothesis testing using the t-test and the F-test:

Table 9 Results of the t-test

Variable	Coefficien		t-Statistic	Prob.
	t	Std. Error		
C	1.273033	2.098145	0.606742	0.5458
X1_CED	-3.016807	0.835730	-3.609788	0.0005
X2_EE	0.453523	2.041232	0.222181	0.8248
X3_GI	3.661764	1.353387	2.705629	0.0084

Source: Data processed using Eviews 13

The following are the outcomes of the above table:

1. The carbon emission disclosure variable has a p-value of 0.0005 (< 0.05) and a coefficient of -3.016807. Therefore, we accept H1 with a negative direction, which means that the firm's worth is significantly reduced due to disclosure of carbon emissions.
2. The eco-efficiency variable's coefficient is 0.453523, and its p-value is 0.8248, which is more than 0.05. So, we may conclude that eco-efficiency does not impact the firm's valuation (H2 is rejected).
3. The green innovation variable has a p-value of 0.0084 and a coefficient of 3.661764. Therefore, we accept H3 in a positive direction. Green innovation benefits corporate profits, according to this data.

Simultaneous Test (F-Test)

Table 10 Test Results F

F-statistic	5.183230
Prob(F-statistic)	0.002598

Source: Data processed using Eviews 13

Table 10's p-value (F-statistic) of $0.002598 < 0.05$ ($\alpha = 5\%$) shows that the firm's worth is impacted simultaneously by carbon emission disclosure, eco-efficiency, and green innovation.

Coefficient of Determination (R2)

Table 11 Determination Coefficient Test Results (R2)

R-squared	0.169850
Adjusted R-squared	0.137081

Source: Data processed using Eviews 13

The independent factors account for 13.71% of the variation in the dependent variable, according to the modified R-square of 0.137081. Factors not covered in this study account for the remaining 86.29%. This low adjusted R2 indicates that a variety of external factors, including global energy costs, macroeconomic conditions, and governmental regulations, also have an impact on business value.

The Effect of Carbon Emission Disclosure on Firm Value

Data from 2020 to 2024 demonstrates that the value of companies in the energy industry was negatively impacted by carbon emission disclosure. This result supports the first hypothesis (H1) but in a negative direction. The increase in carbon emission disclosure highlights the level of social

responsibility companies face, which may lead to lower market perceptions of their performance. This is due to the rising costs companies must incur to manage and reduce carbon emissions, which are raising investor concerns about budget overruns. The market assesses that the costs of addressing global warming can exceed the economic benefits companies derive, especially when carbon emissions disclosure is higher than the previous year. In addition, in general, the market tends to react negatively to Bad News, such as high emissions from companies and climate change issues, as this information can damage the company's image and ultimately lead to declining stock prices (Hsu & Wang, 2013; Putri & Serly, 2024; Sicard et al., 2023). In this situation, energy companies will experience market challenges as clear information about carbon emissions reveals business risks to investors. From an operational viewpoint, businesses might postpone growth or new investments due to rising costs associated with environmental regulations and unclear regulations. Additionally, this situation may lead energy companies to prioritise short-term financial security while slowly adapting their strategies to stay competitive in response to sustainability needs.

Regarding the connections between business value and carbon emission disclosure, eco-efficiency, and green innovation, prior research has produced conflicting results. Given the energy sector's large emissions and serious environmental problems, this topic is especially pertinent.

For corporate leaders, the negative market reaction to carbon emissions disclosures underscores the importance of combining reporting with concrete mitigation efforts and clear communication. Sharing emissions data should go hand in hand with long-term transition plans and new initiatives, so investors see these disclosures as part of building value, not just extra costs. For regulators, these results highlight the need to improve the disclosure framework by making information clearer, more comparable, and more relevant, and by offering incentives to cut emissions and encourage green innovation. For investors, the findings suggest that disclosing emissions alone is not enough to reflect a company's true value. Investment decisions should also consider how well a company manages environmental risks and translates its commitments into long-term financial results.

These findings are consistent with previous research put forward by (Pradnyawati & Werastuti, 2024), Holly et al., (2025), Darmawan & Firmansyah, (2025), Nona & Putikadea, (2025), Muhammad & Aryani, (2021), Shafira, (2024), and Susilawati et al., (2025), who found out that disclosing a company's carbon emissions had a negative impact on its worth. But it contradicts what Noor & Ginting, (2022), Putri & Paramita, (2025), and Ramdani & Nugraha, (2024) found. Disclosure of carbon emissions, it argues, boosts a company's value.

