ESG Dimensions and the Energy Transition in Indonesia

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ABSTRACT

Environmental, social, and governance (ESG) factors are critical determinants of a just and sustainable energy transition. This study employs the Autoregressive Distributed Lag (ARDL) approach to examine the impact of ESG performance on Indonesia's energy transition from 1996 to 2022. The findings reveal that in the short term, governance positively influences the transition, while environmental and social dimensions exhibit temporary negative effects. However, in the long run, all three ESG dimensions of environmental integrity, social development, and governance quality positively contribute to the shift toward clean energy. These results underscore the need for Indonesian policymakers to prioritize ESG integration in energy strategies to ensure a smooth, inclusive, and resilient energy future.

Keywords
Environmental, social, and governance (ESG); Energy transition; Indonesia; ARDL

Introduction

Indonesia, like many developing nations, is at a pivotal moment in aligning its energy development with global sustainability goals. At the 26th Conference of Parties (COP), the country pledged to combat climate change by setting emission reduction targets and achieving net-zero emissions by 2060 (IEA, 2022). This commitment arises amid a significant rise in carbon emissions over the past two decades, placing Indonesia's energy sector as the eighth largest emitter globally. To meet these targets, the nation must undergo a substantial transformation of its fossil-fuel-dependent energy sector. In recent years, Indonesia has made progress by reducing reliance on conventional biomass and increasing the availability of cleaner energy sources such as liquefied petroleum gas. Nonetheless, fossil fuels—particularly coal—still dominate the energy mix, and the transition to renewables has not advanced at the desired pace. This signals a need for stronger structural reforms to accelerate energy decarbonization. In response, Indonesia, in collaboration with the International Energy Agency (IEA), developed the Energy Sector Roadmap to Net Zero Emissions by 2060, which outlines policy and investment strategies for transitioning to a sustainable energy system (IEA, 2022, 2023).

A critical element often underemphasized in this transition is the integration of Environmental, Social, and Governance (ESG) considerations into national energy policies. ESG performance is increasingly seen by global institutions as central to enabling a just, inclusive, and sustainable energy transition. The environmental pillar addresses climate action and carbon reduction; the social pillar emphasizes equity, community inclusion, and access to clean energy; while the governance pillar ensures accountability, regulatory quality, and transparency. However, the impact of ESG performance on shaping Indonesia's energy transition remains underexamined. While ESG frameworks are discussed in international strategy documents, their implementation, current direction, and effectiveness in the Indonesian context have not been clearly articulated. This gap is significant because ESG factors could play a vital role in shaping the pace, inclusivity, and resilience of Indonesia's energy reform efforts.

This study addresses these concerns by focusing specifically on the current state and influence of ESG performance in Indonesia. It explores how ESG integration supports or hinders the transition towards a cleaner energy system. It builds upon global frameworks but narrows its lens to provide Indonesia-specific insights that are lacking in existing literature. Thus, this research contributes to three keyways: First, it provides a structured examination of ESG variables and their relevance to energy transition. Second, it introduces a novel empirical framework using principal component analysis (PCA) to analyze ESG dimensions in the Indonesian context. Third, it offers practical insights into how ESG alignment can enhance national strategies for a more sustainable and equitable energy future.

The remainder of the article is structured as follows: Section 2 presents the literature review; Section 3 outlines the data, model, unit of analysis, and methods; Section 4 presents the results and discussion; and the final section concludes with key findings and policy implications.

Literature Review

This section reviews recent literature at the intersection of Environmental, Social, and Governance (ESG) performance and energy transitions. It highlights current theoretical approaches and empirical evidence, especially as they pertain to Indonesia, and identifies critical gaps that this study aims to address.

Over the past two decades, researchers have increasingly linked ESG frameworks to energy transition outcomes. While numerous studies focus on the role of environmental degradation, economic inequality, or institutional quality, few have integrated these into a unified ESG structure. Mupa et al. (2024) and Kandpal et al. (2024) show that ESG integration improves investment sustainability and policy alignment in clean energy initiatives. Yet, in the context of developing countries, especially Indonesia, such relationships remain empirically underexplored.

Many scholars underscore the role of environmental challenges in accelerating energy transitions. Sagar et al. (2006), and Riti et al. (2018) argue that negative ecological impacts have driven the adoption of cleaner energy globally. Puttachai et al. (2022) found that climate vulnerabilities and emissions prompted reforms in countries like Sweden, India, and Cambodia. In Indonesia, Handoyo et al. (2024) reported that regional disparities in environmental performance undermine coordinated emission reduction efforts. Sambodo et al., (2022) highlighted that emission policies in Indonesia lack enforcement mechanisms, slowing renewable energy adoption.

