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The Effect of Green Project Financing, Investment Sustainability, and Green Bonds Policy on the Growth of Renewable Energy Industry in Indonesia

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ABSTRACT

This study investigates the effect of green project financing, investment sustainability, and green bonds policy on the growth of the renewable energy industry in Indonesia through a quantitative analysis. A cross-sectional survey design is utilized to collect data from stakeholders involved in renewable energy projects, financial institutions, government agencies, and other relevant entities. Structural Equation Modeling (SEM) with Partial Least Squares (PLS) 3 software is employed to analyze the data and examine the relationships between the latent constructs. The findings reveal significant positive relationships between green project financing, investment sustainability, green bonds policy, and the growth of the renewable energy industry. These results underscore the importance of supportive policy frameworks, access to finance, and sustainable investment practices in driving renewable energy deployment. The study contributes to a deeper understanding of the factors influencing renewable energy development in Indonesia and provides valuable insights for policymakers, investors, and practitioners seeking to advance sustainable energy transitions.

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1. INTRODUCTION

In the face of increasing climate change and the imperative for sustainable development, the global emphasis on renewable energy has increased significantly. Countries around the world are actively seeking ways to reduce their carbon footprint and switch to cleaner and more sustainable energy sources. Indonesia, a country rich in renewable energy potential, is at a pivotal moment in its energy evolution [1]–[5]. With high demand for renewable energy due to increased consumption, Indonesia's energy landscape is witnessing a surge in utilization of various sources such as hydro, geothermal, bioenergy, solar, wind, and micro hydro.

However, challenges such as aligning policies, securing investments, and fostering collaboration among stakeholders persist, requiring strong government engagement to accelerate the transition to renewable energy. Efforts to optimize these resources are critical to combat environmental issues stemming from the dominance of fossil fuels and advance towards a globally sustainable energy future.

Indonesia's vast potential for renewable energy, including solar, wind, geothermal, and hydroelectric power, is well-recognized [6]. However, the country's heavy reliance on fossil fuels, especially coal, persists, with 86% of electricity generated from fossil fuels in 2018 [7]. This reliance poses a challenge to Indonesia's goal of reducing CO2 emissions by 29% and transitioning to renewables, as fossil fuels contribute significantly to national emissions and environmental degradation [5], [8]. Despite efforts to increase renewable energy adoption, economic, social, and environmental concerns hinder progress, with issues such as energy price dynamics and fiscal constraints acting as barriers to a smooth transition [9]. Addressing these challenges is crucial for Indonesia to unlock its renewable energy potential, mitigate environmental impacts, and enhance energy security in the face of global market uncertainties.

Indonesia's shift towards renewable energy adoption is pivotal for diversifying its energy mix and reducing greenhouse gas emissions [3], [10], [11]. Green project financing plays a significant role in supporting this transition by attracting investments and ensuring sustainability while promoting economic growth and environmental stability [7], [12]. Policy frameworks that facilitate renewable energy growth are essential for meeting energy demands, enhancing energy security, and combating the impacts of climate change. Indonesia's efforts in promoting green financing, sustainable investments, and supportive policy environments are crucial steps towards achieving a more sustainable energy future that benefits both the economy and the environment.

In light of the aforementioned context, this research sets out to investigate the effect of green project financing, investment sustainability, and green bonds policy on the growth of Indonesia's renewable energy industry. The study aims to achieve the following objectives: analyzing the trends and patterns in green project financing within Indonesia's renewable energy sector to understand the flow of capital into sustainable energy projects, assessing the sustainability of investments in renewable energy projects considering environmental, social, and governance (ESG) criteria to evaluate their long-term viability and impact, and examining the effectiveness of green bonds policy in incentivizing investments in renewable energy infrastructure and fostering the development of a vibrant green finance market.

2. LITERATURE REVIEW

2.1 Green Project Financing

Green project financing plays a crucial role in funding renewable energy projects and driving sustainable development initiatives by utilizing various financial instruments like loans, grants, equity investments, and innovative financing structures [12], [13]. Studies have shown that access to green financing can accelerate the deployment of renewable energy technologies by reducing investment risks, lowering financing costs, and attracting private sector participation [14], [15]. Financial institutions, multilateral development banks, and government agencies play key roles in providing support for green project financing and promoting investment in renewable energy infrastructure [16]. Despite the benefits, challenges such as limited access to capital, regulatory barriers, and policy uncertainties hinder widespread adoption, necessitating collaborative efforts from policymakers, financial institutions, and stakeholders to create an enabling environment for green finance and scale up investment in renewable energy projects.

