

*Original Research Article***Forecasting Renewable Energy Transition Using Error Correction Model: Addressing Environmental and Sustainable Development****Hoerun Nisa¹, Dessy Rachmawatie^{1*}, Younes Ziat², Dyah Titis Kusuma Wardani¹**¹ Master of Economics, Universitas Muhammadiyah Yogyakarta, Yogyakarta, Indonesia.² Engineering and Applied Physics Team, Superior School of Technology, Sultan Moulay Slimane University, Beni Mellal, Morocco.* Corresponding Author, email: d.rachmawatie@umy.ac.id

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**Abstract**

In the context of global warming, the transition from fossil fuels to renewable energy is crucial to reduce carbon emissions and achieve the Sustainable Development Goals. From 1990 to 2022, this study examines new energy consumption in Indonesia and examines its relationship with GDP, foreign direct investment (FDI), urbanization, carbon emissions (CO₂), the exchange rate, and subsidies received. To determine the short- and long-term impacts, the ECM is used. In the short term, economic growth has a positive and significant effect on energy consumption; however, in the long term, the negative effect becomes more pronounced. Direct investment (FDI) has no significant effect on renewable energy consumption, creating a negative long-term trend. There are significant positive and negative dampening effects of urbanization on new energy consumption in the long term, but no significant short-term effects. Energy consumption, carbon emissions have a significant negative effect. The solution to construction and environmental challenges in Indonesia is to increase the capacity of renewable energy sources.

Keywords: Carbon emissions; FDI; GDP; renewable energy; tax revenue; urbanization**1. Introduction**

Climate change is a critical global issue driven primarily by fossil fuel consumption and rapid economic growth, leading to rising temperatures and environmental degradation (Chen et al., 2022). It impacts biodiversity, habitats, and extreme weather patterns while also posing health risks (Yadav et al., 2024a). The development of renewable energy significantly helps reduce carbon emissions (CO₂), which are the main cause of climate change. One of the key elements in efforts to preserve the environment and combat climate change is the use of renewable energy. One of the key elements in the fight against climate change is the use of renewable energy (Anthony and Patra, 2022; Sains Dan Teknologi Kelautan et al., 2024). Renewable energy sources such as solar, wind, biomass, hydro, and geothermal play a crucial role in mitigating climate change by reducing carbon emissions (Aziz et al., 2024a). Advancements in renewable technologies, including efficient solar panels, aerodynamic wind turbines, and improved battery storage systems, are making clean energy more accessible and effective (Zhiznin et al., 2019; Bouzaid et al., 2024). These innovations are essential for addressing climate change and ensuring sustainability for future generations (Ziat et al., 2018).

Economic growth leads to higher energy demand and transportation use, resulting in increased pollution and carbon emissions. Inflation also plays a crucial role in environmental quality across Asia,

requiring region-specific climate policies (Ahmad et al., 2021). While fossil fuels have historically fueled economic progress, concerns about climate change, air pollution, and resource scarcity are accelerating the global transition toward energy efficiency and renewable sources (Kartal et al., 2024; Shittu et al., 2021).

The widening gap between energy supply and demand has heightened the risk of energy insecurity (Yin and Qamruzzaman, 2024), pushing many countries to adopt sustainable energy strategies to address environmental challenges (Azam et al., 2021). Indonesia's energy consumption projections for the next 10 years are based on population and economic growth data, with the last 10 years showing the dominance of the transportation sector until there is a shift to the industrial sector in 2022 due to increasing demand for coal, so that the industrial sector becomes the largest with a share of 45%, followed by transportation at 37%, households at 13%, commercial at 4.2%, and other sectors at 1% (DEN & S.J. 2023a). This is because new and renewable energy (NRE) in Indonesia faces barriers related to financing that require a special approach in terms of funding, technology, and raw materials, and is influenced by government policies in energy budget allocation. In addition, the dependence on conventional energy, such as coal and petroleum, as well as existing infrastructure, makes the transition to NRE difficult, requiring long-term policies and commitments to reduce dependence on fossil energy (SolarKita, 2023).

