ESG Practices and CO_2 Emissions Intensity in Malaysia's Listed Energy Firms: Evidence from Firm-Level Panel Data

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ABSTRACT

This study investigates whether Environmental, Social, and Governance (ESG) practices are associated with firm-level decarbonization performance. The study focuses on Carbon Dioxide (CO_2) emissions intensity in Malaysia's energy industry, consistent with Sustainable Development Goal (SDG) 13: Climate Action. Firm-level evidence on emissions efficiency in Malaysia's energy sector remains limited. Despite growing ESG-carbon literature, firm-level evidence on emissions efficiency in the Malaysian energy sector remains limited. Most studies focus on ESG-financial performance or reporting quality rather than on CO_2 emissions intensity, and often use aggregate ESG scores rather than separate ESG dimensions. ESG performance is estimated using Refinitiv ESG Scores, and decarbonization performance is measured by the intensity of Scope 1 and 2 CO_2 emissions, using panel data on energy firms listed on Bursa Malaysia Public-Listed Companies (PLCs) over the period 2018-2024. Pooled Ordinary Least Squares (OLS) regression results, estimated using SPSS and controlling for subsector and firm-year effects, reveal a negative association between overall ESG practices and CO_2 emissions intensity. Among the ESG dimensions, the environmental pillar demonstrates the most consistent relationship with emissions intensity. The study contributes industry-specific evidence from Malaysia's energy sector and identifies the ESG dimension most closely associated with emissions efficiency, offering practical implications for stakeholders pursuing decarbonization through ESG integration.

Keywords-ESG practices; sustainable development goals; energy transition; renewable energy; CO_2 emissions intensity; decarbonization performance; Malaysia's energy industry

I. INTRODUCTION

Globally, energy systems are undergoing profound changes as either developed or developing countries strive to achieve Net Zero Carbon Emissions (NZCE) by 2050 and aim to limit the rise in global temperatures to 1.5 °C [1]. Malaysia's National Energy Transition Roadmap (NETR) sets renewable energy targets of 31% by 2025, 40% by 2035, and 70% by 2050, supported by initiatives in energy efficiency, hydrogen, bioenergy, green mobility, and carbon capture technologies. These efforts aim to deliver a sustainable, inclusive, and economically viable transition [2, 3].

On the other hand, the energy industry remains the largest contributor to Greenhouse Gas (GHG) emissions since 2019, accounting for 78% of total emissions. In line with SDG 7 of the 2030 Agenda, Malaysia's energy industry is expected to expand access to affordable, reliable, and sustainable energy. Moreover, Malaysia's energy industry supports inclusive economic growth and decent work while advancing climate action, aligning with the United Nations SDGs (UNSDGs) 8 and 13. This transition is essential, especially for Malaysia's energy industry to meet international obligations under the Paris Agreement and the UNSDGs [2, 4-14].

To improve transparency and comparability in the sustainable energy transition and the SDG agenda, Bursa

Malaysia has strengthened sustainability reporting requirements for PLCs. The updated framework aligns with IFRS S1 and S2 Sustainability Disclosure Standards (SDS) under the National Sustainability Reporting Framework (NSRF). Under the enhanced listing requirements, all PLCs are now required to disclose Environmental, Social, and Governance (ESG) information in their annual sustainability statements [15, 16]. Hence, Malaysia's energy industry, through these developments, is an ideal setting for examining whether stronger ESG practices can drive measurable developments in decarbonization performance.

Despite these policy advances, Malaysia continues to face significant challenges in decarbonization. CO_2 emissions and carbon intensity remain high in this country compared to other upper-middle-income economies. Malaysia reported 252.2 million tons of CO_2 emissions in 2023, representing a 119% increase since 2000 and accounting for 0.7% of global CO_2 emissions. The country is also among the region's higher emitters, with per capita emissions of 7.1 tons in 2022. In parallel, Malaysia's energy mix remains heavily fossil-fuel-dependent, with coal accounting for 37%, oil for 32%, and natural gas for 31% of total emissions [17]. By sector, electricity has been the largest source over the past two decades, with an average per capita consumption of 4.963 MWh in 2021. Consequently, electricity production in the energy industry is reported to be the largest contributor to GHG emissions in this country [18]. At the same time, although renewable energy declined by 1%, it is expected to rebound sharply in 2025 and, on average, increase by 10% over 2025-2027. Solar Photovoltaic (PV) growth is expected to continue at a rapid pace, with an annual average rate just above 20% through 2027, and to constitute 4% of the energy mix, which marks a significant improvement over the past decade. This momentum is commonly attributed to climate-mitigation policies and renewable energy programs, including Feed-in Tariffs (FiT), Large-Scale Solar (LSS) initiatives, and Net Energy Metering (NEM) schemes [18, 19]. In alignment with the National Energy Policy (NEP) 2022-2040, Malaysia is therefore expected to accelerate structural transformation by shifting away from fossil-based production and consumption toward renewable energy. Consistent with this policy direction, the government has set a target of achieving 31% renewable energy capacity by 2025 [4, 20].