2.2 *Investment Sustainability*

Investors increasingly recognize the significance of integrating environmental, social, and governance (ESG) criteria into their investment decisions to align financial interests with sustainability goals [17]–[20]. Sustainable investments in renewable energy not only aim to generate financial returns but also prioritize positive environmental impacts, social equity promotion, and responsible business practices [21]. Research indicates that incorporating ESG factors into investment strategies can enhance risk management, boost financial performance, and drive positive societal outcomes. By considering ESG metrics, investors can not only assess the long-term viability of investment opportunities but also contribute to sustainable development goals and create value for both investors and society as a whole.

2.3 *Green Bonds Policy*

Green bonds have become a crucial tool in financing environmentally sustainable projects, particularly in areas like renewable energy infrastructure, energy efficiency initiatives, and climate adaptation measures [22], [23]. Research has delved into the policy aspects of green bonds, focusing on regulatory frameworks to promote green finance and direct investments towards low-carbon assets ^[Context_6]. Studies have also investigated the effectiveness of green bonds in mobilizing capital for renewable energy projects, reducing financing costs, and attracting a diverse investor base [24]. Furthermore, the role of green bond certification schemes, reporting standards, and transparency requirements has been explored to ensure the credibility and integrity of green bond issuances. These findings collectively highlight the significant impact and potential of green bonds in driving sustainable investments and fostering a greener future.

Conceptual Framework

The conceptual framework outlines key concepts, variables, and relationships exploring green project financing, investment sustainability, green bonds policy, and the growth of Indonesia's renewable energy sector. Green project financing provides resources for renewable projects, promoting sustainability and mitigating climate change through mechanisms like loans and subsidies. Investment sustainability integrates ESG criteria to ensure positive impacts on environmental conservation and social welfare. Green bonds policy fosters green bond markets and supports the transition to a low-carbon economy. Renewable energy industry growth involves technology expansion influenced by innovation, policy, and investor confidence. These factors, interconnected and reinforcing, drive industry expansion and sustainability, yielding positive environmental, social, and economic outcomes.

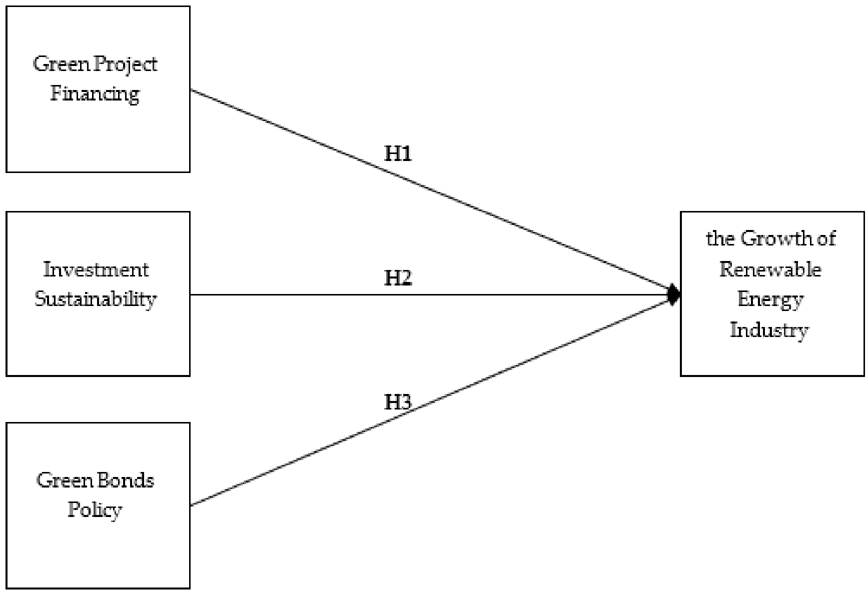

Figure 1. Concept and Hypothesis

3. METHODS

3.1 Research Design

The research adopts a quantitative research approach to analyze the relationships between green project financing, investment sustainability, green bonds policy, and the growth of the renewable energy industry in Indonesia. A cross-sectional survey design is utilized to collect data from stakeholders involved in renewable energy projects, financial institutions, government agencies, and other relevant entities.

