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The Effect of Clean Energy Technology Infrastructure Development on Regional Economic Growth in Indonesia

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ABSTRACT

This study investigates the effect of clean energy technology infrastructure development on regional economic growth in Indonesia. Using a quantitative research design, data were collected from 70 respondents across different regions using a Likert scale ranging from 1 to 5. The analysis was conducted using SPSS version 26 to examine the relationship between clean energy infrastructure and regional economic performance. The results show a strong positive correlation between clean energy technology infrastructure and regional economic growth, with a statistically significant relationship. Furthermore, multiple regression analysis indicates that clean energy infrastructure development significantly predicts economic growth, while geographic location and government policy also play important roles. These findings suggest that investments in clean energy infrastructure are crucial drivers of regional economic development and highlight the need for supportive policies to maximize the benefits of renewable energy projects. This study provides valuable insights for policymakers and stakeholders in advancing sustainable development through clean energy initiatives.

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1. INTRODUCTION

The transition to clean energy technologies is essential for sustainable development and economic growth, particularly in Indonesia. This shift addresses environmental concerns while creating jobs, enhancing energy security, and fostering new industries. Technologies like solar, wind, and geothermal are replacing fossil fuels, reducing emissions and boosting economic growth globally, driven by climate commitments [1]. In Indonesia, projects such as the Sidrap and Jeneponto wind farms show renewable energy's potential to meet electricity demand and create jobs, though challenges like pricing policies remain (Susanto, 2024). Renewable energy also diversifies the energy mix, reducing dependence on imports and improving access in underserved regions [2]. Urban green infrastructure, like in Bandung and Jakarta, illustrates how renewables support economic growth and sustainability [3]. Financial strategies similar to China's green finance model could help accelerate clean energy development in Indonesia [4].

Policy recommendations include supportive legal frameworks and leveraging technology for a smoother transition [2], [5]

Indonesia's potential in clean energy is bolstered by its rich natural resources and diverse geography. The government's goal of 23% renewable energy by 2025 is key for sustainability and economic growth. Projects like wind farms in South Sulawesi demonstrate this potential, though economic and pricing challenges with PLN remain [5]. Technological advancements, like the Internet of Things, can speed up implementation but need policy support [5]. A robust legal framework is critical for investment and innovation, while resolving regulatory issues is vital for large-scale projects [6], [7]. Solar projects like the Tembesi Floating Solar Plant prove economic viability, enhanced by carbon credits [8]. Integrating renewable energy into business strategies supports sector sustainability and ensures inclusiveness for all [9].

The relationship between clean energy technology infrastructure development and regional economic growth in Indonesia is complex, involving socio-economic, policy, and regional factors. Clean energy initiatives have the potential to drive growth, but their impact varies by region due to differences in infrastructure, policy frameworks, and regional disparities. A study shows that transitioning to clean energy can increase the Household Development Index (HDI) by 3.72%, particularly benefiting rural areas [10]. Infrastructure development, especially in electricity, plays a key role in economic growth, though its impact differs by region, with negative effects observed in Eastern Indonesia [10]–[12]. Renewable energy growth is further supported by green financing, investment sustainability, and policy frameworks, essential for regional economic development [13]. However, Indonesia's archipelagic geography poses challenges, particularly in remote areas where road access, human resources, and bureaucratic inefficiencies hinder progress, requiring government intervention and local collaboration [14]. Previous research has emphasized the macroeconomic benefits of renewable energy; however, studies focused on specific regional impacts are limited, particularly in the Indonesian context. Therefore, this study aims to fill this gap by quantitatively analyzing the effect of clean energy technology infrastructure development on regional economic growth across various Indonesian regions.

2. LITERATURE REVIEW

2.1 Clean Energy Technology and Economic Growth

The adoption of clean energy technologies is vital for economic growth and environmental sustainability, offering alternatives to fossil fuels while promoting job creation and innovation [15]. Renewable energy reduces costs, improves efficiency, and attracts global investment due to climate goals [1]. It enhances energy security, socio-economic development, and mitigates climate change [2]. In South Asia, GDP growth correlates with clean energy adoption, especially in cooking technologies [16]. Solar, wind, and geothermal energy are key to reducing emissions, with the potential to eliminate carbon from electricity by 2050 [17]. However, challenges like market failures and raw material needs must be addressed [2]. Sustainable development requires prioritizing renewables despite the shift to non-renewable sources during economic growth [16]. However, research specifically focusing on the regional economic impact of clean energy infrastructure is still limited, particularly in emerging economies like Indonesia.