The Effect of Eco-Efficiency on Firm Value

According to the study's results, Eco-efficiency has no impact on the value of energy firms as measured by Tobin's Q from 2020 to 2024. So, we may say that hypothesis 2 (H2) is false. Investors have not reaped any benefits from owning ISO 14001 certification, which is an indication of Eco-efficiency, due to the little impact of Eco-efficiency on the firm's worth. Instead of seeing ISO 14001 certification as a competitive advantage, investors often see it as a conventional duty. Silaban

& Dewi, (2023), Nashrulloh & Achyani, (2024), and Yuliandhari et al. (2023) have all reached similar conclusions. Their research indicates that environmental friendliness does not significantly impact the value of the company. Wasyiah et al., (2025), Dianti & Puspitasari, (2024), and Fanda & Dwijayanti (2024) found that eco-efficiency positively affected the firm's worth, therefore this doesn't add up.

The Influence of Green Innovation on Firm Value

Partial test results, which demonstrate that green innovation increases a firm's worth, support the third hypothesis (H3). The results suggest that when companies increase their green innovation efforts, their value increases. By implementing green innovation, businesses promote sustainability in their operations, give value to stakeholders, and adhere to social standards. By using more ecologically friendly technology and procedures that meet the needs of the stakeholders, green innovation also helps to lower the amount of pollutants produced throughout the production process. Additionally, Companies may increase their value through green innovation, which encourages them to turn industrial waste into sellable products. Investors are becoming more confident in a company's commitment to social and environmental responsibility, and the many benefits that come with green innovation could attract capital (Agustia et al., 2019; Damas et al., 2021; Husnaini & Tjahjadi, 2021; Mardawaningati & Handayani, 2025). Green innovation's positive benefits on energy companies' value imply that these businesses are more adaptable throughout the energy transition, use resources more efficiently, and are better equipped to handle new laws. Energy companies with a focus on clean technology, renewable energy, or emission-reducing procedures are thought to have more room for expansion and fewer long-term hazards. This demonstrates that green innovation is seen as a way to obtain a competitive advantage in addition to a strategy to address environmental problems.

For corporate management, these results highlight the need to invest in research and development, adopt clean technologies, and support innovation to boost long-term competitiveness and build investor trust. For regulators, the findings underscore the importance of creating policies, fiscal incentives, and rules that motivate companies to pursue green innovation and accelerate the shift to a low-carbon energy system. For investors, the results show that companies with strong innovation and active environmental strategies are more likely to grow over time and face less risk, underscoring the importance an green innovation in investment decisions.

These findings corroborate those of previous research showing that Green Innovation increases a company's worth (Dai & Xue, 2022; Oriska & Kusumawardani, 2024; Yuniarti et al., 2022; Zhang et al., 2020). Despite this, studies cited by Ramadhan et al., (2023) and Meilani & Sukmawati, (2023) indicate that Green Innovation does not impact the firm's value.

The Simultaneous Effect of Carbon Emission Disclosure, Eco-efficiency, and Green Innovation on Firm Value

Controlling for other factors not included in the model, the adjusted R-squared value of 0.1371 indicates that green innovation, eco-efficiency, and carbon emission disclosure jointly explain approximately 13.71% of the variation in firm value (Tobin's Q). Table 10 displays the test findings, which reveal an F-statistical value of 5.183230 and a Prob value (F-statistic) of 0.002598 < 0.05. That being the case, we adopt the fourth hypothesis (H4), which states that the value of the business is affected by eco-efficiency, green innovation, and disclosure of carbon emissions alike.

CONCLUSION

According to the study, disclosure of carbon emissions has a negative impact on a company's value, suggesting that the market still views emissions transparency as a higher risk and possible financial burden for energy businesses. Environmental efficiency initiatives have not been seen as a strategic element that can increase market value, as evidenced by the fact that eco-efficiency has no discernible impact on business value. However, businesses in the energy industry benefit from green innovation as it shows that they can adjust to the energy transition, boost their competitiveness, and provide long-term growth opportunities. It also demonstrates how the value of the company is impacted by these three elements taken together.

Overall, the study shows that the market does not always respond to a company's sustainability practices in the same way. Investors value green innovation the most, while carbon emissions disclosure and environmental efficiency are still struggling to create short-term economic value for energy companies in Indonesia.

This study is subject to several limitations. The sample size is relatively small, consisting of 16 energy firms, and the observation period is limited to 2020–2024, which may affect the generalizability of the findings. In addition, sustainability variables are measured using index-based indicators that may not fully capture implementation quality. Future research is encouraged to expand the sample size and time horizon, include other industry sectors or cross-country analysis, and incorporate additional variables such as corporate governance, regulatory pressure, or investor ESG awareness to further strengthen the robustness and explanatory power of the results.

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