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TRANSITIONING TO RENEWWABLE ENERGY: CHALLENGES, POLICIES, AND ECONOMIC IMPLICATIONS IN INDONESIA (1990-2023)

Muhammad Syahrul Hidayat
UIN Sunan Ampel Surabaya, Indonesia
Email: syahrulhidayat@gmail.com

Ahmad Munir Hamid
Sekolah Tinggi Ilmu Ekonomi Cendekia Bojonegoro, Indonesia
Email: mazidahnurul@stiekia.ac.id

Nurul Mazidah
Universitas Islam Darul ‘Ulum Lamongan, Indonesia
Email: munirhamid@unisda.ac.id

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Corresponding Author:
syahrulhidayat@gmail.com

Abstract

The Indonesian Government, through the National Energy Council, has set a roadmap for achieving zero emissions energy by 2060, with targets for increasing renewable energy use each year. Despite aiming for a 23% target by 2025, the current annual increase in new renewable energy in Indonesia is only 0.55%, far below the required 0.9%. This calls for more progressive policy planning to achieve the new energy target. Challenges include the dispersed nature of Indonesia's renewable energy potential, limited grid capacity, and domestic industry capability. This study examines the impact of renewable and non-renewable energy on Indonesia's economic growth from 1990 to 2023. Employing a quantitative approach with the Error Correction Model (ECM) statistical test, the research explores short-term and long-term relationships among variables. Findings reveal that non-renewable energy consumption (CONRE) positively and significantly impacts economic growth by 6.15%, while renewable energy for electricity (REFE) also has a positive and significant effect of 7.19%. However, renewable energy from water resources (REWR) shows no significant positive impact in the long term, at only 0.19%. In the short term, CONRE positively and significantly affects economic growth by 6.43%, whereas REFE and REWR exhibit insignificant impacts of 0.075% and 0.071% respectively. The study suggests the government should optimize renewable energy potential to achieve more environmentally friendly energy policies, considering factors beyond those studied, such as societal innovation and creativity in identifying energy source potential and gaps.

INTRODUCTION

The Indonesian Government through the National Energy Council has formulated a roadmap towards zero emissions. The aim is to achieve a transition to zero emissions energy by the year 2060. Each year will implement targets for increasing the use of renewable energy, starting from 2025 with an initial target of 23%, up to 66% by 2060. The Indonesian Government aims to achieve the 23% target for new renewable energy by 2025; however, the reality is that the increase in new renewable energy in Indonesia is only 0.55% per year. The target that the government should achieve for the annual attainment of new renewable energy is 0.9% (National Energy Council, 2020). Therefore, more progressive policy planning is needed to achieve this new energy target. Analysis is required regarding how the government observes macroeconomic factors influencing the use of new renewable energy, as currently, the comparison of new renewable energy usage with conventional energy such as oil, natural gas, and coal is only at 10%.

The use of conventional energy, as mentioned (Janiszewska, 2019; Jebli & Hakimi, 2023) is still significantly greater than the use of new renewable energy. Various efforts to achieve an ideal energy mix, especially the New and Renewable Energy (NRE) mix as outlined in government scenarios, have yet to meet the expected targets. Several challenges commonly arise in Indonesia's efforts to achieve renewable energy milestones, including the dispersed nature of Indonesia's new renewable energy potential, limited grid capacity to accommodate intermittent electricity from some new renewable sources, necessitating large-scale electricity storage facilities. Additionally, referring to (Secretariat General of the National Energy Council, 2022a) the limited domestic industry capability in terms of technology and market uncertainty also pose persistent barriers that have not improved in alignment with the targets.

In this regard, the Indonesian government has endeavored to increase the productivity of renewable energy procurement through consistent investment efforts in renewable energy. The Directorate of Energy Conservation noted that the realization of investments in 2017 reached Rp 48 billion, which certainly surpassed the set target of Rp 41.4 billion. Throughout 2017, the majority of energy efficiency investment implementations resulted from partnerships in energy audit-rated investments in 2015 and 2016. (Secretariat General of the National Energy Council, 2022b) mentions that cooperation between the central and regional governments in the field of energy efficiency has become more apparent with the emergence of investments from regional budgets since 2017.