Decarbonization progress remains constrained by the economy's structural dependence on fossil fuels. By 2019, Malaysia's GHG intensity relative to Gross Domestic Product (GDP) had declined by 35.90% compared to 2005 levels. The country has established an unconditional target to reduce carbon intensity by 45% relative to 2005 GDP levels by 2030. However, the energy transition is complicated by the macroeconomic role of fossil fuels, which account for roughly 20% of GDP and 40% of government revenue, thereby creating political-economic incentives that can slow the diffusion of ESG-oriented practices. Moreover, fragmented stakeholder efforts, including among PLCs, regulatory gaps, and limited renewable energy investment, continue to impede transition progress [1, 4, 5, 21-28]. These conditions underscore Malaysia's continued reliance on carbon-intensive energy sources and the upward pressure on emissions.

This study employs stakeholder theory to develop a conceptual framework for measuring the relationship between ESG Practices and CO_2 emissions intensity. Stakeholder theory applies to both large and small firms and recognizes that organizations are influenced by and affect multiple stakeholder groups. It guides corporate strategy and operations beyond shareholders to include employees, customers, suppliers, financiers, communities, and regulators. From this perspective, to address stakeholder expectations and to maintain supportive stakeholder relationships over time, responsible environmental conduct is an outcome of managerial efforts [29-32].

On the other hand, in the context of sustainability and climate concerns, stakeholder expectations increasingly emphasize accountability for environmental impacts, including GHG emissions. The policies and actions of firms that adopt ESG practices may focus on environmental stewardship, social responsibility, and corporate governance, thereby aligning corporate conduct with stakeholder priorities [33]. Under stakeholder theory, ESG practices are expected to influence CO_2 emissions intensity through stakeholder-driven mechanisms. Stakeholder theory suggests two main channels through which ESG practices affect emissions. First, pressure from regulators, customers, and communities encourages firms to strengthen environmental management practices such as energy efficiency and emissions monitoring. Second, support from investors, suppliers, and partners provides resources for low-carbon initiatives. Together, these mechanisms improve operations and reduce CO_2 emissions intensity [33-36]. Hence, based on stakeholder theory, ESG practices can encourage stakeholders to support the SDGs and, internally, motivate firms to pursue a sustainable energy transition to achieve decarbonization performance.

Furthermore, ESG practices are expected to improve emissions outcomes by strengthening governance routines such as monitoring, accountability, and environmental management systems. These mechanisms align with ESG scoring frameworks, which capture disclosure, policies, and performance across environmental governance. Together, they support reductions in CO_2 emissions, including Scope 1 and 2 emissions [37]. On top of that, the environmental pillar of ESG directly addresses climate-related challenges by encouraging firms to adopt measures that mitigate pollution, manage resources efficiently, and reduce GHG emissions [38]. These actions support national and global CO_2 reduction targets, which are key indicators of decarbonization performance. In addition, the social and governance dimensions complement environmental efforts by promoting fair labor practices, community engagement, and ethical decision-making. They enhance corporate reputation and attract investment to support the energy transition and sustainable development goals [39, 40].

While previous data on ESG criteria and their carbon emissions impacts are increasing, most empirical studies remain focused on large markets or multi-country firms [36, 41, 42]. Existing data on ESG criteria and carbon come primarily from panels of large markets, which limits industry-specific data at the energy firm level, where transition policies and levels of maturity in information disclosure differ.

Furthermore, many studies focus on ESG-financial performance or ESG reporting quality rather than on Scope 1 and 2 CO_2 emissions intensity as an operational measure of decarbonization performance [41-45]. Existing research on decarbonization performance often relies on single-pillar ESG scores that treat ESG dimensions separately. However, these studies rarely test the direct link between ESG practices and emissions efficiency [46-49]. Mixed results in the literature persist because ESG is often treated as a single composite score or separated into individual pillars when explaining carbon emissions efficiency. This study addresses these gaps by analyzing Malaysian energy firms listed on Bursa Malaysia from 2018 to 2024. It examines how overall ESG performance and its individual pillars relate to Scope 1 and 2 CO_2 emissions intensity using Refinitiv data.

To meet the objectives of the NETR, Malaysia's energy sector will likely require stronger shifts toward renewable energy, efficiency gains, and deeper ESG integration into corporate strategy and governance. Firms are under increasing pressure to reduce emissions while maintaining energy security and competitiveness, highlighting the importance of firm-level actions in achieving national transition outcomes. ESG integration has emerged as a key response to stakeholder demands and sustainability governance challenges [50]. However, evidence remains mixed, as improvements in ESG ratings do not always translate into lower carbon emissions. Overall, firm-level evidence on ESG and emissions efficiency in Malaysian listed energy firms remains limited, warranting further investigation.