2.2 The Role of Infrastructure in Regional Development

Infrastructure development is a key driver of economic growth, particularly in regional contexts, as it boosts productivity, attracts investment, and stimulates industrial expansion, especially in underdeveloped areas. Clean energy infrastructure provides sustainable energy solutions while fueling economic activity. Infrastructure projects enhance regional economic potential and reduce environmental impacts, contributing to sustainable growth [18]. In ASEAN,

infrastructure improves connectivity and productivity, emphasizing the need for investment alongside institutional reforms for inclusive growth [19]. Clean energy infrastructure, especially electricity, positively impacts economic growth, as seen in sub-Saharan Africa and parts of Asia [19]–[22]. Effective infrastructure investments rely on supportive policies and government backing to ensure long-term economic benefits [19], [21].

2.3 Clean Energy Infrastructure in Indonesia

The renewable energy sector in Indonesia holds significant potential due to its abundant resources, yet it remains underdeveloped, primarily due to infrastructure and policy challenges. Despite ambitious targets, Indonesia still heavily relies on coal and petroleum, presenting both challenges and opportunities for regional economies, especially in rural areas. While Indonesia has ample geothermal, solar, and wind resources, regulatory inconsistencies and inadequate infrastructure hinder their development [6]. Wind power projects in regions like South Sulawesi demonstrate potential, though issues such as pricing policies and lack of government support remain obstacles [5]. Renewable energy projects can boost local economies by creating jobs and improving energy security, particularly in rural areas, but inconsistent policies and infrastructure limitations restrict large-scale growth [14]. Government initiatives and private sector engagement are crucial for accelerating clean energy adoption and realizing its economic benefits [23]. A robust legal framework and cohesive policy support are essential to encourage investment and innovation in renewable energy technologies [6], [7]

2.4 Theoretical Frameworks

The study of the relationship between clean energy infrastructure and economic growth is often grounded in endogenous growth theory, which highlights the role of technological innovation and human capital in driving economic development. Romer (1990) emphasized that innovation, including clean energy technologies, plays a crucial role in boosting productivity and ensuring environmental sustainability. Another key framework is the energy-growth nexus, which explores the bidirectional relationship between energy consumption and economic growth. Kraft and Kraft (1978) first suggested a causal link between energy access and industrial development, a concept extended by Payne (2010) to include the benefits of renewable energy in promoting long-term economic growth through efficiency and reduced environmental costs. Despite these well-established connections, gaps remain, particularly in understanding how clean energy infrastructure affects regional economies, especially in emerging markets like Indonesia. Limited studies have focused on the specific regional economic impacts of clean energy using quantitative methods, and there is a lack of research on how clean energy can help reduce regional disparities in economic development, a critical issue for Indonesia given its geographical diversity.

3. METHODS

3.1 Research Design

This study utilizes a quantitative research design to examine the relationship between clean energy technology infrastructure development and regional economic growth in Indonesia. Data were collected through a survey method from various regions, providing a broad perspective on the impact of clean energy infrastructure on local economies. The survey data were analyzed using descriptive and inferential statistics to determine the significance and strength of the relationship between the independent and dependent variables. Quantitative research is ideal for this study as it enables the systematic measurement of perceptions regarding clean energy infrastructure and its effect on economic growth, allowing for replicable results that can guide policy decisions.

3.2 Population and Sample

The population for this study comprises various stakeholders involved in clean energy development and regional economic planning across Indonesia,

including local government officials, energy experts, and business leaders. A sample of 70 respondents was selected from regions where clean energy infrastructure projects have been implemented or are under consideration, using purposive sampling. This non-probability sampling method was chosen to ensure that participants had the necessary knowledge and involvement in clean energy and regional development. The sample size of 70 is considered sufficient for exploratory analysis, offering valuable insights into the regional economic impacts of clean energy initiatives.

3.3 Data Collection

Data was collected using a structured questionnaire distributed to the selected respondents, designed to gather information on the development of clean energy infrastructure in their regions and perceptions of its impact on economic growth. A Likert scale was used to quantify attitudes and perceptions, allowing for statistical analysis of the relationships between variables. The survey was administered through both online and in-person channels to ensure high response rates and comprehensive coverage across various regions.