According to the website of the National Development Planning Agency (BAPPENAS), through the Indonesia Green Growth Program, Indonesia is committed to reducing emissions by 29% through self-reliance and up to 41% with international assistance by 2030, as stated in the Nationally Determined Contribution (Nationally Determined Contribution / NDC). Of the total emission reduction target, 11% comes from the energy sector. In addition, the government has stipulated that 23% of energy in Indonesia must come from new and renewable energy sources by 2025 at the latest. According to DEN & S.J. (2023b), in 2022, Indonesia's total primary energy supply reached 246 million TOE (Ton Oil Equivalent), with the dominance of fossil energy sources, namely coal 42%, petroleum 31%, and natural gas 14%, while new and renewable energy (NRE) still contributes relatively little at 12.3%. Then the utilization of renewable energy in 2023 has experienced significant progress, with biodiesel production reaching 13.2 million KL (kilo liters) (up 11% compared to the previous year), biodiesel exports of 0.18 million KL, domestic consumption of 12.3 million KL, mixing biodiesel in Biogasoil by 34.9%, utilization of biomass in the industrial sector reaching 7.9 million tons, communal biogas in the household sector of 110 million m³, and the use of solar water heaters that produce 261 thousand TOE of hot and direct geothermal water in the industrial sector reaching 6.2 Thermal MWh (Ministry of Energy and Mineral Resources, 2023). Figure 1 shows a diagram of the use of renewable energy and fossil energy in Indonesia (Hannah Ritchie, 2024).

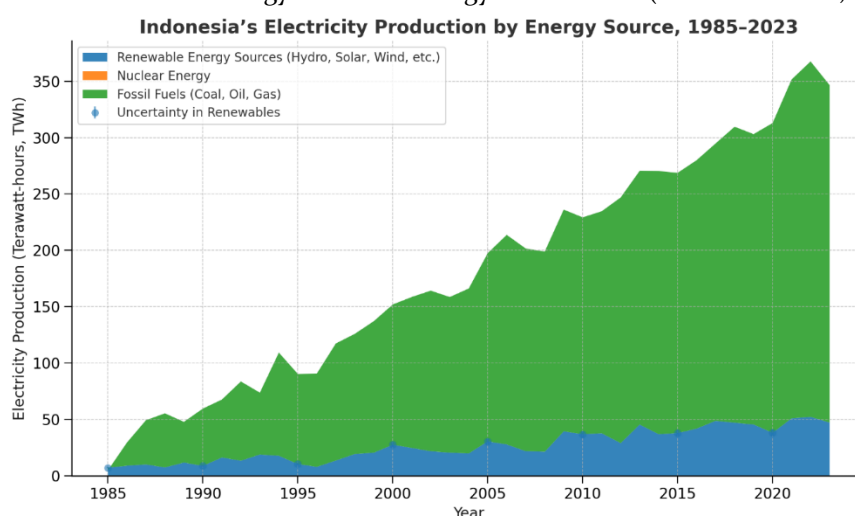


Figure 1. Renewable Energy Consumption In Indonesia

Source: Our World in Data (2024); Energy Institute – Statistical Review of World Energy (2024)

Based on Figure 1, renewable energy consumption in Indonesia remains low, with only 65 TWh used in 2023 compared to 284 TWh from fossil fuels, highlighting challenges in the clean energy transition. Government intervention is crucial in promoting energy efficiency, particularly in developing countries where energy costs are a significant expense (Dilanchiev et al., 2023). Sustainable economic growth and the adoption of clean energy align, as industries using renewable energy produce fewer environmental externalities (Hao et al., 2021). The Environmental Kuznets Curve (EKC) states that patterns of environmental degradation vary across industrialized and developing countries (Tsandra et al., 2023). Studies on GDP and renewable energy use show mixed results, while long-term economic growth positively affects renewable energy adoption in OECD countries (Alam and Murad, 2020). Research on Indonesia, Shafira Annisa et al. (2024), indicates a negative relationship. Meanwhile, in Pakistan, GDP has a long-term positive effect on renewable energy utilization, but no effect in the short term (Aziz et al., 2024b).