In general, Indonesia is highly optimistic about renewable energy for the future and is transitioning from energy changes to renewable energy. Several studies (Damodaram et al., 2022; Xu & Wu, 2023; Yalçın Dokumacı et al., 2023) discuss how global conditions serve as a reference for Indonesia in advancing renewable energy, and insights into non-renewable energy are provided by some significant findings. The use of renewable energy and financial development do not have a strong influence on economic growth (Fareed & Pata, 2022; Hao, 2022). However, it is concluded that the use of renewable energy has a positive impact on financial development. Therefore, (Khan et al., 2023) suggest that the use of renewable energy should be encouraged by domestic policymakers. However, it is revealed (Elshimy & El-Aasar, 2020; Joshi & Waghole, 2024; Khan et al., 2023) that to understand key indicators of economic growth, many different factors must be considered. The concepts of renewable energy and renewable energy sources, the relationship between renewable energy sources and sustainable energy supply are positively confirmed and consistent with the findings of relevant previous studies.

Indonesia's economic growth is closely related to investment (Yurioputra, 2022), as mentioned in (Fazaalloh, 2022; Millia et al., 2022) which has a positive impact on Gross Regional Domestic Product (PDRB) or national income. Investment also has a positive relationship with Gross Domestic Product (GDP) (Fazaalloh, 2022). In the context of energy, although there is no direct data mentioning the percentage of energy investment to Indonesia's PDRB, several studies (Hanim & Wilantari, 2022; Jannah et al., 2022; Millia et al., 2023; Murniati, 2023) indicate that energy investment has a significant impact on economic growth. One study (Suhartina, 2023) suggests that a 1% increase in energy investment can increase economic growth by 0.2%. Investment in the energy sector has a significant impact on economic growth. This indicates that increased energy investment can enhance production, productivity, and efficiency, which will eventually affect PDRB or national income. Therefore, energy investment can be considered one of the important factors in Indonesia's economic growth. Furthermore, the most crucial point from the study findings (Amigues et al., 2015; Bukhari et al., 2023; Fadilah et al., 2020; Tipantuña & Hesselbach, 2020) is that sustainable energy supply is found to have a positive impact on sustainable economic growth in Vietnam. (Deka et al., 2024; Ohlan, 2016; Paramati et al., 2018) illustrate that one of the key components in accelerating economic growth in the energy sector is government support, which is one of the main drivers of the positive impact on renewable energy and significant electricity generated from renewable energy sources, CO2 emissions, on economic growth. However, the positive and significant impact of carbon dioxide remains a challenge to achieve sustainability. Policies have been identified to develop the necessary energy networks in the future. Renewable energy mentioned in (Anwar et al., 2021; Deka et al., 2024; Ohlan, 2016; Paramati et al., 2018; Pata et al., 2023; Ramedani et al., 2011) is a potential global source and particularly in Indonesia, renewable energy must be developed sustainably for a country's activities. When viewed from the movement of renewable and non-renewable energy in Indonesia, it is presented as follows:

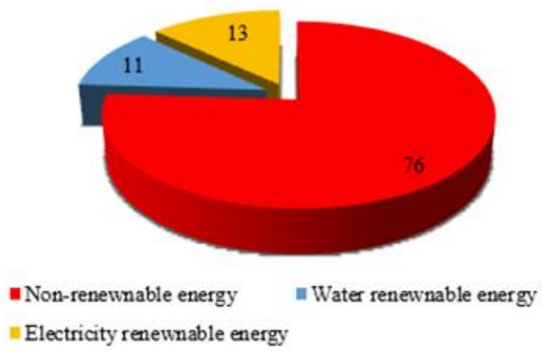


Figure 1. Percentage of energy usage in Indonesia during the years 1990-2023

Figure 1 illustrates the consumption trends of renewable and non-renewable energy in Indonesia from 1990 to 2023. During this period, non-renewable energy sources accounted for 76% of Indonesia's total energy consumption, while renewable energy, including hydro resources, contributed 13% to the electricity generation. Since 2010, Indonesia has been engaged in a deliberative process aimed at enacting Government Regulation No. 79 of

2014, which outlines the National Energy Policy. However, this regulation primarily focuses on energy supply and lacks specific targets for greenhouse gas emissions reduction, despite a shift in energy policy towards addressing demand-side issues. In support of the National Energy Policy's objectives related to the integration of new and renewable energy (EBT), the Indonesian government has implemented various regulations, including Feed-in Tariffs, to incentivize the sale of electricity from renewable sources. Nonetheless, some studies have suggested that the implementation of these regulations has been suboptimal due to higher prices, thus hindering the widespread adoption of renewable energy in Indonesia (Shahbaz et al., 2020).

