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Towards Achieving SDG 7 in Indonesia: Analysis of the Impact of Co_2 Emissions, Energy Use, and Economic Growth on Renewable Energy Consumption

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Abstract. Indonesia's economic growth has remained relatively stable; however, the accompanying energy consumption patterns have not progressed in tandem with this growth, revealing a misalignment with sustainable development principles. This study explores the influence of economic growth, total energy consumption, and CO_2 emissions on renewable energy consumption (REC) in Indonesia to provide insights for achieving Sustainable Development Goal (SDG) 7. Utilizing Indonesia's annual data from 2004 to 2021, the analysis employs the Autoregressive Distributed Lag and Error Correction Model (ARDL–ECM). The cointegration test confirms a stable long-term relationship among the variables. In the long run, both total energy consumption and CO_2 emissions exert a significant negative effect on REC, indicating that increases in these factors are associated with a lower share of renewables, likely due to persistent fossil fuel dependence. Conversely, economic growth exhibits a significant positive influence, serving as a potential driver for renewable energy adoption through enhanced investment capacity. Short-term estimates reveal a strong and rapid adjustment process toward long-term equilibrium, as evidenced by a highly significant Error Correction Term. These findings underscore the critical role of strategically steering the energy transition in Indonesia, highlighting that sustainable economic growth must be deliberately coupled with policies that actively decouple energy demand and emissions from fossil fuels to accelerate renewable energy consumption and achieve SDG 7 targets.

Keywords : *renewable energy consumption* (REC), economic growth, CO2 emissions, energy consumption, ARDL-ECM, SDG 7, Indonesia

INTRODUCTION

The global energy system has undergone a significant structural transition over the past three decades, characterized by steadily increasing demand and a persistent reliance on fossil-based resources. Despite global commitments to sustainability, progress remains slow. According to Tracking SDG 7: The Energy Progress Report 2024, the share of renewable energy in the world's total final energy consumption reached only 18.7% in 2021, indicating that the global energy transition requires substantial acceleration to meet SDG 7 targets. SDG 7 explicitly aims to ensure access to affordable, reliable, sustainable, and modern energy for all, with a key benchmark being a substantial increase in the renewable energy mix. This urgency is compounded by intensifying global pressure to reduce emissions, as energy-related CO_2 emissions reached a record high of 37.8 Gt in 2024 (IEA et al., 2024; UN, 2024; IEA, 2025).

This global phenomenon also occurs in Indonesia, where dependence on coal and oil remains high, while the share of renewable energy is relatively low (Hasan et al., 2012; Pambudi et al., 2023). Official data from the Central Statistics Agency (BPS) show that the proportion of renewable energy in final energy consumption in 2022 was 12.3%, still far from the 2025 target of 23%, as stipulated in the National Energy Policy through Government Regulation No. 79/2014. The goal of accelerating the energy transition to achieve a higher renewable energy mix is also emphasized in the IISD (2024) report on strategies to accelerate renewable energy adoption in Indonesia. This situation illustrates a structural dilemma hindering the achievement of the SDG 7 target—namely, the challenge of maintaining economic growth while curbing the rise of CO_2 emissions from fossil-based energy consumption (BPS, 2024; Suharsono et al., 2025).

The correlation between economic growth, energy consumption, and CO_2 emissions has been analyzed within the framework of the energy-growth nexus and the Environmental Kuznets Curve (EKC). Various international studies have found a dynamic long- and short-term relationship using the Autoregressive Distributed Lag – Error Correction Model (ARDL-ECM) method, while highlighting the contribution of renewable energy to emission reduction. Domestic research using ARDL-ECM has also demonstrated a long-term correlation between energy consumption, carbon dioxide emissions, and economic growth. Research conducted by Cherni and Jouini (2017), Zhang and Zhang (2021), and Shodrokova et al. (2024) shows that the use of renewable energy can reduce CO_2 emissions in both the long and short term, emphasizing the importance of energy efficiency in carbon reduction efforts. These findings are consistent with Rahayu et al. (2024), who indicate that renewable energy use has a significant negative effect on CO_2 emissions, while economic and population growth have insignificant effects in the long term. Both studies also identify a long-term relationship through the ECM approach, reinforcing the relevance of shifting from fossil energy to renewable sources as a means of reducing carbon emissions within the context of national economic growth.