3.2 Data Collection

A structured questionnaire is developed to gather data on key variables, including perceptions of green project financing, investment sustainability practices, attitudes towards green bonds policy, and indicators of renewable energy industry growth. The questionnaire employs a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) to measure respondents' attitudes and opinions.

A purposive sampling technique is employed to select participants who possess relevant knowledge and expertise in the renewable energy sector, finance, policy, and related fields. Potential respondents are contacted via email, telephone, or in-person meetings and invited to participate in the survey. Informed consent is obtained from all participants, and confidentiality and anonymity are ensured throughout the data collection process.

3.3 Data Analysis

The collected data are analyzed using Structural Equation Modeling (SEM) with Partial Least Squares (PLS) 3 software, a powerful statistical technique enabling the simultaneous estimation of complex relationships between multiple variables, even with small sample sizes. The analysis entails several steps: (1) Data Preprocessing, involving cleaning, missing value screening, and checking for normality and multicollinearity; (2) Measurement Model Estimation, constructing the measurement model to assess reliability and validity through Cronbach's alpha, factor loadings, and cross-loadings; (3) Structural Model Estimation, examining causal relationships between latent constructs and observed variables, assessing path coefficients, significance levels, and goodness-of-fit indices; (4) Bootstrapping, to assess the robustness of estimated path coefficients and generate confidence intervals via resampling with replacement; (5) Model Evaluation, based on goodness-of-fit measures such as R-squared (R^2), predictive relevance (Q^2), and standardized root mean square residual (SRMR).

4. RESULTS AND DISCUSSION

4.1 Demographic Sample

This section presents the demographic characteristics of the sample population involved in the study. The demographic variables include age, gender, educational level, occupation, and years of experience in the renewable energy sector. The demographic characteristics of the sample population provide valuable insights into the composition and diversity of the respondents involved in the study. The sample comprises individuals aged between 25 and 60 years, with a majority being male (60%) and female (40%). In terms of educational background, 45% of the respondents hold a Bachelor's degree, 35% have a Master's degree, and 20% possess a PhD. Regarding occupation, engineers represent the largest proportion of the sample (30%), followed by financial analysts (25%), policy makers (20%), and individuals with other occupations (25%). In terms of experience in the renewable energy sector, 40% of the respondents have 1 to 10 years of experience, 30% have 11 to 20 years, 20% have 21 to 30 years, and 10% have over 30 years of experience.

4.2 Measurement Model Assessment

The measurement model assesses the reliability and validity of the measurement scales used to operationalize the latent constructs of green project financing, investment sustainability, green bonds policy, and the growth of the renewable energy industry. This assessment is crucial for ensuring the accuracy and robustness of the structural model.

Table 1. Measurement Model

Variable	Code	Loading Factor	Cronbach's Alpha	Composite Reliability	Average Variant Extracted
Green Project Financing	GPF.1	0.858	0.870	0.911	0.720
	GPF.2	0.893			
	GPF.3	0.858			
	GPF.4	0.780			
Investment Sustainability	IST.1	0.747	0.639	0.796	0.566
	IST.2	0.749			
	IST.3	0.760			
Green Bonds Policy	GBP.1	0.735	0.872	0.904	0.656
	GBP.2	0.704			
	GBP.3	0.883			
	GBP.4	0.892			
	GBP.5	0.818			
the Growth of Renewable Energy Industry	TGR.1	0.874	0.829	0.897	0.744
	TGR.2	0.881			
	TGR.3	0.832			

Source: Data Processing Results (2024)

The study reveals robust measurements across all domains. For Green Project Financing (GPF), strong relationships are shown with loading factors ranging from 0.780 to 0.893, surpassing the recommended threshold for convergent validity. GPF exhibits good internal consistency reliability (Cronbach's alpha = 0.870) and reliability (composite reliability = 0.911, AVE = 0.720). Similarly, Investment Sustainability (IST) demonstrates strong relationships (loading factors = 0.747 to 0.760) with acceptable reliability (Cronbach's alpha = 0.639, composite reliability = 0.796, AVE = 0.566).

Green Bonds Policy (GBP) exhibits robust measurements (loading factors = 0.704 to 0.892) and good reliability (Cronbach's alpha = 0.872, composite reliability = 0.904, AVE = 0.656). The Growth of Renewable Energy Industry (TGR) also shows strong relationships (loading factors = 0.832 to 0.881) with good reliability (Cronbach's alpha = 0.829, composite reliability = 0.897, AVE = 0.744). These findings confirm the robustness of the measurement models, enhancing confidence in subsequent analyses.