Recent studies indicate that while some countries, more advanced than Indonesia, have not yet achieved sustainable development of renewable energy and continue to rely heavily on non-renewable sources, others have made significant progress (Klass, 2003; Pishgar-Komleh et al., 2012; Sharif et al., 2019; Yu et al., 2023) Additionally, research has shown that energy consumption, including both non-renewable and renewable sources, as well as factors such as capital and labor, significantly influence economic growth. A comprehensive study examining 99 countries worldwide has concluded that while energy consumption is crucial for economic growth, overreliance on non-renewable sources poses environmental challenges(Eisgruber, 2013; Li et al., 2015; Shah et al., 2020) Therefore, prioritizing the renewable energy sector is recommended to ensure the development of an efficient and environmentally friendly energy system.

Despite the advocacy of G-20 countries for addressing global warming and climate change, they continue to fund fossil fuel production, leading to adverse environmental impacts (Murshed et al., 2021; Wen et al., 2022). In Indonesia, the development of renewable energy is hindered by fiscal policy changes influenced by various political interests, institutional challenges, and limited inter-agency communication among stakeholders. Although Indonesia has implemented fiscal policies to attract investment in infrastructure projects, including renewable energy, political instability and policy uncertainty remain significant barriers(Heeter & Bird, 2013; Nugroho & Fei-Lu, 2017). This study aims to comprehensively analyze the impact of renewable and non-renewable energy on the Indonesian economy over a 33-year period. The expected outcome is to provide insights into the long-term and short-term effects of renewable and non-renewable energy on the Indonesian economy, serving as a valuable reference for energy development in Indonesia.

Energy Transition Theory examines the shift from non-renewable fossil fuel-based energy systems, such as oil, gas, and coal, to renewable energy sources like solar, wind, and hydropower (Yakubu, 2023). This theory encompasses various aspects such as technology, policy, economy, and society (Byrne, 2017). The transition requires changes in energy infrastructure, consumption patterns, and government regulations. In Indonesia, this transition faces significant challenges, including dependency on fossil fuels, inadequate infrastructure, and resistance from existing industries. Public Policy Theory explains how policies are formulated, implemented, and evaluated. In the context of energy transition in Indonesia, government policies are crucial in determining the direction and speed of the transition (Midttun & Witoszek, 2015). This theory helps understand how the government formulates policies related to fossil fuel subsidies, incentives for renewable energy, and regulations to reduce carbon emissions (Leal-Arcas, 2022). These policies act as key determinants in overcoming the challenges of the energy transition. Green Economy Theory focuses on achieving sustainable economic growth while minimizing negative environmental impacts (Scipioni et al., 2023). This includes developing the renewable energy industry, which can create new jobs, reduce dependence on energy imports, and enhance local economic welfare (Boudellal, 2023). In the context of Indonesia, applying this theory involves analyzing how investments in the renewable energy sector can impact economic growth and income distribution within society. Social Change Theory explains how societies adapt to significant changes in economic, technological, and cultural structures (Sokoiowski, 2022). In transitioning to renewable energy in Indonesia, these changes involve shifts in public perceptions of energy sources, adaptation in energy consumption practices, and increased awareness of climate change impacts (Hall et al., 2015). This theory helps identify social factors that may support or hinder the energy transition, such as public knowledge about renewable energy, social acceptance, and behavioral changes.

RESEARCH METHODS

This research adopts a descriptive quantitative approach to problem-solving, involving the presentation, analysis, and interpretation of data. The data utilized are secondary and sourced from various publications, official data platforms, and data collection books. The observational scope encompasses Indonesia, with a time series spanning 33 years (1990-2023). The data are sourced from the official website https://data.worldbank.org/. Below is a synopsis of the variables, units, descriptions, and data sources utilized in this study:

Economic Growth: This variable gauges the expansion and advancement of income (GDP) derived from the production of goods and services within Indonesia.

Non-renewable Energy Consumption: This encompasses the percentage of total energy consumption derived from fossil fuels, including coal, oil, petroleum, and natural gas products.