Although many previous studies have been conducted, the majority have treated carbon emissions or economic growth as dependent variables. Few have explicitly analyzed the factors affecting Renewable Energy Consumption (REC) as a dependent variable within the ARDL-ECM framework. Moreover, research simultaneously examining the effects of economic growth, total energy consumption, and CO_2 emissions on renewable energy use in Indonesia remains limited, particularly with updated data post-2004.

Thus, there exists a gap in empirical research within Indonesia's energy literature. This study aims to examine the influence of total energy consumption, carbon dioxide (CO_2) emissions, and economic growth during the 2004–2021 period using the ARDL-ECM approach. The findings are expected to make an original contribution to the energy transition literature, strengthen evidence of long- and short-term correlations between energy and macroeconomic variables, and provide policy implications for accelerating renewable energy adoption toward achieving Indonesia's SDG 7 targets.

Renewable Energy Consumption (REC)

In the field of energy economics and sustainable development, Renewable Energy Consumption (REC) is widely recognized as an important indicator of the energy transition and a key measure for achieving Sustainable Development Goal (SDG) 7, particularly in increasing the share of renewable energy in total final energy consumption. Based on official SDG 7.2.1 data released by the United Nations Statistics Division, REC reflects the extent of change in energy consumption patterns from fossil fuels to clean, low-carbon energy sources. Thus, REC not only describes energy use but also indicates progress in transforming national energy systems.

Renewable Energy Consumption (REC) is influenced by economic growth, environmental pressures, and energy consumption patterns. This suggests that REC should be viewed as an outcome variable in energy transition analyses (Radmehr et al., 2021), as its growth does not occur automatically with economic expansion but depends on policy interventions and responses to emission pressures. Moreover, REC is strongly affected by the dominance of fossil energy in the national energy mix; therefore, increases in total energy consumption are not always accompanied by proportional growth in renewable energy (Hoa et al., 2024). These findings underscore the importance of using REC as a dependent variable to assess whether economic growth and environmental pressures truly contribute to progress toward SDG 7—particularly in the Indonesian context, which remains heavily reliant on fossil fuels.

Economic Growth to Renewable Energy Consumption (REC)

Economic growth, as measured by gross domestic product (GDP), plays a significant role in shaping renewable energy consumption patterns. GDP growth can increase the use of renewable energy by enhancing investment capacity—both from the government and the private sector—and by strengthening environmentally friendly energy and technology infrastructure. Under these conditions, economic progress serves as a driver of the energy transition when increasing national income is supported by energy policies that facilitate the development of renewable energy sources (Dat et al., 2020).

However, the relationship between GDP and Renewable Energy Consumption (REC) is not always positive. In developing countries, economic growth often triggers higher energy demand, which continues to be dominated by fossil energy sources due to cost advantages and infrastructure availability. Consequently, even if GDP rises, the proportion of renewable energy in total final energy consumption may stagnate. These findings indicate that the impact of GDP on REC is contextual—dependent on national circumstances—and is strongly influenced by the energy mix and policy direction. In this regard, within the Indonesian context, empirical analysis is required to determine whether economic growth functions as a driver of or remains insufficient in supporting increased renewable energy utilization (Rahman et al., 2023).

Carbon Dioxide (CO_2) Emissions to Renewable Energy Consumption (REC)

Carbon dioxide (CO_2) emissions indicate environmental degradation resulting from economic activities dependent on fossil fuels and are generally regarded as negative externalities in environmental economics. In the context of the energy transition, persistently high CO_2 emissions signal a fundamental reliance on fossil fuels that could hinder, rather than stimulate, renewable energy development—especially in countries still in the early phases of the energy transition.

Empirical evidence supports this perspective. A reduction in CO_2 emissions tends to occur only after renewables constitute a significant share of the energy system, suggesting that high emissions reflect a lagging transition rather than a catalyst for renewable adoption. Moreover, empirical studies have found a negative relationship between CO_2 emissions and renewable energy use in Asian countries, indicating that fossil fuel dependence and inadequate policy frameworks impede renewable energy's growth response to environmental pressures (Perone, 2024; Ali et al., 2025).

Total Energy Consumption (EC) to Renewable Energy Consumption (REC)

Total energy consumption represents the aggregate primary energy use within an economy, regardless of source. In Energy Transition Theory, a high level of energy consumption is often associated with fossil fuel dominance, particularly in developing economies undergoing industrialization and urbanization. According to Stern (2011), when overall energy consumption increases without structural changes in energy sources, dependence on fossil fuels intensifies, thus suppressing the development of renewable energy.