Research on urbanization and renewable energy consumption in ASEAN reveals various impacts. While Shafira Annisa et al. (2024a) found an insignificant short-term impact, they found a significant negative long-term influence. Vo et al. (2024) show that urbanization harms the use of renewable energy in the short term, but has a positive impact in the long term, except in Malaysia. The Philippines has successfully balanced both factors over time. Nathaniel and Khan (2020) suggest that urbanization and economic growth drive renewable energy consumption. Regarding financial influences, Tiwari et al. (2022) found no correlation between stock market development and renewable energy use in Asia but observed that trade and economic growth reduce energy consumption through technological advancements. Meanwhile, FDI supports renewable energy in low-income Asian countries but harms BRICS nations, possibly due to resource reallocation or technological progress that lowers energy demand (Yadav et al., 2024b).

This study examines the factors that influence current energy consumption in Indonesia, with special emphasis on GDP, FDI, urbanization, CO₂ emissions, water consumption, and temperature. GDP reflects economic growth and its impact on energy demand, but FDI has an important role in financing and developing new energy technologies. Urbanization increases energy consumption, which requires more efficient energy solutions, while CO₂ emissions increase energy demand. CO₂ emissions increase energy demand. Investment demand in this sector is influenced by production and export volumes. To provide a comprehensive understanding of the recent energy transition and energy consumption efficiency in Indonesia, this study uses ECM to discuss the dynamic and long-run nature of the relationship.

2. Methods

2.1. Data Collection Method

The objects of this study include renewable energy consumption (REC), Gross Domestic Product (GDP), Foreign Direct Investment (FDI), carbon emissions (CO₂), urbanization (UPG), the Rupiah-US Dollar exchange rate (IDR), and tax revenue (TR). The type of data used is secondary data, obtained indirectly from several official sources such as the World Development Indicators (WDI), One Data Indonesia, and other relevant publications. These secondary data consist of information collected and published by authorized institutions in the form of documentation, annual reports, and previous research findings. The dataset is a time series with a span of 1990 to 2022, which is compiled continuously in a certain period, and includes the variables mentioned previously: REC, GDP, FDI, CO₂, UPG, IDR, and TR.

2.2. Data Analysis Method

The analysis uses the Error Correction Model (ECM) as an econometric tool to examine the relationship between long and short periods resulting from cointegration between the research variables. Furthermore, descriptive analysis is used to analyze data trends and patterns. To estimate the ECM, this

study conducted several statistical tests, particularly the stationarity test (unit root test), to ensure the absence of unit roots in the data. This test verifies the equilibrium relationship between the variables.

Following the ECM estimation, a series of classical assumption tests were performed, including the normality test, autocorrelation test, and heteroskedasticity test, to ensure the validity and reliability of the model (Basuki, A. T., & Prawoto, N., 2016). Econometric Long-run model and Short-run model following equation 1 and 2

$$REC = a_0 + a_1GDP_t + a_2FDI_{1t} + a_3CO2_{2t} + a_4UPG_{3t} + a_5IDR_{4t} + a_6TR_{5t} + e_t \quad (1)$$

$$REC_t = a_0 + a_1D(GDP)_t + a_2D(FDI)_{1t} + a_3D(CO2)_{2t} + a_4D(UPG)_{3t} + a_5D(IDR)_{4t} + a_6D(TR)_{5t} + ECT(-1)_t + e_t \quad (2)$$

Where:

REC : Renewable energy consumption

GDP : Economic growth

FDI : Foreign Direct Investment

UPG : Urbanization

CO₂ : Carbon emissions

IDR : Indonesia's exchange rate

TR : Tax revenue

t : Periods

3. Results and Discussion

3.1. Result

The unit root test aims to evaluate whether a variable has a stationary property or contains a unit root, which is characterized by an autoregressive coefficient of one. The first step in this test is to estimate an autoregressive model for each variable to identify long-term data movement patterns. In this study, the Augmented Dickey-Fuller test (ADF) was used as the main method to test the stationarity of the data, ensuring that the variables used did not contain random trends that could lead to biased or misleading regression relationships.