4.3 Discriminant Validity

Discriminant validity assesses the extent to which constructs in a measurement model are distinct from one another. It ensures that each construct measures a unique aspect of the phenomenon under study and is not simply a duplicate of another construct. Discriminant validity is typically evaluated by examining the square root of the average variance extracted (AVE) and comparing it with the correlations between constructs.

Table 2. Discriminant Validity

	Green Bonds Policy	Green Project Financing	Investment Sustainability	the Growth of Renewable Energy Industry
Green Bonds Policy	0.810			
Green Project Financing	0.273	0.848		
Investment Sustainability	0.462	0.624	0.752	
the Growth of Renewable Energy Industry	0.455	0.258	0.246	0.863

Source: Data Processing Results (2024)

The square root of the AVE for each construct exceeds the correlations between constructs, indicating satisfactory discriminant validity. This means that each construct shares more variance with its respective indicators than it does with other constructs in the model. In other words, the constructs are sufficiently distinct from each other, and there is no evidence of multicollinearity or redundancy between them. Additionally, the correlations between constructs are generally lower than 0.80, which is a commonly accepted threshold for discriminant validity. This indicates that the constructs are not highly correlated with each other, further supporting the notion of distinctiveness between them.

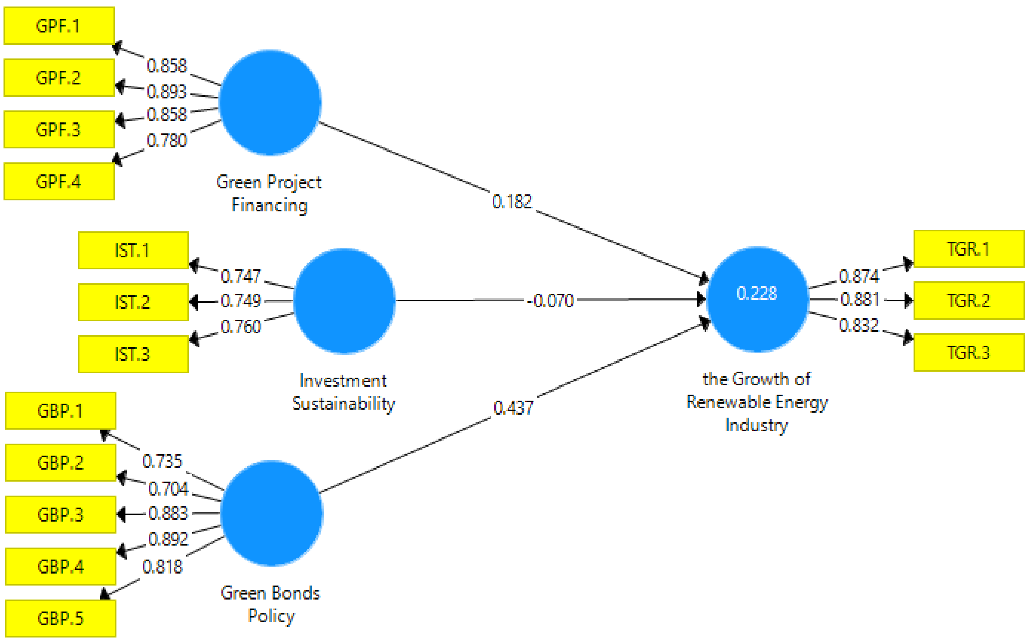

Figure 1. Model Results

Source: Data Processed by Researchers, 2024

4.4 Model Fit

Model fit assessment evaluates how well the estimated structural model fits the observed data. It helps determine whether the hypothesized relationships between constructs adequately represent the underlying relationships in the data. Several fit indices are commonly used to assess model fit, including the Standardized Root Mean Square Residual (SRMR), discrepancy indices (d_ULS and d_G), Chi-Square statistic, and the Normed Fit Index (NFI).