Empirically, several studies confirm that greater total energy consumption does not necessarily foster the growth of renewable energy shares, particularly in nations where fossil sources predominate. According to Yadav and Mahalik (2024), in developing economies where the energy structure is still highly dependent on non-renewable resources, growing energy demand tends to discourage renewable adoption, as fossil fuels remain cheaper and supported by mature infrastructure compared with clean energy systems still in developmental stages.

This finding aligns with Indonesia's energy profile, where rising national energy consumption remains dominated by coal and oil, limiting renewable energy's penetration within the overall energy mix. Global data likewise indicate that the share of renewables in total energy consumption remains relatively small despite the expansion of new and renewable energy (NRE) capacity. This trend reflects the broader challenges of the energy transition in developing countries and confirms that rising energy consumption without strong substitution and transition policies can, in fact, slow the growth of renewable energy consumption.

RESEARCH METHODS

This study was conducted by applying a quantitative approach using the time series analysis method to examine the correlation between renewable energy consumption (REC) and economic and environmental factors in Indonesia. The quantitative approach was chosen because it objectively explains the relationships among variables through econometric modeling. Time series analysis is used since the data analyzed have a temporal dimension and the potential to exhibit both long-term and short-term dynamics. In the context of energy economics, this approach is suitable for capturing the adjustment processes that occur to achieve equilibrium as economic and environmental variables change over time.

The methodology of this research is grounded in the Energy Growth Nexus theory and the Environmental Kuznets Curve (EKC) hypothesis. According to the Energy Growth Nexus theory, the relationship between energy consumption and economic growth may be one-directional or bidirectional, depending on a country's economic structure. Meanwhile, the EKC hypothesis posits that the relationship between economic activity and environmental pressure is dynamic and evolves with the level of economic development. Integrating these two theoretical perspectives necessitates the use of dynamic models capable of distinguishing between long-term and short-term effects. Therefore, the Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM) are employed as the primary analytical tools.

The conceptual framework of this study suggests that renewable energy consumption (REC) is influenced by total energy consumption, carbon dioxide (CO_2) emissions, and economic growth. Energy consumption reflects the structure of the energy mix, which influences the potential for substitution toward renewable energy. Carbon dioxide emissions represent environmental pressures that may drive changes in energy policies and consumption choices. Meanwhile, economic growth indicates an increase in production capacity and income, which in turn affects energy demand and the adoption of clean energy technologies.

Based on the Energy Growth Nexus theory and the Environmental Kuznets Curve (EKC) hypothesis, this study formulates hypotheses that can be empirically tested. These hypotheses are designed to determine how each independent variable correlates with renewable energy consumption (REC) and whether a long-term relationship exists among these variables. Therefore, the research hypotheses are structured as follows:

H1 : Total energy consumption affects renewable energy consumption (REC) in Indonesia

H2 : Carbon dioxide (CO2) emissions affect renewable energy consumption (REC) in Indonesia

H3 : Economic growth affects renewable energy consumption (REC) in Indonesia

H4 : There is a long-term correlation between renewable energy consumption (REC), total energy consumption, CO2 emissions and economic growth in Indonesia.

The study used *Autoregressive Distributed Lag* (ARDL) and *the Error Correction Model* (ECM). The ARDL-ECM method was applied to analyze the long-term and short-term relationship between renewable energy consumption (REC), economic growth, energy consumption and carbon dioxide (CO2) emissions in Indonesia. This method is used because it is able to accommodate variables with different levels of stationaryness, either stationary at level (l(0)) or at the first difference (l(1)) while there are no variables that are stationary at the second difference (l(2)). The ARDL model is also suitable when used on a limited sample size and provides an opportunity to estimate long-term and short-term relationships simultaneously. The long-term model applied in this study is formulated as follows:

$$\ln RECt = \beta 0 + \beta 1 \ln EUt + \beta 2 \ln CO2t + \beta 3GDPt + ut$$

Description :