The study focuses on two main variables: the independent variable, clean energy technology infrastructure development, and the dependent variable, regional economic growth. Clean energy technology infrastructure development refers to the implementation of renewable energy technologies such as solar, wind, geothermal, and hydroelectric power in the respondents' regions. Regional economic growth is measured by the respondents' perceptions of the economic impacts of clean energy infrastructure, including job creation, income generation, energy cost reduction, and overall economic activity.

3.4 Data Analysis

The data collected from the survey was analyzed using SPSS version 26, following a structured process. Descriptive statistics were used to summarize respondents' demographic characteristics and provide an overview of the data, including frequencies, means, and standard deviations for key variables. Reliability and validity testing was conducted using Cronbach's Alpha, with a value of 0.70 or higher indicating acceptable internal consistency of the questionnaire. Inferential statistics, including Pearson's correlation, were employed to assess the relationship between clean energy infrastructure development and regional economic growth. Multiple regression analysis was also performed to evaluate the extent to which clean energy infrastructure predicts regional economic growth.

The following hypotheses were tested in the study:

H1: Clean energy technology infrastructure development has a positive and significant effect on regional economic growth in Indonesia.

H0: Clean energy technology infrastructure development does not have a significant effect on regional economic growth in Indonesia.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The demographic profile of the respondents revealed a diverse group of stakeholders involved in clean energy infrastructure development, including government officials, energy experts, and business leaders. Of the 70 respondents, 45% were government officials, 30% were business leaders, and 25% were energy sector professionals. The geographic distribution of the respondents spanned across several key regions in Indonesia, with a majority from provinces actively engaged in clean energy projects such as Java, Sumatra, and Bali. Table 1 below summarizes the descriptive statistics of the responses related to clean energy technology infrastructure development and regional economic growth:

Table 1. Descriptive Statistics

Variable	Mean	Standard Deviation	Min	Max

Clean Energy Infrastructure Development	4.12	0.55	3.00	5.00
Perceived Regional Economic Growth	4.05	0.62	2.75	5.00

The mean value of 4.12 for clean energy infrastructure development suggests that most respondents agreed that their regions are actively developing clean energy infrastructure. Similarly, the mean value of 4.05 for regional economic growth indicates that respondents perceived a positive economic impact from these developments.

4.2 Reliability and Validity Testing

Before conducting further analysis, the reliability of the questionnaire was tested using Cronbach's Alpha to ensure the consistency of the data. The Cronbach's Alpha for the clean energy infrastructure and regional economic growth items was 0.827, indicating good internal consistency. This result confirms that the questionnaire items were measuring the intended constructs reliably.

4.3 Inferential Analysis

4.3.1 Pearson's Correlation Analysis

To explore the relationship between clean energy technology infrastructure development and regional economic growth, Pearson's correlation analysis was conducted. The results of the correlation analysis are presented in Table 2 below:

Table 2. Correlation Analysis

Variables	Correlation Coefficient (r)	Significance (p-value)	Min	Max
Clean Energy Infrastructure Development	0.685	< 0.001	3.00	5.00
Regional Economic Growth			2.75	5.00

The correlation coefficient of 0.685 indicates a strong positive relationship between clean energy technology infrastructure development and regional economic growth. The p-value of < 0.001 demonstrates that this relationship is statistically significant at the 0.05 level. This result supports the hypothesis (H1) that clean energy infrastructure development has a significant and positive effect on regional economic growth in Indonesia.

4.3.2 Multiple Regression Analysis

To further investigate the extent to which clean energy infrastructure development predicts regional economic growth, multiple regression analysis was conducted, controlling for other factors such as geographic location and government policies. The regression model is presented in Table 3:

Table 3. Multiple Regression Analysis

Variable	Coefficient (B)	Standard Error	t-value	Sig
Clean Energy Infrastructure Development	0.528	0.118	4.734	0.000
Geographic Location (Control Variable)	0.187	0.097	2.007	0.048
Government Policy (Control Variable)	0.238	0.104	2.308	0.025
Constant	2.103	0.506	4.205	0.001

The multiple regression analysis reveals that clean energy infrastructure development significantly predicts regional economic growth, with a coefficient (B) of 0.528 and a p-value of 0.000. This finding confirms that clean energy infrastructure has a substantial positive effect on regional economies, even when controlling for geographic location and government policy. The results also show that geographic location (B = 0.187, p = 0.048) and government policy (B = 0.238, p = 0.025) are significant factors influencing regional economic growth, indicating that regions with favorable policies

and strategic locations tend to experience greater economic benefits from clean energy projects.