Renewable Energy from Water Resources:

This variable represents renewable freshwater resources per capita measured in cubic meters. It refers to domestic renewable resources, including domestic river flows and groundwater from rainfall, within Indonesia. The calculation of renewable domestic freshwater resources per capita utilizes population estimates from the World Bank.

Renewable Energy in the Form of Electricity: This denotes the percentage of total electricity generation derived from renewable sources. It pertains to the portion of electricity generated by renewable power plants within the overall electricity generation mix.

RESULTS AND DISCUSSIONS

Stationarity testing in this study employs the Augmented Dickey-Fuller Test (ADF) method, which is commonly used to assess the stationarity of a time series. The ADF test involves testing the null hypothesis (H0) that a time series has a unit root, indicating non-stationarity. If the absolute t-value (test statistic) is greater than the absolute critical value of MacKinnon corresponding to the chosen significance level, we reject H0, indicating that the time series data is stationary. Conversely, if the t-value does not exceed the MacKinnon critical value, we fail to reject H0, suggesting that the time series data is non-stationary. For negative t-values, a similar analysis is conducted. If the t-value is less than the MacKinnon critical value, we reject H0, indicating stationarity. Conversely, if the t-value does not exceed the MacKinnon critical value, we fail to reject H0, indicating non-stationarity.

Table 1. Unit Root Test Results

Variable	ADF t-Statistic	Prob	Results	Results

EG	-1.6368	0.3143	Accepted H0	Non-stationary
CONRE	-4.9437	0.0006	Rejected H0	Stationary
REFE	-3.7648	0.0786	Accepted H0	Non-stationary
REWR	-2.4153	0.6174	Rejected H0	Non-stationary

Table 1 presents the results of the unit root test conducted on the variables. The variables are Economic Growth, Consumption of Non-Renewable Energy, Renewable Electricity Production, and Renewable Freshwater Resources. For each variable, the table shows the Augmented Dickey-Fuller (ADF) t-statistic, the associated probability (Prob), and the result of the test. The results column indicates whether the null hypothesis (H0) of a unit root is accepted or rejected, which determines the stationarity of the variable. Based on the table, the variable Consumption of Non-Renewable Energy has an ADF t-statistic of -4.9437 and a probability of 0.0006. Since the probability is less than the significance level of 0.05, the null hypothesis of a unit root is rejected, indicating that the variable is stationary.

On the other hand, variables Economic Growth, Renewable Electricity Production, and Renewable Freshwater Resources have ADF t-statistics of -1.6368, -3.7648, and -2.4153, respectively. The probabilities associated with these variables are 0.3143, 0.0786, and 0.6174, respectively, all of which are greater than 0.05. Therefore, the null hypothesis of a unit root is accepted for these variables, indicating that they are non-stationary. Therefore, a retest will be conducted using the root test at the first difference level for each variable, with the results presented in the next table

Table 2. Results of the root test at the first difference level

Variable	ADF t-Statistic	Prob	Results	Results
EG	-7.1476	0.0000	Accepted H0	Stationer
CONRE	-5.7468	0.0112	Accepted H0	Stationer
REFE	-7.3448	0.0000	Accepted H0	Stationer
REWR	-6.8053	0.0000	Accepted H0	Stationer

In Table 2, the results of the unit root test conducted at the first difference level for all variables show that they exhibit stationary properties. This implies that the data used in this study is integrated at the first order, denoted as I (1), and is free from spurious regression issues. Meeting the stationarity requirement allows for further processing in the subsequent stage of data analysis.

The objective of cointegration testing is to determine whether there is a long-term relationship between independent and dependent variables. The Engle-Granger (EG) cointegration test method is utilized for this purpose. If the absolute value of the t-statistic exceeds the critical value in absolute terms based on the MacKinnon critical value, it indicates the presence of residual cointegration, which implies a long-term relationship between the variables. Conversely, if the t-statistic is negative and smaller than the MacKinnon critical value, it also suggests residual cointegration and thus a long-term relationship between the variables.

Table 3. Engle-Granger Cointegration Test Results

Variable	ADF T-Statistic	Prob	Results	Results
Ect(-1)	-42.732	0.002	Rejected H0	Stationer

Based on Table 3, the results of the cointegration test using the Engle-Granger method indicate that the residual (resid01) exhibits stationary characteristics at an observable level, as evidenced by the t-count values exceeding the MacKinnon critical values at the 5% and 10% significance levels. This indicates the presence of residual cointegration, suggesting a long-term relationship between the independent and dependent variables.