$RECt$ = renewable energy consumption (REC)/renewable energy consumption

EUt = energy consumption

$CO2t$ = carbon dioxide emission

$GDPt$ = economic growth (GDP per capita)

t = time period

$\beta 0$ = intersep

$\beta 1, \beta 2, \beta 3$ = long-term regression coefficient

ut = residual

To understand short-term changes and adaptation mechanisms towards long-term equilibrium, the model is changed to the form of *Error Correction Model* (ECM) as follows:

$$\Delta ln\, REC_t = \beta_0 + \beta_1 \Delta ln\, EU_t + \beta_2 \Delta ln\, CO2_t + \beta_3 \Delta GDP_t + \gamma ECT_{\{t-1\}} + \varepsilon_t$$

Description :

Δ = variable change

$ECT_{\{t-1\}}$ = *error correction term*

γ = *speed of adjustment*

ε_t = error term

It is expected that the error correction term coefficient has a statistically significant negative value, indicating the adjustment process from short-term deviations toward long-term equilibrium.

At the initial stage of the time series analysis, a stationarity test was conducted on all variables using the Augmented Dickey-Fuller (ADF) test to determine the degree of integration of each variable. The stationarity test ensures that the data used are stationary, thereby preventing pseudo-regression. The test was carried out at both the level and first-difference stages in accordance with time series econometric standards. After confirming that all variables met the stationarity requirements, the next step involved constructing a long-run equation by regressing the dependent variable on the independent variables.

Once the degree of integration of the variables was determined, the ARDL model was estimated with the optimal lag length selected based on the Akaike Information Criterion (AIC). A cointegration test was then performed to examine whether long-term relationships exist among the variables. This study employed the Bounds Testing Approach within the ARDL framework and the Johansen cointegration test to reinforce the findings. When the F-statistic value in the Bounds Test exceeds the upper bound critical value and the Johansen test indicates the presence of a cointegrating vector, it can be concluded that the variables in the model exhibit a long-run equilibrium relationship.

The validity and robustness of the models in this study were evaluated using diagnostic and stability tests commonly applied in the ARDL-ECM framework. Autocorrelation was tested using the Breusch-Godfrey Serial Correlation LM Test, which is suitable for dynamic models containing lagged variables. A model is considered free from autocorrelation if the chi-square probability value exceeds the 5 percent significance threshold, indicating no serial correlation in the residuals. Heteroskedasticity was examined using the Breusch-Pagan-Godfrey Test; the model is deemed homoskedastic if the chi-square probability value is greater than 5 percent. Model stability was assessed through CUSUM and CUSUM of Squares tests, with the model considered stable when the test graphs remain within the 5 percent confidence bands. After fulfilling all these diagnostic and stability tests, the ARDL-ECM model applied in this study is deemed both feasible and valid for empirical analysis.

The data used in this study consist of annual time series secondary data covering the period 2004–2021. Data for all variables were obtained from the World Bank and other official sources to ensure validity, reliability, and comparability across time. The variables—renewable energy consumption (REC), energy consumption, and carbon dioxide emissions—were transformed into natural logarithmic form to reduce variance heterogeneity and facilitate coefficient interpretation as elasticities. Data processing was carried out consistently to ensure that all variables share the same observation period. Thus, the dataset used in this study is appropriately structured for analysis using the ARDL-ECM approach.

RESULTS AND DISCUSSION

Data analysis was conducted to examine the correlation among energy consumption, Gross Domestic Product (GDP) per capita, carbon dioxide (CO_2) emissions, and renewable energy consumption (REC) in Indonesia during the period 2004–2021 using the ARDL-ECM method.

The analysis began with a stationarity test. The unit root stationarity test is a preliminary test that must be performed before applying the ARDL-ECM approach. The purpose of this stationarity test is to determine whether the mean and variance of the data remain constant over time, and whether the variance of the time series data depends on the time lag between two or more periods. The results of the stationarity test are presented in Table 1. Next:

Stationariness test

Table 1. Stationariness Test (ADF Test)

Variabel	Level		First Difference	
	p-value	Conclusion	p-value	Conclusion
REC	0.9521	Not Stationary	0.0168*	Stasions
WE	0.9340	Not Stationary	0.0055*	Stasions
CO2	0.9327	Not Stationary	0.0015*	Stasions
GDP	0.5071	Not Stationary	0.0439*	Stasions

Source : Processing Data Eviews 12, 2025

Description:
*) Significant at the level of 5 percent

Stationary testing was applied using Augmented Dickey Fuller (ADF). The results of the test showed that the variables of renewable energy consumption (REC), energy consumption (EU), carbon dioxide (CO2) emissions and *Gross Domestic Product (GDP)* were not stable at the level level, but became stable at *the level of first difference*. Therefore all variables are integrated on order (l(1)), so they are eligible for analysis using ARDL-ECM.