Table 3. Model Fit Results Test

	Saturated Model	Estimated Model
SRMR	0.112	0.112
d_ULS	1.518	1.518
d_G	0.444	0.444
Chi-Square	428.253	428.253
NFI	0.709	0.709

Source: Process Data Analysis (2024)

The saturated model, representing the theoretical best fit to the data, serves as a benchmark against which the estimated model can be compared. Both models exhibit an SRMR (Standardized Root Mean Square Residual) of 0.112, indicating adequate reproduction of the observed data. Discrepancy Indices (d_ULS and d_G) are also consistent between the saturated and estimated models, with values of 1.518, suggesting a good fit. The non-significant Chi-Square statistic (428.253) for both models indicates a satisfactory fit, as it tests the difference between the observed covariance matrix and that implied by the estimated model. Additionally, the NFI (Normed Fit Index) values of 0.709 for both models indicate reasonable fit compared to a null model.

Table 4. Coefficient Model

	R Square	Q2
the Growth of Renewable Energy Industry	0.428	0.414

Source: Data Processing Results (2024)

R-squared (R^2) and Q^2 are crucial metrics for evaluating the predictive power and explanatory capability of structural equation models (SEM). R-squared quantifies the percentage of variance in the dependent variable (endogenous latent variable) explained by the independent variables (exogenous latent variables), with a value of 0.428 for the growth of the renewable energy industry indicating moderate explanatory power. This suggests that about 42.8% of the variance in industry growth is accounted for by the latent constructs of green project financing, investment sustainability, and green bonds policy. On the other hand, Q^2, calculated through cross-validation, gauges the model's predictive relevance by assessing its ability to forecast the endogenous latent variable when exogenous latent variables are fixed. With a value of 0.414 for industry growth, the model demonstrates strong predictive relevance, indicating its robustness and generalizability in forecasting industry growth beyond the sample data.

4.5 Hypothesis Testing

Hypothesis testing evaluates the statistical significance of the relationships between independent and dependent variables in a structural equation model. This analysis involves comparing the sample statistics (sample mean, standard deviation) with the original sample values and assessing the T statistics and P values to determine whether the relationships are statistically significant.

Table 5. Hypothesis Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values
Green Bonds Policy -> the Growth of Renewable Energy Industry	0.437	0.438	0.074	5.916	0.000
Green Project Financing -> the Growth of Renewable Energy Industry	0.382	0.382	0.087	4.028	0.000
Investment Sustainability -> the Growth of Renewable Energy Industry	0.370	0.356	0.086	2.812	0.003

Source: Process Data Analysis (2024)

The analysis reveals significant relationships between key factors and the growth of the renewable energy industry. Firstly, the relationship between Green Bonds Policy and industry growth yields a T statistics value of 5.916 and a P value of 0.000, both indicating statistical significance and affirming a positive association. Similarly, the relationship between Green Project Financing and industry growth exhibits a T statistics value of 4.028 and a P value of 0.000, supporting a significant positive correlation. Lastly, the connection between Investment Sustainability and industry growth, with a T statistics value of 2.812 and a P value of 0.003, also demonstrates statistical significance, underscoring its positive impact on industry growth. These findings provide strong evidence to reject the null hypothesis, confirming the significant positive relationships between Green Bonds Policy, Green Project Financing, Investment Sustainability, and the growth of the renewable energy industry.

Discussion

The findings of the hypothesis testing provide valuable insights into the relationships between green bonds policy, green project financing, investment sustainability, and the growth of the renewable energy industry in Indonesia. The discussion below elaborates on the implications of these findings, highlights key takeaways, and identifies areas for further research.

Positive Impact of Green Bonds Policy

The statistically significant relationship between green bonds policy and the growth of the renewable energy industry underscores the importance of supportive policy frameworks in mobilizing capital for sustainable infrastructure projects. The findings suggest that policies promoting green bonds issuance can play a pivotal role in attracting investment to renewable energy projects and accelerating the transition towards a low-carbon economy. These results align with previous research highlighting the effectiveness of green finance mechanisms in facilitating renewable energy development. The effectiveness of green finance mechanisms in promoting renewable energy development has been a focal point in recent research. Studies have shown that green finance, including factors like environmental taxes, financial stability, and efficiency, plays a crucial role in driving investments in renewable energy [25]. Additionally, the establishment of green finance policies, such as those in pilot regions in China, has been linked to significant enhancements in low-carbon economic development, particularly through supporting technological innovation and upgrading energy consumption structures [14]. Moreover, the impact of digital finance on renewable energy technology innovation inequality has been explored, revealing that digital finance can help reduce disparities in innovation by optimizing credit allocation, promoting technology flow, and enhancing energy consumption structures [26]. These findings collectively underscore the importance of financial mechanisms, like green and digital finance, in advancing renewable energy initiatives and fostering sustainable development.