The results of the OLS represent a long-term model of the influence of non-renewable energy consumption (CONRE), renewable water resources (REWR), and renewable electricity (RE) on economic growth (EG). Therefore, the long-term equation results are as follows (in Table 4):

Table 4. Results of Ordinary Least Squares (OLS)

Variable	Coefficient	Standard Error	t-Statistic	Prob.
CONRE	6.1527	3.4862	3.6543	0.0528*
REWR	0.1936	0.0879	2.7165	0.0376*
REFE	0.0469	0.0583	1.4629	0.2372
C	-68.862	40.517	-3.1964	0.0335

Information: ***Significant at α=0.01. **Significant at α=0.05, *Significant at α=0.10

EGt = -68.862 + 6.1527CONREt + 0.1936REWRt + 0.0469REFEt + et (-3.1964) (3.6543) (2.7165) (1.4629)

The long-term model results indicate a positive and significant influence of non-renewable energy consumption (CONRE) and renewable electricity (REFE) on Indonesia's economic growth from 1990 to 2023. However, renewable water resources (REWR) do not have a significant effect on Indonesia's economic growth during this period. A short-term model, known as the Error Correction Model (ECM), is formulated to address imbalances and calculate short-term effects. The ECM is presented as follows:

Table 5. ECM Short-Term Estimation Results

Variable	Coefficient	Standard error	t-Statistic	Prob.
D (CONRE)	6.432571	46.45872	0.254464	0.0092
D (REFE)	0.075328	0.076328	0.768936	0.4432
D (RIWR)	0.071463	0.058325	2.888263	0.2876
ECT (-1)	-0.043226	0.047732	2.834672	0.0454

C	0.035264	0.386355	0.635834	0.7853

Information: **Significant at α=0.01. *Significant at α=0.05, ECM: Error correction model

$D(EG_t) = 0.035264 + D(6.432571)CONRE_t + D(0.075328)REFE_t + D(0.071463)RIWR_t + (-0.043226)ECT(-1)$ (0.635834) (0.254464) (2.834672) (2.888263) (2.834672)

The negative coefficient of the Error Correction Term (ECT) in the short-term ECM estimation results indicates that the model specification is valid. The coefficient value of -0.043226 is statistically significant at the 0.05 significance level. This implies that the short-term ECM meets the conditions for validity. In this context, short-term fluctuations in the balance (disequilibrium) toward long-term equilibrium will be rectified. Approximately 43.22% of the adjustment process occurs in the first year, with the remaining 56.78% occurring in the subsequent year. The speed of adjustment from the short term to the long term is approximately 1/0.043 or 23.2 months. The difference between the actual value of the real exchange rate and the equilibrium value ($\hat{Y}$) is 0.043226 and will be adjusted in approximately 25.6 months or 1 year 2 months 33 days.

Multicollinearity can be detected by examining the Variance Inflation Factor (VIF) values, if the VIF value is <10, then it is stated that multicollinearity does not occur, here are the test results:

Table 6. Multicollinearity Test Results

Short term equation		
Variable	**VIF**	**Results**
CONRE	6.367432	Tolerated
REFE	1.087763	Tolerated
REWR	1.311452	Tolerated

Table 6 presents the results of the multicollinearity test for the short-term equation. Multicollinearity refers to the phenomenon where two or more independent variables in a regression model are highly linearly related. The test uses the Variance Inflation Factor (VIF), which measures the extent to which the variance of the estimated regression coefficients is increased due to multicollinearity. For the variables Consumption of Non-Renewable Energy, Renewable Electricity Production, and Renewable Freshwater Resources, the VIF values are 6.367432, 1.087763, and 1.311452, respectively. Typically, VIF values greater than 10 are considered indicative of multicollinearity, while values below 10 are generally considered acceptable. In this case, all three variables have VIF values below 10, indicating that multicollinearity is not a significant issue. Therefore, all variables are considered to be "tolerated" in the model, meaning that they do not exhibit high levels of multicollinearity.