Specifically, this paper aims to examine the direct relationship between ESG practices and CO_2 emissions intensity (Scope 1 and 2) among Malaysia's Public Listed Energy Firms during 2018 to 2024. On the other hand, it aims to capture decarbonization performance since it is important to operationalize CO_2 emissions intensity to achieve a sustainable, energy-intensive industry transition [51]. Therefore, to address the gaps, the present paper hypothesized that ESG practices are negatively associated with CO_2 emissionσ intensity among Malaysia's publicly listed energy firms. The hypotheses are:

- H1: ESG practices have a positive impact on decarbonization performance, thereby reducing CO_2 emissions intensity.
- H1a: The environmental pillar has a negative impact on CO_2 emissions intensity.
- H1b: The social pillar has a negative impact on CO_2 emissions intensity.
- H1c: Governance pillar has a negative impact on CO_2 emissions intensity.

Despite growing sustainability reporting, firm-level evidence linking ESG to CO_2 emissions intensity in Malaysia's energy sector remains limited, especially for Scope 1 and 2 emissions. The current study addresses this gap by using Malaysian listed energy firms in an emerging-market context, focusing on emissions efficiency rather than disclosure or financial outcomes. It also decomposes ESG into ESG pillars to identify which dimensions are most strongly associated with emissions performance.

II. METHODOLOGY

This study employs a quantitative method, using a longitudinal panel model to examine changes across multiple firms over seven years. Consistent with positivist and objectivist paradigms, this research emphasizes the objective collection and analysis of numerical data to identify observable patterns and relationships. The sample is constructed using purposive, non-probability sampling, in which firms are selected based on their relevance to the Malaysian energy industry and the availability of the required data.

The empirical setting is Malaysia's energy industry, specifically the collection of data from PLCs in Bursa Malaysia. This study focuses only on 32 Malaysian energy firms listed on Bursa Malaysia, with ESG scores spanning 7 years from 2018 to 2024. The target population in this study comprises various energy firms, including core businesses in conventional fossil fuels (coal, oil, and natural gas); renewables (solar, wind, hydro, and bioenergy); and a mix of fossil fuel and renewable or clean energy firms. The firms are scattered across three categories: Conventional Energy (CON_E), Renewable Energy (RE), and Mixed Energy (MIX_E). All three categories of energy firms will be segregated based on the Malaysia Standard Industrial Classification (MSIC) 2008, Refinitiv DataStream, and the Bursa Malaysia Sector Classification, which reflect their core business, as presented in Table I [52].

Over the seven years from 2018 to 2024, this study collected data from the Refinitiv Workplace. This study covers only the period 2018-2024 to ensure consistent ESG disclosure availability and comparability among Malaysian-listed energy firms, following the completion of Bursa Malaysia's phased introduction of sustainability statement requirements and the ESG index by 2015. Since Bursa Malaysia has implemented mandatory ESG reporting by 2023, the end year 2024 is selected as the latest year with complete observation across the study variables, and to avoid conflating results with the implementation of Malaysia's National Sustainability Reporting Framework, which was issued on 24 September 2024 and began phased adoption for reporting periods starting from 2025 [53-58]. Therefore, the study, which used 32 Malaysian listed energy firms spanning 7 years (2018-2024) and yielding 224 firm-year observations, was restricted by data availability prior to this period. However, after filtering for missing ESG data and CO_2 emissions intensity data, the final sample consists of only 158 firm-year observations, as shown in Table IV.

Besides, Refinitiv DataStream offers one of the most comprehensive ESG databases and has been recently used to conduct studies on similar topics [38, 59-61]. Refinitiv also provides data on GHG emissions, with a focus on CO_2 emissionσ intensity (Scope 1 and Scope 2). Therefore, the baseline models are constructed as follows, starting with model 1 regarding the overall ESG, as presented in:

$$CO_{2_{it}} = \beta_0 + \beta_1 ESG_{it} + \varepsilon_{it} \quad (1)$$

Model 1 represents the direct relationship between ESG and CO_2 emissions intensity. Specifically, CO_{2it} denotes the CO_2 emissions intensity of the firm i in year t, measured as the firm's Scope 1 and 2 emissions intensity indicator in the dataset. The highest values indicate greater emissions intensity among the firms. ESG_{it} is the overall Refinitiv ESG score of the firm i in year t, measured on a 0-100 scale, where higher scores reflect stronger ESG performance, as presented in (1). In Model 1, β_1 represents the average change in CO_2 emissions intensity with a one-unit increase in the overall ESG score of firm i in year t. Thus, a negative value of β_1 indicates that better ESG performance is associated with lower CO_2 emissions intensity, whereas a positive value indicates the opposite. The intercept β_0 represents the expected CO_2 emissions intensity when the ESG score is zero or at the relevant baseline level, depending on the scale used for ESG. Ultimately, the error term ε_{it} incorporates all other firms and year-related factors that influence CO_2 emissions intensity and are not included in the model.