4.4 Discussion

The findings of this study confirm that clean energy technology infrastructure development plays an important role in driving regional economic growth in Indonesia. The significant positive relationship between clean energy infrastructure and regional economic performance is in line with previous research highlighting the economic benefits of renewable energy investments, as shown by several studies. The transition to clean energy has been shown to improve household socio-economic development, with a 3.72% increase in the Household Development Index (HDI) for those who switch to clean energy, especially in rural areas [10]. In addition, transport infrastructure development, such as in Tanah Bumbu regency, improves regional connectivity and economic activity, emphasising the role of sustainable infrastructure in regional growth [24]. In Bali, strategic infrastructure investments have resulted in a 9.71% increase in Gross Regional Domestic Product (GRDP), demonstrating the economic benefits of infrastructure development [25]. However, infrastructure development policies under the Jokowi administration have had mixed impacts on economic inequality, with some types, such as electricity, reducing inequality in Eastern Indonesia, while other types show mixed impacts [12]. The growth of the renewable energy sector in Indonesia is further supported by green project financing, sustainable investment, and policy frameworks, which are critical to driving regional economic growth [13].

4.4.1 Clean Energy Infrastructure as a Driver of Economic Growth

The strong correlation between clean energy infrastructure development and economic growth supports the argument that renewable energy projects contribute to regional development by creating jobs, improving energy security, and attracting investment. This aligns with the findings of Apergis and Payne (2010), who noted that renewable energy investments stimulate economic growth, particularly in energy-dependent regions. In Indonesia, the development of clean energy infrastructure not only delivers environmental benefits but also creates new economic opportunities, especially in rural and underdeveloped areas. This highlights the potential of clean energy to drive sustainable development across the country, offering valuable insights for policymakers and investors.

4.4.2 The Role of Geographic Location and Government Policy

The findings suggest that geographic location and government policy play crucial roles in the relationship between clean energy infrastructure and economic growth. Regions strategically located near energy resources or major markets tend to experience greater economic benefits from clean energy projects. Additionally, supportive government policies, such as tax breaks or subsidies, can amplify the positive economic impact of renewable energy infrastructure. This is consistent with Bhattacharya et al. (2016), who highlighted the importance of policy frameworks and institutional support for the success of renewable energy investments. In Indonesia, the government's commitment to achieving 23% renewable energy in its energy mix by 2025 has fostered a favorable environment for clean energy development, though challenges remain in ensuring equal benefits across all regions.

4.4.3 Implications for Policy and Practice

The results of this study have significant implications for policymakers and stakeholders in Indonesia's energy and economic planning. Prioritizing investments in clean energy infrastructure, particularly in regions with abundant renewable resources, can substantially boost regional economic growth while contributing to national environmental goals. Additionally, consistent and supportive government policies are crucial, including incentives for private sector involvement and ensuring access to infrastructure and resources in remote and rural areas. By addressing these factors,

Indonesia can accelerate its transition to clean energy and promote more balanced regional economic growth.

5. CONCLUSION

This study has demonstrated that clean energy technology infrastructure development has a significant positive impact on regional economic growth in Indonesia. The findings provide strong evidence that investments in renewable energy projects contribute not only to environmental sustainability but also to economic development in various regions. The positive correlation and significant predictive power of clean energy infrastructure on economic growth underscore the importance of continuing to expand clean energy initiatives across the country. Additionally, geographic location and government policies were found to be influential factors, suggesting that regions with favorable conditions and supportive regulatory frameworks are more likely to experience the economic benefits of clean energy infrastructure.

For policymakers, the study underscores the importance of creating consistent and supportive policies to promote public and private investment in renewable energy. This includes improving access to renewable resources, providing financial incentives, and ensuring equitable infrastructure development across regions. The findings suggest that clean energy projects can drive regional development, especially in underdeveloped areas, by fostering job creation and attracting new investments. Future research should explore the long-term impacts of clean energy infrastructure on regional economies and its potential to reduce economic disparities. Incorporating variables like energy consumption patterns and technological advancements could deepen the understanding of how clean energy contributes to sustainable economic growth.

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