In this study, the Glejser test method was used, which is then presented in the estimation results of the heteroskedasticity test as follows:

Table 7. Heteroskedasticity Test Results

Short term equation	
F-statistic	2.073281

Obs*R-squared	6.568313
Scaled explained SS	4.361372
Prob. F (3,28)	0.4763
Prob. Chi-square (3)	0.4636
Prob. Chi-Square (3)	0.4743

The analysis of the short-term equation's heteroskedasticity reveals important insights. The F-statistic, which tests the overall significance of heteroskedasticity, is 2.073281, suggesting no significant heteroskedasticity. This conclusion is supported by the p-value of 0.4763 associated with the F-statistic, indicating that there is no strong evidence against the null hypothesis of no heteroskedasticity. Additionally, the Obs*R-squared, a measure of the overall explanatory power of the model, indicates a moderate level of explanatory power. The Scaled explained SS, representing the proportion of variation explained by the model, further supports the adequacy of the model in explaining the variation in the dependent variable. Moreover, the Prob. Chi-square values, which provide alternative measures of significance, are both relatively high (0.4636 and 0.4743), reinforcing the conclusion that there is no significant heteroskedasticity in the short-term equation.

In this study, testing was conducted using the Breusch-Godfrey Serial Correlation LM Test, presented as follows:

Table 8. Autocorrelation Test Results

Breush-Godfrey serial correlation LM test	
Short term equation	
F-statistic	14.65218
Obs*R-Squared	18.32781
Prob. F (2,36)	0.0002
Prob. Chi-square (2)	0.0001

The test utilized is the Breusch-Godfrey Serial Correlation LM Test, as presented in the table. Based on Table 8, the Prob value is known. The Chi-squared value in the short-term equation is 18.32781 ≥ 5%, concluding that there is no indication of autocorrelation.

The renewable energy potential in Indonesia, spanning marine energy, geothermal, bioenergy, wind, hydropower, and solar energy, represents a significant opportunity for further development. This potential underscores the pressing need for expanded efforts in this area. Indonesia's energy policies are in alignment with global directives focused on mitigating greenhouse gas emissions, transitioning towards renewable energy sources, and fostering sustainable economic growth through eco-friendly technologies. Indonesia's commitment to these international energy policies is demonstrated by its initiatives to increase the adoption of new and renewable energy sources, decrease reliance on fossil fuels, enhance electricity access across sectors including households, industry, and transportation, and leverage carbon capture and storage technologies (Ministry of Energy and Mineral Resources, 2019).

This reflects the significant untapped potential of renewable energy in Indonesia(Chakraborty et al., 2019), For example, Indonesia's solar energy potential is estimated at 2,898 GW, yet only about 0.2 GW is currently installed. Indonesia's energy policies are in accordance with global directives to reduce greenhouse gas emissions and transition towards renewable energy sources (Data Books., 2022)). This is illustrated by Indonesia's commitment to increasing the adoption of new and renewable energy sources and decreasing reliance on fossil fuels (Ministry of Energy and Mineral Resources, 2019). Indonesia is also working to enhance electricity access across various sectors, including households, industry, and transportation, through the development of renewable energy infrastructure.

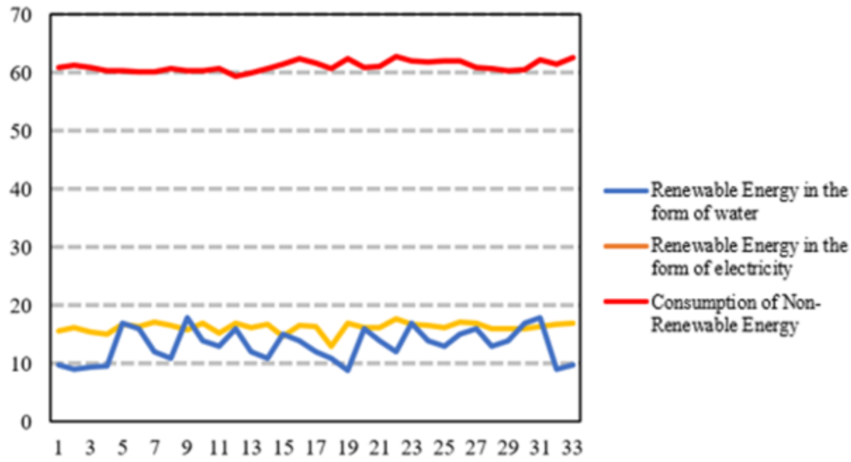
The statistical findings elucidate the impact of renewable and non-renewable energy on Indonesia's economy spanning from 1990 to 2023. In the long term, the consumption of non-renewable energy (CONRE) exhibits a significant positive influence, evidenced by a coefficient value of 6.1527. This implies that a 1% rise in total consumption can spur economic growth by 6.15%. Similarly, renewable electricity consumption (REFE) demonstrates a significant positive effect, with a coefficient value of 7.1936. Thus, a 1% increase in total consumption correlates with a notable 7.19% upsurge in economic growth. Conversely, renewable energy derived from water resources (RIF) does not yield a significant positive impact on Indonesia's economic growth. In the short term, the error correction model (ECM) underscores a positive and significant effect of non-renewable energy consumption (CFE), reflected in a coefficient value of 6.432571. This suggests that a 1% augmentation in total consumption can stimulate economic growth by 6.43%. However, both renewable electricity (RE) and renewable energy from water resources (RIF) do not manifest a significant positive influence on Indonesia's economic growth throughout the aforementioned period.