The second model (Model 2) examines the ESG pillars, where Model 2a represents the environmental pillar, Model 2b the social pillar, and Model 2c the governance pillar, corresponding to:

$$CO_{2it} = \beta_0 + \beta_1 ENG_{it} + \varepsilon_{it} \quad (2)$$

$$CO_{2it} = \beta_0 + \beta_1 SOC_{it} + \varepsilon_{it} \quad (3)$$

$$CO_{2it} = \beta_0 + \beta_1 GOV_{it} + \varepsilon_{it} \quad (4)$$

Model 2 represents the direct relationships between Environmental (ENV), Social (SOC), and Governance (GOV) performance and CO_2 emissions intensity (CO2_Intensity). Each ESG's pillar score is measured on a 0-100 scale. These three pillars are analyzed separately in Model 2 to identify which ESG dimension is more strongly associated with CO_2 emissions intensity, as shown by (2), (3), and (4). This Model estimates separate bivariate specifications linking CO_2 emissions intensity to each ESG pillar individually. β_1 represents the average change in emissions intensity associated with a one-unit increase in the ENV (Model 2a), SOC (Model 2b), or GOV (Model 2c) pillars. A negative β_1 indicates that better performance for each pillar is associated with lower emissions intensity, while a positive β_1 indicates higher emissions intensity. The intercept β_0 represents the predicted emissions intensity for a pillar score of zero. The error term (ε_{it}) captures other firm-year influences on CO_2 emissions intensity that are not explained by the single included pillar in the model.

The third model (Model 3) refers to the overall ESG with control variables. Model 3a represents the overall ESG and subsector pillar, Model 3b the overall ESG, subsector pillar, and year EE, corresponding to:

$$CO2_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 RE_i + \beta_3 Mix\_E_i + \varepsilon_{it} \quad (5)$$

$$CO2_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 RE_i + \beta_3 Mix\_E_i + \sum_{t=2019}^{2024} \lambda_t Year_t + \varepsilon_{it} \quad (6)$$

Finally, Model 3 represents the direct relationship between ESG practices and CO_2 emissions intensity, controlling for subsector and year fixed effects. To account for systematic differences in CO_2 emissions intensity across energy business models, in this study, initially, the subsector is controlled using two dummy variables.

- RE_i is a RE_dummy variable, which assumes that equals 1 if the firm is in the RE, 0 otherwise.
- Mix_E_i is a MIX_E dummy variable, which assumes 1 if the firm is in the Mixed Energy subsector, 0 otherwise. Meanwhile, CON_E firms serve as the reference group.

TABLE I. SUMMARY OF SAMPLE COMPOSITION OF ENERGY FIRMS

Category (Subsector)	Bursa Malaysia Sector Classification	Industry/Sector Group	No. of Firms
CON_E	Consumer Products & Services	Oil & Gas Refining and Marketing	1
	Energy	Oil & Gas Related Equipment and Services	8
		Oil, Gas & Consumable Fuels	1
		Oil & Gas Refining and Marketing	2
		Machinery, Tools, Heavy Vehicles, Trains & Ships	2
	Industrial Products & Services	Chemicals	1
	Utilities	Natural Gas Utilities	1
		Multiline Utilities	2
		Water & Related Utilities	1
RE	Energy	Electric Utilities & Solar (IPPs)	1
		Construction & Engineering	1
	Transportation & Logistics	Transportation Infrastructure	1
	Utilities	Electric Utilities & Solar (IPPs)	1
		Water & Related Utilities	1
MIX_E	Energy	Oil & Gas Related Equipment and Services	5
	Transportation & Logistics	Transport Infrastructure	1
	Utilities	Electric Utilities & Solar (IPPs)	2
Total Firms			32

Additionally, to control time-specific shocks that affect all firms, such as policy changes and macroeconomic shifts, the model includes year dummy variables for 2019-2024, with 2018 being the reference year, as presented in (6). Under

Model 3, β_1 can be interpreted as the expected change in emissions intensity associated with a one-unit increase in ESG, within the same sub-sector and year. The subsector coefficients are interpreted relative to the omitted reference group. Thus, β_2 represents the conditional mean difference in emissions intensity between firms in the renewable energy sector and those in the conventional sector, and β_3 represents the conditional mean difference between those in the mixed energy sector and those in the conventional sector, holding ESG and annual effect constant. The annual effect λ absorbs macroeconomic and policy changes that affect all firms in a given year, thereby helping to isolate inter-firm variations in ESG and subsector type from economy-wide fluctuations. Ultimately, ε_{it} captures firm-year shocks not explained by the included variables. Moreover, all models are estimated using pooled OLS regression and analyzed in IBM SPSS Statistics v. 31, with statistical inference based on conventional model-based standard errors. Given the unbalanced firm-year panel, the results are interpreted with appropriate caution because conventional OLS standard errors may be sensitive to heteroskedasticity and within-firm error dependence.