Long-Term Equations

Table 2. ARDL Long-Term Estimation Results

Variable Dependen: REC				
Variabel	**Coeficin**	**Std. Error**	**t-*statistic***	**p-value**
C	8.624379	0.1488409	5.794362	0.0001*
WE	-0.735971	0.166513	-4.419897	0.0008*
CO2	-1.043584	0.193071	-5.405182	0.0002*
GDP	9.79E-05	2.64E-05	3.714230	0.0030*
F-statistic	373.2965		R-*squared*	0.992028
Prob (F-stat)	0.000000		*WO R-Squared*	0.989370

Source : Processing Data Eviews 12, 2025

Description:
*) Significant at the level of 5 percent

Cointegration Test

The cointegration test is run to test the residual on the long-term model whether it is stationary at the level level or not.

Table 3. Bound Cointegration Test

Test Statistic	Value	Signif.	I(0)	I(1)
	25.463733	10%	2.37	3.2
		5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Source : Processing Data Eviews 12, 2025

Table 4. Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eignvalue	Trace Statistic	0.05 Critical Value	Prob**
None*	0.768906	49.61515	47.85613	0.0338

Source : Processing Data Eviews 12, 2025

The results of the long-term cointegration test conducted using the Bounds Testing Approach are presented in Table 3. The F-statistic value of 25.461515 is greater than the upper bound critical values at the 1 percent, 5 percent, and 10 percent significance levels. This confirms the existence of a cointegration relationship among the variables. The results are further supported by the Johansen cointegration test using Trace statistics, which identified a single cointegration vector at the 5 percent significance level. Thus, it can be concluded that renewable energy consumption (REC), CO_2 emissions, energy consumption, and economic growth move together in a long-term equilibrium.

The Effect of Energy Consumption (EC) on Renewable Energy Consumption (REC)

The findings indicate that energy consumption (EC) has a negative and significant effect on renewable energy consumption (REC) in Indonesia. The EC coefficient is -0.735971, with a t-statistic of -4.419897 and a probability value of 0.0008. These results suggest that a 1 percent increase in total energy consumption leads to a decrease of approximately 0.73 percent in renewable energy consumption, ceteris paribus. This significance level indicates that Indonesia's energy consumption remains dominated by fossil-based sources, meaning that rising energy demand continues to limit opportunities for renewable energy utilization.

These findings are consistent with Yadav and Mahalik (2024), who revealed that in developing countries, increases in total energy consumption do not necessarily raise the share of renewable energy, mainly because their energy structures remain heavily reliant on fossil fuels. The result reinforces the argument that when energy systems are dominated by non-renewable sources, growth in total energy consumption strengthens dependence on fossil energy and constrains renewable energy adoption.

In the Indonesian context, these findings confirm that the increase in total energy use between 2004 and 2021 has not been accompanied by sufficient substitution toward renewable sources. Therefore, an increase in national energy consumption without strong transition policies has the potential to hinder the growth of renewable energy consumption and impede the achievement of SDG 7 targets.

The Effect of CO_2 Emissions on Renewable Energy Consumption (REC)

The findings also indicate that CO_2 emissions have a negative and significant effect on renewable energy consumption (REC), with a coefficient of -1.043584 and a probability value of 0.0008. These results imply that rising carbon emissions in Indonesia do not drive the energy transition; instead, they reflect the structural dependence on fossil fuels that continues to dominate the national energy system.

These findings align with Fibula (2024), who emphasized that reductions in CO_2 emissions generally occur only when renewable energy sources have been significantly integrated into the national energy system. In situations where fossil fuels remain dominant, increasing emissions do not automatically stimulate the growth of renewables—instead, they signal a slow transition process.

Similarly, Ali et al. (2025) demonstrated using a dynamic panel model for several Asian countries that CO_2 emissions have a negative effect on renewable energy consumption (REC), as nations with high emission levels tend to preserve fossil-based energy systems to sustain economic growth and ensure energy stability. Without effective policy interventions, continued carbon emissions hinder renewable energy adoption because of the inertia created by existing fossil-fuel technologies and infrastructure (Ali et al., 2025).