The advancement of renewable energy in Indonesia is hindered by complex principal-agent problems (Zainudina et al., 2019). These issues arise between PT PLN (the National Electricity Company), which has sole authority over electricity transmission management, and several principals, including the Ministry of State-Owned Enterprises (BUMN), the Ministry of Energy and Mineral Resources, the Ministry of Industry, and the Ministry of Finance, who act as intermediaries between domestic and foreign renewable energy (RE) industries. Furthermore, changes in feed-in-tariff (FiT) policies by the Ministry of Energy and Mineral Resources suggest uncertain policy directions, and fiscal incentive policies by the Ministry of Finance, apart from FiT, to promote RE development in Indonesia remain suboptimal.

Access to energy is a major challenge in implementing renewable energy, with disparities between urban and rural areas being pronounced (Triansyah et al., 2023; Yurioputra, 2022). Rural areas often have limited energy access due to inadequate infrastructure, including a lack of electricity grids and limited use of renewable energy in transportation. Socio-economic factors exacerbate these disparities, with lower income levels and reduced community capacity to access renewable energy technologies observed in rural areas compared to urban areas (Irawan et al., 2022; Murniati, 2023; Yurioputra, 2022) To develop inclusive energy infrastructure, it is crucial to address the equal distribution of energy access so that all segments of society, including rural populations, can benefit equally from the transition to renewable energy.

Despite a positive relationship, the consumption of new and renewable energy does not significantly affect Indonesia's Gross Domestic Product (GDP) due to suboptimal development processes and regulatory frameworks. Indonesia still relies heavily on non-renewable sources to meet its energy demand. While electricity consumption has a more significant impact in the short term, its effect diminishes in the long run as Indonesia continues to depend on non-renewable energy sources. Over the period from 1990 to 2023, Indonesia's energy consumption has been predominantly from non-renewable sources such as oil, coal, natural gas, and electricity. This reliance on non-renewable energy sources is reflected in the energy consumption graph over the past 33 years.

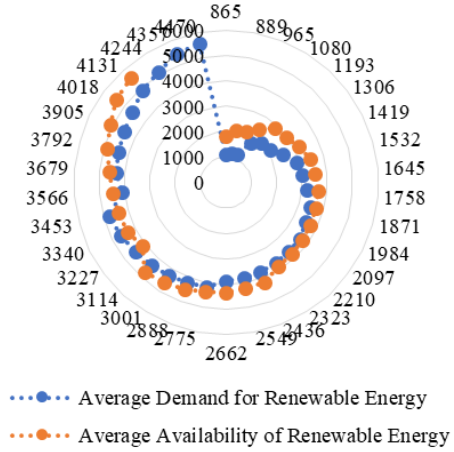
Figure 2. Average Consumption of Renewable and Non-Renewable Energy in Indonesia 1990-2023