III. RESULTS AND DISCUSSION

A. Descriptive Statistics

The data collection yields a panel dataset comprising 32 companies and 224 firm-level observations (32 × 7 years). Table II displays the distribution of companies across conventional, renewable, and mixed energy subsectors. Nineteen of them are under CON_E, eight are under MIX_E, and five are under RE.

Table II reports the subsector composition of the 32 sampled firms. Conventional energy (CON_E) firms constitute the majority of the sample (n = 19; 59.4%), followed by mixed energy (MIX_E) firms (n = 8; 25.0%) and renewable energy (RE) firms (n = 5; 15.6%), with a cumulative share of 84.4% concentrated in fossil-fuel-based and hybrid business models. This distribution is consistent with the structural composition of Malaysia's energy industry, which remains predominantly fossil-fuel-intensive, and substantiates the inclusion of subsector controls in the subsequent regression specifications to mitigate potential confounding arising from heterogeneity in firms' core business models. The sector's classification under Bursa Malaysia, to which the companies belong, is illustrated in Table III.

TABLE II. SUBSECTORS OF THE FIRMS

Subsector	Frequency	Percent	Cumulative percent
CON_E	19	59.4	59.4
MIX_E	8	25.0	84.4
RE	5	15.6	100.0
Total	32	100.0	

TABLE III. BURSA MALAYSIA SECTOR'S CLASSIFICATION OF THE FIRMS

Sector Classification	Frequency	Percent	Cumulative Percentage
Consumer Products & Services	1	3.1	3.1
Energy	20	62.5	65.6
Industrial Products & Services	1	3.1	68.7
Transportation & Logistics	2	6.3	75
Utilities	8	25.0	100.0
Total	32	100.0	

Due to ESG disclosure, both the composite score and its component dimensions (ENV, SOC, GOV) are incomplete for some firm-years, and CO_2 emissions intensity is not consistently available across observations, resulting in an unbalanced panel. To ensure comparability across specifications and to avoid shifts in sample composition across models, the study adopts a complete-case strategy. Correlation and OLS regression analyses are therefore estimated using only firm-year observations with non-missing values for ESG, ENV, SOC, GOV, and CO_2_Intensity, yielding a final sample of 158 firm-year observations. Table IV reports year-by-year coverage. All models are estimated in SPSS using OLS, with statistical inference based on conventional standard errors.

TABLE IV. DATA COVERAGE BY YEAR

	Year	Total_firmYears	Total_ESGCO2	Total_ENVCO2	Total_SOCCO2	Total_GOVCO2
1	2018	32	12	12	12	12
2	2019	32	12	12	12	12
3	2020	32	12	12	12	12
4	2021	32	30	30	30	30
5	2022	32	31	31	31	31
6	2023	32	30	30	30	30
7	2024	32	31	31	31	31
Missing (N)	0	0	66	66	66	66
Valid (N)	7	224	158	158	158	158

B. Independent Variables

The independent variable concerns ESG practices, specifically the ESG scores of Malaysian publicly listed energy firms. The ESG scores reflect a company's overall performance in ENV, SOC, and GOV sustainability practices. It captures the organization's stance on human rights, the integration of sustainability into core operations, efforts to reduce emissions, and initiatives to protect the environment. The indicator integrates qualitative and quantitative data on water and energy consumption, CO_2 emissions, human rights compliance, and workplace equity [59]. The detailed explanation of ESG dimensions is listed below:

- The ENV score measures the extent to which emissions produced by a company contribute to air pollution. A higher score indicates lower emissions, demonstrating better ENV performance.

- The SOC score evaluates the company's human resources initiatives aimed at enhancing employee welfare and improving Human Resources (HR) management practices.
- The GOV score reflects the organization's commitment to corporate SOC responsibility principles, particularly in managing SOC and ethical issues effectively.

For the ESG scores, Refinitiv Database uses 12 grades to assess companies' ESG performance. The score is between D- and A+ (0 to 100), with the first quartile from D- to D+ (0 to <25) representing 1 to 3 grades, indicating poor relative ESG performance. The second quartile from C- to C+ (25 to <50) represents 4 to 6 grades, indicating satisfactory relative ESG performance. The third quartile from B- to B+ (50 to <75) represents 7 to 9 grades, indicating good relative ESG performance, and the last quartile from A- to A+ (75 to 100) represents 10 to 12 grades, indicating excellent relative ESG performance [38, 59, 62]. Based on past empirical studies, therefore, this work only used grades 1 - 4, with 4 corresponding to the highest grade (A) (75-100), whereas 1 corresponds to the lowest grade (D) (0-<25) [59, 63]. The descriptive statistics of the independent variables are outlined in Table V.