In the Indonesian context, these findings confirm that environmental pressures alone are insufficient to transform the energy structure toward renewable sources in the absence of robust policy support. Therefore, CO_2 emissions in Indonesia reflect structural barriers to the energy transition rather than acting as a direct driver of increased renewable energy consumption.

The Effect of Economic Growth (GDP per capita) on *Renewable Energy Consumption* (REC)

These empirical findings indicate that GDP per capita has a significant positive effect on *renewable energy consumption* (REC) in Indonesia in the long term with a coefficient of 9.79E-05 and a probability of 0.0030. The positive coefficient shows that the increase in revenue expands the financing capacity of clean energy technology. This shows an increase in the economic ability of communities and the public sector to switch to clean energy sources that are often more expensive at the beginning of their implementation. Economically, this is in line with *the theory of the energy ladder* and the clean energy transition, where countries with higher per capita incomes tend to have more advanced energy demand patterns as well as policies that encourage investment in clean energy because they are able to bear the costs of new technologies and improve energy efficiency.

Referring to the findings, these findings show that economic growth does not directly lead to an increase in the use of renewable energy. This is due to the fact that the additional energy needs in developing countries are still largely met by more economical fossil energy sources and supported by existing infrastructure. Rahman et al. (2023)

In the Indonesian context, although per capita income has a positive impact on *renewable energy consumption*, this influence shows that there is potential that has not been fully utilized structurally. Thus, economic growth can only play a role in supporting the energy transition if combined with energy policies that proactively direct increased energy demand towards renewable energy sources.

Short-Term Equations

Table 5. ECM Short-Term Estimate Results

Variabel	Coeficin	Std. Error	t-*statistic*	Prob
	-0.990369	0.076012	-13.02912	0.0000

Source : Processing Data Eviews 12, 2025

Description:

*) Significant at the level of 5 percent

These findings indicate that the Error Correction Term (ECT_{-1}) has a value of −0.990369 and is statistically significant, demonstrating the existence of a short-term adjustment mechanism toward long-term equilibrium. An ECT value approaching −1 shows that almost all short-term deviations from the long-term balance among Renewable Energy Consumption (REC), Energy Use, CO_2 emissions, and GDP per capita are corrected within a single period. This result suggests that the long-term relationship among these variables is stable and binding, implying that short-term fluctuations are not persistent.

The results of this study are supported by Xuan et al. (2025), who found that a significant error correction coefficient reflects the strength of the structural relationship among economic variables, energy use, and carbon emissions. Their study emphasizes that the magnitude of the ECT in absolute value indicates the system's capacity to return to its long-term equilibrium path after encountering short-term disturbances, whether driven by changes in economic activity or environmental factors. Therefore, the ECT functions not only as evidence of cointegration but also as a measure of the speed of the system's response to disequilibria.

A relatively high ECT value indicates that Indonesia's energy–economic system can adapt effectively to temporary disruptions. However, these results also suggest that, without structural shifts in the long-term equilibrium—particularly regarding the continued dominance of fossil energy sources—a rapid adjustment process may reinforce existing patterns. The ECM findings confirm that Indonesia's main challenge in achieving SDG 7 lies not in instability within short-term dynamics, but in the orientation of a long-term equilibrium that has yet to sufficiently support the expansion of renewable energy use.

Classic Assumption Test

Classical assumption tests are carried out to ensure the validity of the model created as a prediction generator.

Table 6. Normality Test Results, Autocorrelation (LM Test), Heterokedasticity

Classic Assumption Test	p-value	Remarks
Normality	0.4132	Failed to Reject Ho
Autocorrelates	0.2187	Failed to Reject Ho
Heterokedastisitas	0.6876	Failed to Reject Ho