Table 1. Stationarity test

Variabels	Unit Root Test			
	Level		First Difference	
	ADF	Prob.	ADF	Prob.
REC	-0.331	0.909	-6.326	0.0000
GDP	0.685	0.9899	-4.192	0.0026-
FDI	-2.201	0.209	-5.361	0.0001
UPG	0.435	0.8911	-5.376	0.0001
CO ₂	-0.443	0.888	-4.505	0.0015
IDR	-1.091	0.706	-6.732	0.0000

Based on Table 1, the test results at this level show that none of the variables meet the stationarity requirements because the probability value still exceeds 0.05. However, after the first differentiation (1st difference), all variables become stationary, as indicated by a probability value that has dropped below 0.05. Therefore, all variables were declared to have passed the stationarity test and were prepared to be used in the next stage of analysis.

Table 2. Long-term estimates

Variabels	Coefficient	Probability
GDP	-0.002*** (0.0005)	0.0006
FDI	-0.157	0.5691

Variables	Coefficient	Probability
CO ₂	(0.272) -17.150***	0.0000
UPG	(2.823) -1.605*	0.0753
TR	(0.866) 0.375	0.1061
IDR	(0.224) -0.0006***	0.0028
C	(0.0002) 77.250 (5.853)***	0.0000
R-squared: 0.990216		
Adjusted R-squared: 0.987959		

Based on Table 2, economic growth significantly affects energy consumption, with a coefficient of determination of -0.002 indicating a negative relationship between the two. energy consumption, indicated by a negative correlation between the two variables (a coefficient of determination of -0.002). Table 2 shows that economic growth has a significant effect on energy consumption, with a coefficient of determination of -0.002 indicating a negative relationship between the two variables. Table 2 shows that economic growth has a significant impact on energy consumption, with a coefficient of determination of -0.002 indicating a negative relationship between the two. For example, when the economy is experiencing difficulties, energy consumption tends to decrease. emissions have decreased significantly, along with a coefficient of determination of -17.150, indicating that an increase in carbon emissions with a decrease in energy consumption. In addition, foreign investment and tax revenue variables do not have a significant effect on the use of new energy. Emissions have decreased significantly with a coefficient of determination of -17.150, indicating that an increase in carbon emissions decreases along with a decrease in energy consumption. And tax revenue does not have a significant impact on the use of new energy. With a coefficient of determination of -1.605, urbanization shows a significant negative impact on energy consumption, indicating that increasing urbanization is inversely proportional to the level of energy consumption. With a value of -1.605, urbanization shows a large negative impact on energy consumption. This shows that increasing urbanization is inversely proportional to the level of energy consumption. In addition, the rupiah exchange rate against the dollar has a significant effect with a coefficient of -0.0006, indicating that changes in the ratio value can affect the level of new energy consumption in the economy. can affect the level of new energy consumption in the economy. The rupiah exchange rate against the dollar has a significant effect with a coefficient of -0.0006, indicating that changes in the ratio value can affect the level of new energy consumption in the economy.

Table 3. Cointegration test

Variable	Prob.	Std. Error
ECT (-1)	0.0002	There is Cointegration

Based on table 3, the probability of the Error Correction Term (ECT) variable is 0.002, which is below the threshold of 0.05. This shows that the ECT variable is stationary at the data level and confirms the cointegration relationship between renewable energy use, stationary, FDI, urbanization, carbon emissions, exchange rates, and income taxes. at the data level and confirms the cointegration relationship between renewable energy use, GDP, FDI, urbanization, carbon emissions, exchange rates, and income taxes. With this long-term relationship, the analysis can proceed to the short-term dynamics estimation stage. To analyze the interaction of these variables in the short term, the Error Correction Model (ECM) method is applied. This model serves to assess the level of error correction and adjust deviations, thereby

returning the system to long-term equilibrium. The Error Correction Model (ECM) estimation results are presented in Table 4.