TABLE V. DESCRIPTIVE STATISTICS OF THE INDEPENDENT VARIABLES

ESG Practices & Each Dimension	ESG Grade	Minimum	Maximum	Mean	Std. Deviation	N
ESG Score	A (75-100)	75.00	85.48	78.71	4.11	16
	B (50-<75)	50.25	74.87	61.99	7.16	70
	C (25-<50)	26.76	49.87	41.29	6.24	66
	D (0-<25)	11.34	23.76	17.81	6.00	6
Total						158
ENV Score	A (75-100)	75.36	85.50	80.16	3.60	10
	B (50-<75)	50.15	74.85	60.62	6.49	68
	C (25-<50)	25.40	49.54	39.53	7.30	56
	D (0-<25)	1.34	23.99	13.28	6.88	24
Total						158
SOC Score	A (75-100)	75.99	92.38	83.82	4.42	31
	B (50-<75)	50.14	74.59	61.94	7.36	71
	C (25-<50)	26.13	49.86	39.03	7.12	50
	D (0-<25)	11.34	24.42	17.55	5.71	6
Total						158
GOV Score	A (75-100)	75.20	94.93	81.12	5.63	38
	B (50-<75)	50.84	74.84	63.87	6.36	57
	C (25-<50)	26.00	49.51	38.35	7.14	46
	D (0-<25)	10.34	23.87	17.91	4.14	17
Total						158

Table V presents descriptive statistics for ESG performance and each dimension of ESG across four ESG grades (range 1-4), where range 4 corresponds to Grade A (75-100) and represents excellent performance, while range 1 corresponds to Grade D (0-<25) and represents poor ESG performance. The results confirm that the grading procedure is internally consistent, as the minimum and maximum ESG scores within each grade fall within the defined thresholds. Mean ESG scores increase monotonically across grades, with Grade A representing the highest average ESG scores (Mean = 78.71; SD = 4.11), followed by Grade B (Mean = 61.99; SD = 7.16), Grade C (Mean = 41.29; SD = 6.24), and Grade D (Mean = 17.81; SD = 6.00). The relatively lower dispersion in Grade A (N = 16) suggests more consistent ESG performance among top-rated firm-year observations. In comparison, higher dispersion in the mid-grade categories (B and C) represents 70 and 66 firm-year observations, respectively, indicating greater heterogeneity among firms with moderate ESG performance. These descriptive findings provide a validated foundation for subsequent correlation and regression analyses examining whether ESG performance, including each ESG's dimensions, is associated with CO_2 emissions intensity outcomes.

C. Dependent Variable

Using Refinitiv DataStream, this study employs CO_2 emissions intensity to capture decarbonization performance while controlling for firm-level characteristics (sub-sector) and time effects. This is important in the energy industry, where ESG practices can affect CO_2 emissions, as energy firms vary greatly in size and output. Based on Refinitiv DataStream, CO_2 emissions intensity is calculated by dividing a company's CO_2 emissions for a given year by its total revenue for that year. CO_2 emissions intensity was calculated using Scope 1 and Scope 2 emissions, aligned with the standard GHG emissions protocol accounting boundaries. Scope 1 refers to direct emissions from production processes by the firm, such as combustion, while Scope 2 refers to indirect emissions caused by the firm's energy consumption, including electricity, heat, cooling, and steam [37]. CO_2 emissions intensity is a key metric for evaluating decarbonization performance among selected companies in Malaysia's energy industry.

Table VI provides descriptive statistics for the dependent and control variables based on the analysis sample. The dependent variable, CO_2 Emissions Intensity, shows a mean of 1551.02 (SD = 2971.31), indicating substantial variation in emissions intensity across firm-year observations. Subsector composition is captured using dummy variables for RE and MIX_E, with CON_E being the reference category. The means of RE_dummy (0.14) and MIX_E_dummy (0.25) indicate that approximately 14% and 25% of the sample observations fall into these subsectors, respectively. Additionally, year fixed effects are represented by annual dummy variables (Y2019-

Y2024), where 2018 is the reference year. The mean of each year dummy variable reflects the proportion of observations in this year, suggesting an unbalanced distribution across time within the usable sample.