Social variables such as education, employment, and inequality influence clean energy access and public support. Zhao et al. (2023) and Owjimehr and Samadi (2023) link human capital to renewable energy adoption, emphasizing skills and public awareness. Yi et al. (2023) showed that inclusive economic growth supports energy equity. In Indonesia, Cahyani et al. (2022) noted persistent gaps in energy access between urban and rural areas, while Perdana et al. (2025) found that public trust and participation are essential in community-driven renewable energy initiatives. Governance determines the efficiency and effectiveness of energy transitions. Vringer et al. (2021), and Edomah et al. (2017) found that regulatory quality, institutional strength, and transparency facilitate clean energy policy implementation. Wang (2017) further emphasized that local governments often lack the technical and financial capacity to implement national energy strategies.

Despite the growing body of literature on ESG and energy transitions, there is limited empirical evidence assessing the impact of ESG performance on energy transition outcomes in Indonesia. Existing studies often examine each ESG pillar separately or focus narrowly on corporate ESG reporting. This study addresses that gap by proposing a unified framework that empirically evaluates how ESG dimensions collectively influence national energy transitions. The novelty of this study lies in two main aspects: First, it integrates all three ESG dimensions of environmental, social, and governance into a single analytical framework. Second, it applies principal component analysis (PCA) to extract composite ESG indices and reduce multicollinearity in the dataset, a method not previously applied to Indonesia's energy transition analysis. This approach offers a more robust and data-driven understanding of ESG's systemic role in national energy planning. Accordingly, this study aims to evaluate the impact of these ESG dimensions on Indonesia's energy transition using empirical modelling techniques.

Methods

The transition from traditional energy systems to sustainable alternatives requires the holistic integration of Environmental, Social, and Governance (ESG) dimensions. Environmental factors encompass efforts to mitigate pollution, reduce emissions, and preserve ecosystems. Social indicators reflect progress in employment creation, equity, and community welfare, while governance metrics emphasize transparent policymaking, institutional accountability, and efficient allocation of resources. By constructing ESG indices, this study aims to assess how these dimensions collectively shape Indonesia's energy transition and support long-term sustainability. The empirical model used in this study is specified as follows:

$$lnET_t = \alpha_0 + \beta_1 lnENV_t + \beta_2 lnSOC_t + \beta_3 lnGOV_t + e_t \quad (1)$$

Where
ET : energy transition,
ENV : environment variables,
SOC : social variables
GOV : governance variables

To estimate both the short-run and long-run relationships among the variables, the Autoregressive Distributed Lag (ARDL) approach proposed by Pesaran et al. (2001) is employed. This method is particularly well-suited for small samples and is flexible with respect to the stationarity of variables, accommodating a mixture of I(0) and I(1) series, but not I(2). Consequently, the analysis begins with unit root tests to assess the stationarity of each time series. Upon confirming the integration order, the ARDL bounds testing approach is applied to determine the existence of a cointegrating relationship among the variables. If cointegration is established, the long-run coefficients are estimated, followed by the error correction model (ECM) to capture short-run dynamics. To validate the model, several diagnostic tests will be conducted, including: (i) Ramsey RESET test to assess functional specification, (ii) Lagrange Multiplier (LM) test for residual serial correlation, (iii) Jarque–Bera test for normality, and (iv) Breusch–Pagan test to check for heteroskedasticity. These steps ensure the reliability and robustness of the empirical results. Overall, this methodology provides a comprehensive framework to evaluate the influence of ESG performance on Indonesia's energy transition, offering insights that can inform policy design and sustainable development strategies.

Data Collection

This study utilizes annual time-series data spanning from 1996 to 2022, with Indonesia serving as the unit of analysis. The data is collected from two authoritative sources: the World Bank (2023) and the International Energy Agency (IEA, 2023). These sources provide comprehensive and internationally standardized macro-level indicators relevant to energy use, emissions, governance, and social development, ensuring the consistency and comparability of variables across time.

Given the country-level scope of this research, no sampling technique is applied. Instead, the study uses complete secondary data for the entire national population of Indonesia over the designated period. This approach is appropriate for macroeconomic and policy-oriented research where data are derived from national accounts and global institutional databases rather than individual-level observations.

To analyze the multidimensional nature of ESG factors, Principal Component Analysis (PCA) is applied to construct composite indices for each dimension—Environmental (ENV), Social (SOC), and Governance (GOV). Similarly, a composite Energy Transition Index (ETI) is created to reflect changes in Indonesia's energy system performance. The Table 1 summarizes the indicators included in each index.