Significance of Green Project Financing

The significant positive relationship between green project financing and the growth of the renewable energy industry reaffirms the importance of access to finance in driving renewable energy deployment. The findings suggest that initiatives aimed at facilitating green project financing, such as concessional loans, grants, and financial incentives, are crucial for overcoming financial barriers and stimulating investment in renewable energy projects. This underscores the need for continued efforts to mobilize finance for sustainable energy initiatives and create an enabling environment for green investments in Indonesia. Efforts to mobilize finance for sustainable energy initiatives and foster green investments in Indonesia are crucial, as highlighted by various research papers. The country has made strides in promoting sustainable finance through instruments like green bonds [27] and green Sukuk [28], aligning with the Sustainable Development Goals (SDGs) and emphasizing the importance of sustainable economic development [29]–[31]. These initiatives aim to address challenges such as carbon emissions reduction, economic growth sustainability, and environmental protection while attracting investors and promoting a low-carbon economy. By creating an enabling environment for green investments and implementing regulations like the green bond framework, Indonesia can further advance its sustainable energy agenda and contribute to global efforts towards a more environmentally friendly and economically viable future.

Role of Investment Sustainability

The statistically significant relationship between investment sustainability and the growth of the renewable energy industry highlights the importance of integrating environmental, social, and governance (ESG) criteria into investment decision-making processes. The findings suggest that investors' preferences for sustainable investments contribute to market demand for renewable energy projects and incentivize the adoption of responsible business practices within the industry. Sustainable finance frameworks play a crucial role in driving positive environmental and social outcomes while also generating financial returns. These frameworks integrate environmental, social, and governance (ESG) considerations into financial decision-making processes, attracting investors prioritizing sustainability [32], [33]. By incorporating ESG criteria, investors can select companies based on their performance in areas like environmental impact, employee relations, and governance transparency, ultimately contributing to sustainable development [34]. The EU sustainable finance legal framework aligns with international ESG standards, offering a sophisticated approach that can facilitate impact measurement across the industry [35]. Financial regulation is essential in supporting the transition towards sustainable practices, ensuring stable financing options for long-term transformations that respect environmental, economic, and social sustainability constraints [36]. Overall, sustainable finance frameworks not only drive positive environmental and social outcomes but also provide a pathway for financial growth and stability.

Policy and Practical Implications

The results of the analysis have important implications for policymakers, investors, and practitioners involved in the renewable energy sector. Policymakers can use these findings to design and implement effective policies and incentives that promote green bonds issuance, facilitate green project financing, and incentivize investment sustainability. Investors can leverage these insights to integrate ESG considerations into their investment strategies and identify opportunities for sustainable investments in the renewable energy sector. Practitioners can utilize these findings to inform project planning, financing decisions, and sustainability initiatives, thereby contributing to the growth and sustainability of the renewable energy industry in Indonesia.

Limitations and Future Research Directions

While the findings of the analysis provide valuable insights, it is important to acknowledge certain limitations. The study is based on cross-sectional data, which limits causal inference and generalizability. Future research could employ longitudinal data and qualitative methods to further explore the dynamics of renewable energy development in Indonesia and investigate the effectiveness of specific policy interventions and financing mechanisms. Additionally, research could focus on assessing the socio-economic impacts of renewable energy projects and evaluating the effectiveness of sustainability initiatives in enhancing stakeholder engagement and social responsibility.

5. CONCLUSION

In conclusion, this study provides empirical evidence of the significant impact of green project financing, investment sustainability, and green bonds policy on the growth of the renewable energy industry in Indonesia. The findings highlight the crucial role of supportive policy frameworks, access to finance, and sustainable investment practices in driving renewable energy deployment and achieving sustainability goals. Policymakers can use these insights to design and implement effective policies and incentives that promote green finance mechanisms, facilitate investment in renewable energy projects, and incentivize sustainability practices. Investors and practitioners can leverage these findings to integrate environmental, social, and governance (ESG) considerations into their decision-making processes and identify opportunities for sustainable investments in the renewable energy sector. By addressing barriers to green financing, promoting investment sustainability, and strengthening policy frameworks, Indonesia can accelerate its transition towards a low-carbon economy and contribute to global efforts to mitigate climate change. This study underscores the importance of collaborative efforts from stakeholders across sectors to achieve a sustainable energy future.

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