TABLE VI. DESCRIPTIVE STATISTICS OF THE DEPENDENT AND CONTROL VARIABLES

Variables	Minimum	Maximum	Mean	Std. Deviation
Dependent Variable				
CO2_Intensity	2.48	20611.81	1551.02	2971.31
Control Variable: Sub-sector				
RE_dummy	0	1	0.14	0.347
MIX_E_dummy	0	1	0.25	0.433
Control Variable: Year Fixed Effects				
Y2019	0	1	0.08	0.266
Y2020	0	1	0.08	0.266
Y2021	0	1	0.19	0.393
Y2022	0	1	0.20	0.398
Y2023	0	1	0.19	0.393
Y2024	0	1	0.20	0.398

D. Correlation

Table VII shows the Pearson's correlation matrix for the variables used in this study. CO_2 intensity is negatively correlated with ESG score (r=-0.154) and its dimensions: ENV score (r=-0.191), SOC score (r=-0.094), and GOV score (r=-0.050), respectively, indicating that higher ESG performance and its dimensions (ENV, SOC, GOV) are associated with lower CO_2 intensity at the bivariate level. However, this relationship appears weak and is not statistically significant, as indicated by the absence of a significance marker. The ESG score is strongly and positively correlated with each pillar: ENV score (r=0.826***, p<0.001), SOC score (r=0.843***, p<0.001), and GOV score (r=0.657***, p<0.001), indicating that firms with higher overall ESG performance tend to score higher across the ESG dimensions. Pillar intercorrelations are also positive and significant, and ENV-GOV (r=0.299***, p <0.001)), showing that ESG dimensions tend to move together. For the subsector controls, correlations between CO_2 intensity and RE_dummy (r= -0.107*)* and MIX_E_dummy *(*r = 0.083) are small and not significant. However, RE_dummy is negatively correlated with MIX_E_dummy (r=-0.230***,* p< 0.01*),* as expected, because firms generally belong to one subsector rather than both.

TABLE VII. PEARSON'S CORRELATION MATRIX

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CO2_Intensity (1)	1						
ESG score (2)	-0.154	1					
ENV score (3)	-0.191	0.826***	1				
SOC score (4)	-0.094	0.843***	0.562***	1			
GOV score (5)	-0.050	0.657***	0.299***	0.384***	1		
RE_dummy (6)	-0.107	0.034	-0.019	-0.032	0.128	1	
MIX_E_dummy (7)	0.083	-0.036	-0.100	0.005	0.011	-0.230**	1

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
*** Correlation is significant at the 0.001 level (2-tailed)

Overall, the correlation results provide preliminary directional evidence with a negative correlation sign (r), consistent with the expectation that stronger ESG practices, particularly ENV performance, may relate to lower CO_2 emissions intensity. Nevertheless, the lack of statistical significance suggests that bivariate associations are weak and may be influenced by subsector composition and time effects. Additionally, the high correlation among ESG's pillars indicates potential overlap or multicollinearity. Hence, the effects of ESG and its pillars are best examined in separate regression models and are confirmed under a controlled specification that includes subsector controls and year dummies.

E. Regression

Table VIII presents the OLS regressions from SPSS for the baseline specification (Model 1) and the controlled specifications (Model 3a-3b) examining the association between ESG practices and CO_2 emissions intensity (Scope 1 and 2). Across all models, the estimated ESG coefficient is consistently negative, indicating that stronger ESG performance is associated with lower CO_2 intensity.

In the parsimonious baseline model, ESG is negatively related to CO_2 intensity, although the effect is not statistically significant at conventional levels (β =-28.93, p *>0.05*). Introducing subsector controls in Model 3a does not materially alter the estimate. ESG coefficient remains negative and statistically insignificant (β =-27.97, p*>0.05*). In contrast, once year fixed effects are added alongside subsector controls under Model 3b, the ESG coefficient becomes statistically significant at the 5% level (β = -30.70, p < *0.05*). Substantively, this implies that a one-point increase in the ESG score is associated with an average decrease of approximately 30.7 units in CO_2 intensity, conditional on subsector affiliation and common year-specific effects. With respect to the control variables, the RE and ME sector indicators (relative to the reference category) are not statistically significant in Model 3a, and the year indicators (Y2019-Y2024) are likewise not statistically significant in Model 3b. Model fit remains modest, with R^2 increasing from 0.024 in Model 1 to 0.052 in Model 3b, consistent with firm-level ESG-emissions research, which has found that emissions intensity is shaped by a broader set of operational, technological, and contextual determinants beyond ESG scores alone.

Table IX presents the direct (uncontrolled) regression of CO_2 intensity on each ESG pillar under Models 2a-2c. This comparison pillar model provides insights into whether the ESG-CO_2_Intensity relationship is driven more by ENV, SOC, or GOV performance. The ENV score shows a negative, statistically significant association with CO_2 intensity (β=-28.85, p<0.05), indicating that stronger ENV performance is associated with lower CO_2 intensity in the bivariate pillar model. In contrast, the SOC (β =-14.77, $p>0.05$) and GOV (β =-6.95, p 0.05) pillars are negative but statistically insignificant, suggesting a weaker direct association with CO_2 intensity. Model fit is modest across the pillar models, with R^2 values of 0.037 for ENV, 0.009 for SOC, and 0.003 for GOV.