Table 1 Variables and Components for Index Construction

Index	Components	Source
Energy Transition Index (ET)	ET1 – Carbon emissions (CO_2 metric tons per capita) ET2 – Renewable energy (% of GDP) ET3 – Energy use (kg of oil equivalent per capita) ET4 – Energy intensity (MJ/$ of GDP) ET5 – Electricity consumption from coal, oil, and gas	World Bank (2023), IEA (2023)
Environmental Index (ENV)	ENV1 – Forest area (% of land area) ENV2 – Air pollution (CO_2 emissions, metric tons per capita) ENV3 – Food production index ENV4 – Natural resource depletion (% of GNI) ENV5 – Agricultural land (% of total land) ENV6 – Biofuel production (barrels/day)	
Governance Index (GOV)	G1 – Control of corruption G2 – Government effectiveness G3 – Political stability G4 – Rule of law	World Governance Indicators (WGI, 2023)

	G5 – Regulatory quality G6 – Voice and accountability	
Social Index (SOC)	SOC1 – Prevalence of undernourishment (% of population) SOC2 – Unemployment (% of labor force) SOC3 – GDP per capita (constant 2010 US$) SOC4 – Secondary school enrollment (% gross) SOC5 – Access to electricity (% of population) SOC6 – Gini index (income inequality)	World Bank (2023)

Results and Discussions

This study begins with an evaluation of descriptive statistics for the key variables, as presented in Table 2. The findings show that the social index has the highest average value (mean = 7.8443), while the environmental index exhibits the lowest average (mean = 0.4937). Variation across variables is moderate, with standard deviations ranging from 0.0862 (governance) to 0.2918 (energy transition). Correlation analysis indicates that the energy transition index is moderately and positively correlated with governance (r = 0.7898) and social (r = 0.7702) indices, suggesting potential predictive relationships.

Table 2 Descriptive statistics and correlation matrix

	lnET	***lnENV***	***lnSOC***	***lnGOV***
Mean	3.5479	0.4937	7.8443	1.9675
Median	3.6891	0.4811	7.8191	1.5938
Maximum	3.8867	0.8326	8.2668	2.4533
Minimum	2.9492	0.1617	7.4868	0.7823
Std. Dev	0.2918	0.1899	0.2609	0.0862
Skewness	-0.7229	0.1192	0.2032	-0.3420
Kurtosis	2.3583	2.0790	1.6373	2.7173
Jarque-Bera	2.6063	0.9428	2.1063	0.5705
Probability	0.0717	0.0641	0.0488	0.0518
	lnET	*lnENV*	*lnSOC*	*lnGOV*
lnET	1.0000			
lnENV	0.7885	1.0000		
lnSOC	0.7702	-0.9553	1.0000	
lnGOV	0.7898	0.9423	-0.9640	1.0000

All variables were tested for stationarity. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests show that the series are non-stationary at level but stationary at first difference, indicating I(1) integration. This validates the use of the ARDL bounds testing framework. The F-statistic for the model with energy transition as the dependent variable was 4.983, exceeding the upper bound critical value at the 5% level, confirming a cointegrating relationship.

Table 3 Unit root tests

	ADF		**Phillips and Perron**	
	Level	**1st Diff**	**Level**	**1st Diff**
lnET	-4.043	-4.479**	-3.233	-8.683**
lnENV	-1.902	-3.711***	-1.117	-6.120***
lnSOC	-3.631	-3.813**	-4.674	-3.908***
lnGOV	-4.150	-6.653***	-3.833	-10.302**

Table 4 Bound test

Dependent variable		Computed F-statistics
lnET		4.983**
lnENV		2.025
lnSOC		1.642
lnGOV		1.008
	Lower Bound I (0)	Upper Bound I (1)
Critical bounds		
1%	*6.687*	*8.985*
5%	*5.054*	*4.524*
10%	*3.332*	*2.087*

ARDL estimation results are presented in Table 5. Long-run coefficients show that all ESG dimensions positively affect the energy transition, with environmental indicators showing the strongest effect (β = 0.945). This supports findings by Riti et al. (2018) and Wu et al. (2020) who emphasize the importance of environmental performance in guiding clean energy policies. Governance also plays a significant long-term role (β = 0.610), in line with Edomah et al. (2017), who highlight that effective institutional frameworks and regulatory incentives foster clean energy transitions. The social dimension shows a modest positive impact in the long run (β = 0.237), confirming earlier research by Adedoyin et al. (2020), Yi et al. (2023), and Owjimehr and Samadi (2022) on the enabling role of inclusive social development.