Source : Processing Data Eviews 12, 2025

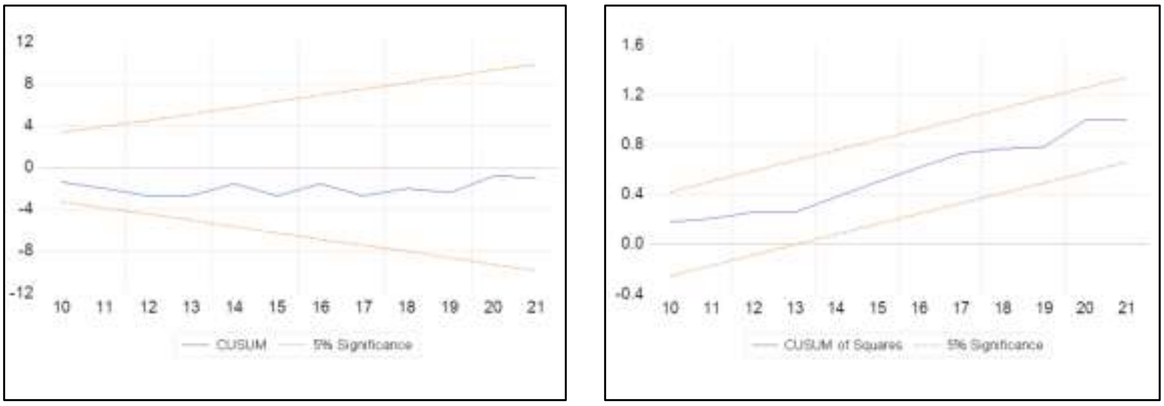
Table 6 shows that the p-values for the normality, non-autocorrelation, and heteroskedasticity tests are higher than the 5 percent significance level. The conclusion drawn is to fail to reject H_0. Thus, it can be concluded that, at the 5 percent significance level, the classical assumptions of normality, autocorrelation, and heteroskedasticity have been satisfied in the model.

The normality test is conducted to examine whether the residuals are normally distributed. Residuals can be considered normally distributed if the probability value exceeds the 5 percent (0.05) significance threshold. The estimated p-value for the normality test in this study is 0.4132, which is greater than 0.05. Therefore, the residuals are normally distributed, confirming that the model satisfies the normality assumption.

An autocorrelation test is applied to detect whether there is a correlation between residual errors across time periods, particularly between period t and period t−1. Based on the autocorrelation test using the Breusch-Godfrey Serial Correlation LM Test, the p-value obtained is 0.2187, which is greater than the 5 percent significance level. These results indicate that there is no autocorrelation present in the model.

The heteroskedasticity test is carried out to analyze whether residual variance is consistent across observations. The results of the heteroskedasticity test using the Breusch-Pagan-Godfrey Test show a p-value of 0.6876, which is greater than 0.05. This indicates that no heteroskedasticity problem exists in the model.

The stability of the ARDL model is evaluated using CUSUM and CUSUM of Squares tests. As shown in Figure 3, the CUSUM and CUSUM of Squares lines remain within the 5 percent significance boundaries throughout the period 2004–2021. These results confirm that the model is stable and does not experience significant structural changes over time, emphasizing its long-term reliability.



Gambar 1. Cumulative sum of recursive residuals (CUSUM)
Source : Processing Data Eviews 12, 2025

This study shows clear evidence that the increase in total energy use and CO_2 emissions in Indonesia does not encourage the use of renewable energy, but rather strengthens dependence on fossil fuels. By formulating renewable energy consumption as an affected variable within the ARDL–ECM framework, the findings suggest that rapid short-term adjustments reflect stability around a long-term balance dominated by fossil fuels, rather than an efficient energy transition. These results explain why progress in achieving SDG 7 is still hampered in fossil fuel-dependent developing countries.

CONCLUSION

This study aims to evaluate the impact of economic growth, energy consumption, and carbon dioxide (CO_2) emissions on renewable energy consumption (REC) in Indonesia by applying the Autoregressive Distributed Lag–Error Correction Model (ARDL-ECM) for the period 2004–2021. The results of the stationarity test indicated that all variables were integrated at the first difference I(1), thereby meeting the requirements for ARDL-ECM analysis. The cointegration test confirmed the presence of a stable long-term relationship among the variables studied.

The long-term estimation results show that energy consumption and CO_2 emissions have a significant negative effect on renewable energy consumption (REC). This finding suggests that growing energy demand and environmental pressures in Indonesia continue to be driven by fossil fuel use, indicating that the energy transition has not yet been effectively achieved. Conversely, economic growth exerts a significant positive influence on renewable energy consumption (REC), implying that increased economic capacity supports renewable energy adoption through enhanced investment and technological development.

The results of the ECM estimation reveal that the coefficient of the error correction term is significantly negative, indicating a swift adjustment process toward long-term equilibrium. Overall, the findings affirm that Indonesia's renewable energy transition depends heavily on structural changes within the national energy mix and continuous policy support aimed at achieving Sustainable Development Goal (SDG) 7.

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