TABLE VIII. OLS REGRESSION H1 FOR MODELS 1 AND 3

Variables	Model 1		Model 3a		Model 3b	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
ESG	-28.93	14.88	-27.97	14.88	-30.70*	15.28
RE_Dummy			-759.02	695.45	-794.63	706.93
MIX_E_Dummy			390.81	558.42	398.22	565.60
Y2019					-24.88	1216.90
Y2020					-25.34	1219.39
Y2021					-420.87	1018.63
Y2022					11.23	1015.84
Y2023					730.56	1024.15
Y2024					114.84	1020.57
Constant	3094.69	827.62	3052.82	849.82	3121.81	1158.15
N	158		158		158	
R²	0.024		0.037		0.052	
Adj. R²	0.017		0.018		-0.006	

The conventional energy subsector is the reference group, the year 2018 is the reference year. Significance: *p<0.05, **p<0.01, ***p<0.001.

TABLE IX. OLS REGRESSION H1 FOR MODEL 2

Variables	Model 2a		Model 2b		Model 2c	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
ENV	-28.85*	11.85				
SOC			-14.77	12.48		
GOV					-6.95	11.06
Constant	2912.69	605.55	2397.59	753.08	1937.69	659.27
N	158		158		158	
R²	0.037		0.009		0.003	
Adj. R²	0.030		0.003		-0.004	

Significance: *p<0.05, **p<0.01, ***p<0.001

Taken together, the results suggest that the ENV pillar is significant in the direct pillar regression and most directly aligned with emissions intensity, which is conceptually consistent because CO_2 intensity is an explicit ENV outcome. In contrast, SOC and GOV are not, suggesting that SOC and GOV pillars may be less directly associated with emissions intensity in this sample (Table IX). Overall, ESG remains negatively signed across specifications and attains statistical significance only after accounting for subsector heterogeneity and year fixed effects (Table VIII). Consequently, this result indicates that ESG practices are associated with lower CO_2 intensity in the controlled specification.

IV. CONCLUSIONS

This study examined the relationship between Environmental, Social, and Governance (ESG) practices and CO_2 emissions intensity (Scope 1 and 2) using firm-year observations from publicly listed energy firms in Bursa Malaysia from 2018 to 2024. The regression results show a consistent negative relationship between ESG practices and CO_2 intensity, with the ESG effect becoming statistically significant after including subsector controls and year fixed effects, as presented in Table VIII. Additionally, regression results for all ESG dimensions indicate that the Environmental (ENV) pillar is the only one with a statistically significant direct association with CO_2 intensity, in contrast to the Social (SOC) and Governance (GOV) pillars (Table IX). Meanwhile, the overall explanatory power is modest across models, suggesting that additional operational and contextual factors beyond ESG influence CO_2 emissions intensity.

This study provides evidence, at the level of the Malaysian listed energy industry, that ESG performance, as measured by Refinitiv's overall ESG score and ESG pillar scores, is associated with Scope 1 and 2 CO_2 emissions intensity. By focusing on measurable emissions efficiency outcomes rather than disclosure or financial performance, the findings enrich ESG research in Malaysia and clarify which ESG dimension is most consistently linked to carbon-intensity performance in the energy industry.

This study has several limitations. First, while the grouped OLS specification includes subsector categories and binary year variables, it does not fully capture unobserved, time-invariant firm characteristics (e.g., asset age, operational efficiency, or management quality) that may influence both ESG scores and emissions intensity. Thus, estimates should be interpreted as associations rather than definitive causal effects. Second, the subsector control (conventional/renewable/mixed energy) is necessarily coarse and may not reflect heterogeneity within subsectors, such as energy mixed, facility technology, or firms' decarbonization strategies. Third, Refinitiv's ESG metrics are derived from firm-reported information and processed using a standardized methodology. Thus, variations in reporting practices and data availability may affect the measured ESG performance. Future research could use panel estimators (e.g., firm fixed effects or dynamic panel methods) and incorporate richer operational controls (e.g., capacity, energy mix, or technology indicators), as well as broader emissions coverage, including Scope 3 emissions where available, to strengthen causal inference and the generalizability of the results. Overall, this study highlights that ESG performance, particularly at the pillar level, has significant links with Scope 1 and 2 CO_2 emissions intensity in the Malaysian listed energy firms, providing sector-specific insights into emissions efficiency outcomes.

DECLARATION OF COMPETING INTERESTS

The authors declare that they have no competing interests in this study.

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DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI USE AND DECLARATION OF GENERATIVE AI USE

During the preparation of this work, the authors used Microsoft 365 Copilot in order to improve language and text readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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