Table 4. Short-term estimates

Variables	Coefficient	Probability
D(GDP)	0.001* (0.0009)	0.0859
D(FDI)	-0.092 (0.156)	0.5589
D(CO ₂)	-14.509 (2.015)	0.0000
D(UPG)	-0.197 (0.816)	0.8108
D(TR)	-0.056 (0.131)	0.6696
D(IDR)	0.0001 (0.131)	0.2573
ECT (-1)	-0.561*** (0.133)	0.0003
C	-0.874 0.22	0.0006
R-squared: 0.766		
Adjusted R-squared: 0.697		

Based on Table 4, the Error Correction Model (ECM) equation can be analyzed as follows. The value of the ECT(-1) coefficient of 0.003, which is smaller than 0.05, indicates that the ECM model has a significant influence in the short term. In other words, the model can adjust imbalances in the previous period towards long-term equilibrium significantly. In addition, an Adjusted R-squared value of 0.697 shows that independent variables, namely GDP, FDI, urbanization, carbon emissions, exchange rate, and tax revenue, contribute to explaining 69.7% of the variation of dependent variables. Meanwhile, the remaining 30.3% was influenced by other factors that were not included in this research model. This indicates that the model has a fairly good match level in explaining the relationship between variables. In these circumstances, incorporating additional factors would not significantly improve explanatory power but could instead lead to redundancy, multicollinearity, and overfitting, so undermining the robustness of inference.

Subsequent estimates reveal that, in the near run, GDP exerts a substantial influence on the dependent variable, with a coefficient of 0.001, signifying that economic growth affects the variation in the variable. Simultaneously, carbon emissions exert a considerable influence, evidenced by a coefficient of -14,509, indicating an inverse correlation between heightened carbon emissions and the utilization of renewable energy. In other terms, increased carbon emissions correlate with diminished demand of renewable energy. Conversely, other factors in this model exhibit no substantial impact in the short term, so they do not directly affect the dynamics of changes in the dependent variables during that timeframe.

Moreover, the core of the ECM is not in formulating the most intricate specification but in clarifying the error-correcting mechanism that connects short-term imbalances to long-term equilibrium. This study distinctly delineates these mechanisms: for example, GDP has a favorable short-term impact on renewable energy usage, which becomes negative in the long term, whereas carbon emissions consistently have a negative influence in both timeframes. These findings underscore that the selected specification is both parsimonious and robust, rendering supplementary variables or comparative modeling superfluous. Model simplicity combined with analytical rigor bolsters the trustworthiness of the results and offers clearer insights into the issues of Indonesia's energy transition.

Table 5 Classical assumption

Classical Assumptions	Coefficient	Information
Normality	0.835	Normally distributed
Autocorrelation	0.639	No autocorrelation
Heterokedastiness	0.776	There is no heterodoxy

The results of the classical assumption test in Table 5 indicate that the regression model in this study has met the requirements, because all coefficients are above the threshold of 0.05. The normality test with a coefficient of 0.835 showed that the data were distributed normally, so that the model could be used without concerns related to residual distribution. Furthermore, the autocorrelation test with a coefficient value of 0.639 confirmed that there was no autocorrelation in the model, ensuring that the independent variable was not affected by serial correlations that could interfere with the validity of the analysis results. Meanwhile, the heterokedasticity test that produced a coefficient of 0.776 showed that the residual variance remained stable, so there were no heterokedasticity problems that could interfere with parameter estimation. With all these classical assumptions fulfilled, the regression model can be considered reliable and worthy of use in analysis.