Table 5 Estimated long-run and short-run results

Long-run Dependent variable lnET				Short run Dependent variable *lnET*			
Regressors	**Coefficient**	**t-statistics**	**p-value**	**Regressors**	**Coefficient**	**t-statistics**	**p-value**
lnENV	0.945	5.602	0.000	$\Delta lnENV$	-0.435	1.920	0.073
lnSOC	0.237	1.840	0.084	$\Delta lnSOC$	-0.553	3.731	0.002
lnGOV	0.610	3.846	0.070	$\Delta lnGOV$	0.319	2.223	0.041
Constant	3.116	2.309	0.035	Constant	1.660	4.423	0.000
				ECT_{t-1}	-0.447	-3.876	0.001
				R-squared	0.802		
				Adj. R-squared	0.760		
				F-statistics	19.225		
				P-value	0.000		
Diagnostic tests							
Serial correlation LM test	0.7766 (0.814)						
Breusch-Pagan Heteroskedasticity test	0.3430 (0.723)						
Ramsey's RESET	4.5358 (0.325)						
Normality test	1.0731 (0.187)						
CUSUM	Stable						
CUSUMSQ	Stable						

In the short run, however, both environmental and social variables exhibit negative coefficients. This suggests transitional challenges such as persistent fossil fuel reliance or resource diversion to pressing social issues like unemployment and undernourishment. For instance, while social development improves long-term energy transitions, short-term fiscal focus on immediate welfare may slow clean energy investments. Interestingly, governance maintains a positive and statistically significant short-run effect (β = 0.319), underscoring Indonesia's implementation of renewable-friendly frameworks such as feed-in tariffs and energy diversification plans. The error correction term

(ECT_{t-1} = -0.447) confirms the existence of a stable equilibrium, with 45% of disequilibrium corrected annually. Diagnostic tests of Serial correlation, LM test, Breusch-Pagan, Heteroskedasticity test, Ramsey's RESET, Normality test, CUSUM and CUSUMSQ show no violations of classical assumptions.
Long-run coefficients show that all ESG dimensions positively affect the energy transition, with environmental indicators showing the strongest effect (β = 0.945). This finding supports previous studies such as Riti et al. (2018) and Wu et al. (2020), which highlight the pivotal role of environmental performance in steering clean energy transitions. In the Indonesian context, sustained investments in renewable energy R&D, reforestation, and biomass exploitation are particularly aligned with these findings and strengthen Indonesia's environmental pillar in ESG performance.

The social index demonstrates a moderate positive long-run effect (β = 0.237), consistent with the evidence provided by Adedoyin et al. (2020), Eren et al. (2019), Yi et al. (2023), and Owjimehr and Samadi (2022). Indonesia's emphasis on inclusive energy programs such as rural electrification and solar panel adoption contributes to bridging social gaps, which in turn enhances support for a sustainable transition. A socially cohesive framework appears to improve long-term energy security and the acceptability of clean energy investments.

Governance has a substantial and favourable long-term influence (β = 0.610), echoing findings from Edomah et al. (2017). Governance-related enablers—such as anti-corruption measures, regulatory stability, and stakeholder participation have been shown to improve investor confidence and promote renewables. In Indonesia, instruments like Feed-in Tariffs (FiTs) and regulatory streamlining continue to reinforce the implementation of national energy targets, thus reflecting a robust institutional alignment with energy transition ambitions.

Conclusion

This study investigates the influence of environmental, social, and governance (ESG) dimensions on Indonesia's energy transition over the period 1996 to 2022, using the augmented autoregressive distributed lag (ARDL) model. The findings confirm a long-run cointegrating relationship among the ESG variables and energy transition, supporting the hypothesis that ESG factors significantly shape energy transition outcomes.

The results reveal that environmental and governance indicators have a substantial and positive influence on long-term energy transition progress, while the social index shows a moderate but still encouraging impact. These findings reinforce the importance of integrating ESG performance into national development strategies. In contrast, the short-run results indicate some initial frictions, particularly with environmental and social dimensions, which may reflect transitional costs and competing policy priorities.

By confirming the long-run significance of ESG variables, this study offers empirical support for the proposition that sustainable energy transitions require coordinated efforts across environmental protection, social equity, and good governance. These results not only answer the research hypothesis but also align with broader goals of sustainable development and energy security in emerging economies like Indonesia.

The implications of these findings suggest that future energy and investment policies should adopt a holistic ESG framework to foster inclusive, resilient, and forward-looking transitions. Strengthening institutional capacity, investing in clean technologies, and improving social inclusion mechanisms are essential for accelerating the momentum toward a low-carbon future.

Limitations and Future Studies

This study has several limitations, primarily due to its reliance on aggregate national-level ESG data, which may overlook regional disparities within Indonesia. Future research could address this gap by incorporating more granular, provincial-level data to yield context-specific insights. Additionally, the analysis is constrained by the scope of ESG indicators used; expanding these to include broader dimensions and integrating qualitative assessments would enhance the robustness and applicability of future findings.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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