3.2. Discussion

Dumitrescu and Hurlin (2012) employ the Granger causality test to illustrate a reciprocal relationship between conventional energy consumption and economic growth, wherein economic growth stimulates an increase in renewable energy consumption and carbon dioxide emissions, while carbon dioxide emissions maintain a neutral relationship with both conventional and renewable energy consumption. The study's findings demonstrate that short-term economic growth substantially enhances renewable energy usage, whereas the effect becomes negative in the long term. The findings are corroborated by Yadav et al. (2024b), who assert that economic growth exhibits a favorable correlation with renewable energy utilization in Brazil, Russia, India, China, and South Africa (BRICS). Conversely, Shafira Annisa et al. (2024b) discovered in their study that GDP exerts a considerable negative impact on renewable energy usage. A multitude of factors can elucidate these findings. In the short term, swift economic expansion stimulates heightened investment in renewable energy technology and the advancement of sustainable infrastructure, bolstered by governmental policies and incentives that facilitate the energy transition (Abban et al., 2021; Dirma et al., 2024). In the long term, escalating industrial activity and heightened energy demands will likely lead to increased reliance on more stable and cost-effective conventional energy sources, resulting in a relative decrease in renewable energy use in relation to total energy consumption. Xu et al. (2022) emphasize the pivotal influence of governmental incentives and regulatory frameworks in fostering the expansion of the renewable energy sector in China, while also revealing the intricate interplay between state control and market dynamics. Mehta et al. (2023) investigated the governance problems of renewable energy investment in South Africa, indicating that although current regulations seem advantageous, their execution is impeded by bureaucratic inefficiencies and insufficient stakeholder cooperation. Furthermore, obstacles include restricted renewable energy capacity, elevated operating expenses, and fluctuations in policies and regulations may lead to a transition in the effects of economic expansion from favorable in the near term to detrimental in the long run. Although the short-term benefits of GDP on renewable energy are evident, Indonesia seems to encounter difficulties in sustaining its dedication to green energy following the early phase of industrialization. This indicates that the sustainability component remains a concern that has not been completely incorporated into the national economic growth strategy (Fadhilah and Susanti, 2019).

Foreign investment, in both the short and long term, does not affect renewable energy usage. This aligns with Tiwari et al. (2022), which found no significant association between stock market development and renewable energy consumption in Asia. The ineffectiveness of foreign investment unimpacting renewable energy consumption in Indonesia, both in the short and long term, can be attributed

to many primary causes. Most foreign investment is still focused on the industrial and manufacturing sectors that rely on conventional energy because they are more stable, cheap, and accessible than renewable energy, which requires high initial costs and adequate supporting infrastructure (Nor et al., 2024; Mauro, 2024). In addition, regulations and incentives from the government related to renewable energy are still not strong enough to attract foreign investors to switch to cleaner energy sources. Policy uncertainty, fluctuations in energy prices, and limited technology and production capacity of renewable energy in Indonesia are also obstacles to foreign investment in encouraging its use. As a result, although foreign investment contributes to national economic growth, its influence on renewable energy usage remains negligible. This underscores the growing significance of private and foreign finance in the renewable energy sector, highlighting the necessity for a more robust regulatory framework to guarantee the sustainability of financing (Nepal et al., 2021). The experience in Brazil (de Deus et al., 2022) illustrates that the effective incorporation of green finance in renewable energy initiatives, particularly in the solar and wind domains, is facilitated by aggressive governmental policies and international cooperation.

The study included a changeable exchange rate of the dollar relative to the rupiah to assess the influence of foreign investment. The results demonstrated that, over the long term, it exerts a substantial negative effect, but in the near term, it becomes negligible for renewable energy. The prolonged adverse impact of the dollar exchange rate relative to the rupiah on renewable energy consumption, which is negligible in the short term, can be ascribed to Indonesia's dependence on foreign investment in the non-renewable energy industry. In the immediate term, exchange rate variations have not directly affected renewable energy initiatives, which typically require considerable time to develop and continue to depend on government policies and the availability of technology (Li et al., 2025). However, in the long term, the depreciation of the rupiah against the dollar could increase the cost of importing renewable energy technology and equipment, most of which is sourced from abroad. This situation can inhibit investment in this sector as foreign investors tend to be more cautious in committing their capital to countries with unstable exchange rates. Additionally, the weakening of the rupiah may also lead investors to favor fossil energy-based projects, which are perceived as more profitable and supported by more established infrastructure than renewable energy.

The findings of this study indicate that urbanization exerts a substantial negative effect on renewable energy consumption in the long term, but this effect is negligible in the short term. This aligns with Shafira Annisa et al. (2024c), which suggests that urbanization exerts a modest short-term influence and a large negative effect on renewable energy usage in ASEAN. Conversely, it diverges with the conclusions of Vo et al. (2024), which indicate that urbanization adversely affects renewable energy consumption in the short term but yields a beneficial impact in the long run throughout growing ASEAN markets, with the exception of Malaysia. The long-term adverse impact of urbanization on renewable energy consumption in Indonesia, although negligible in the short term, can be ascribed to the initial phases of urbanization where urban development emphasizes infrastructure, residential areas, and industrial sectors that continue to depend on conventional energy due to its economic viability and availability. The shift to renewable energy requires substantial expenditures in technology and distribution systems, which are frequently deprioritized during the first development phase. Nonetheless, as urbanization persists throughout time, the escalating energy demand resulting from urban expansion, population growth, and heightened energy consumption in industrial and transportation sectors further solidifies dependence on fossil fuels, constraining the use of renewable energy. The absence of policies to effectively advocate for the integration of renewable energy in urban design has intensified this issue.

Carbon emissions have a significant negative impact on renewable energy consumption, both in the short and long term. Abdullah Abbas Amer et al. (2024) corroborate these findings, indicating that renewable energy utilization has a substantial negative association with carbon emissions (CO₂) in Gulf Cooperation Council (GCC) nations. The detrimental effect of carbon emissions on renewable energy utilization in Indonesia, both short term and long term, is due to the significant reliance on fossil fuels as a primary energy source across multiple sectors, including industry, transportation, and power

generation. In the immediate term, increasing carbon emissions signify the prevalence of fossil fuels, which are more economical and accessible than renewable energy sources, obstructing the shift to cleaner alternatives. In the long term, substantial investments and infrastructure established for fossil fuels pose structural impediments to the advancement of renewable energy. The absence of effective emission control policies and insufficient incentives for green energy development exacerbate this adverse trend. Zeraibi et al. (2024) propose that developing countries can expedite the transition to renewable energy by enhancing green electricity generation capacity and achieving sustainable economic growth through CO₂ emission reduction. Governments may implement taxes and incentives to motivate entrepreneurs and citizens to produce low-carbon, environmentally friendly technologies.

4. Conclusions

This research analyzed the short term and long term factors influencing renewable energy usage in Indonesia using the Error Correction Model (ECM). The results indicate that economic expansion positively influences renewable energy usage in the near term; yet, in the long term, it tends to exacerbate dependence on fossil fuels, a trend frequently seen in developing economies. Foreign direct investment has no significant impact, indicating the predominance of traditional energy-intensive sectors and the restricted focus of foreign money on renewable energy. Fluctuations in the exchange rate against the US dollar adversely affect the long-term utilization of renewable energy, as the nation's reliance on imported green technologies and equipment is intensified. Likewise, urbanization adversely impacts the long term, as urban expansion increases the demand for fossil fuels to sustain infrastructure and industrial growth.

Moreover, increasing carbon emissions correlate with a sluggish transition to renewable energy, underscoring the continued cost-effectiveness and availability of fossil fuels relative to cleaner options. The findings indicate that fortifying regulatory frameworks, augmenting incentives for green investment, and extending renewable energy infrastructure are crucial for expediting Indonesia's clean energy transition. By tackling structural and policy impediments, Indonesia can diminish its reliance on fossil fuels and attain a more sustainable energy future.

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