Source: World Bank, data processed 2024

In Graph 1, Indonesia's average consumption of non-renewable energy over the 33-year period stands at 61.09%. The graph illustrates a consistent upward trend in the use of non-renewable energy sources over the years. Conversely, renewable electricity energy shows a lower and more fluctuating pattern, with an average consumption of 16.31%. Renewable energy from hydropower exhibits minimal and fluctuating usage, with an average consumption of 13.22%. This variability is due to Indonesia's diverse topography, characterized by numerous rivers and water sources. However, not all regions have equal potential for hydroelectric energy development, primarily due to differences in geographical and hydrological conditions (World Bank, 2023). Nevertheless, studies suggest that Indonesia's potential for energy transition could be enhanced by prioritizing the consumption of environmentally friendly renewable electricity (Keshavarzian & Tabatabaienasab, 2021)

Figure 3. Average Availability and Demand of Renewable Energy in Indonesia 1990-2023



Source: World Bank, data processed 2024

There is a discrepancy between the demand for renewable energy and its availability, leading to an imbalance in the equilibrium. The demand for renewable energy has surged from 2109 million joules to 3566 million joules, propelled by increasing awareness of clean and sustainable energy. However, Indonesia's renewable energy infrastructure and technology remain underdeveloped, hindering large-scale and efficient production. Consequently, the prices of renewable energy are relatively high, prompting many communities and industries to rely on cheaper yet environmentally harmful conventional energy sources. This imbalance, where demand outstrips availability, could impede Indonesia's sustainable economic growth. To rectify this situation, substantial investments in renewable energy infrastructure and supportive policies are imperative to facilitate widespread adoption across all economic sectors (Wu et al., 2020).

Additionally, the discrepancy in the equilibrium point is compounded by the challenge of integrating community-based energy into the national income structure. While large companies such as PLN and Pertamina traditionally account for energy in the national income, energy derived from activities like woodcutting or sailboat building using non-renewable sources complicates energy projections. Addressing these diverse energy needs, including natural resource-related and community energy self-sufficiency, necessitates innovative energy policies and strategies. Community creativity plays a pivotal role in identifying energy potentials and gaps, aligning with Schumpeter's theory of economic innovation and change. Indonesia has immense untapped potential in renewable energy that could potentially replace conventional energy sources for several decades. Government policies supporting renewable energy development (EBT) can promote investment and make renewable energy-generated electricity more affordable than fossil fuel-generated electricity, boosting the economy (Erdiwian, 2021). Moreover, addressing issues such as inflation, poverty, and debt can significantly reduce non-renewable energy consumption and environmental degradation (Nepal & Musibau, 2021; Smaili & Gam, 2023; Zhao et al., 2023). Transitioning swiftly from non-renewable to renewable energy is crucial, requiring industries to adopt clean technology and renewable energy while enhancing public awareness of sustainable energy consumption practices (Caldararu et al., 2011; Tateishi et al., 2020). Furthermore, the stimulating impact of non-renewable energy consumption on various economies, including Indonesia, Malaysia, and Colombia, underscores the need for sustainable alternatives. These countries, located near the equator, boast significant solar energy potential, with an average of 6-7 hours of radiation per day (Soonmin et al., 2019; World Bank Climate Change Knowledge Portal, 2020). The Indonesian government's commitment to building solar power plants for various applications signifies progress. However, to sustainably meet future electricity demands driven by economic and population growth, continued reliance on fossil fuels is untenable.

CONCLUSION

Indonesia's journey towards sustainable energy production and consumption is multifaceted, marked by ambitious targets and persistent challenges. The government's strategic roadmap, crafted under the National Energy Council's guidance, envisions achieving carbon neutrality by 2060 through a gradual transition to zero-emission energy sources. Despite concerted efforts to boost renewable energy adoption, the current trajectory falls short of the stipulated targets, indicating a pressing need for more robust policy frameworks.

The macroeconomic determinants shaping the utilization of renewable energy sources underscore the complexity of Indonesia's energy landscape. While substantial investment initiatives have been undertaken to enhance renewable energy procurement, challenges persist, including decentralized resources, grid constraints, and technological barriers. Collaboration between central and regional governments has shown promise, but further efforts are needed to overcome market uncertainties and spur renewable energy development. The discourse on renewable energy's impact on economic growth underscores its potential as a catalyst for sustainable development. Studies have elucidated the positive correlation between renewable energy consumption and economic growth, urging policymakers to prioritize renewable energy integration into the national energy portfolio. However, fiscal policy changes and institutional challenges pose significant hurdles, necessitating strategic interventions to accelerate progress.

Indonesia's renewable energy potential offers a pathway to mitigate environmental degradation and foster economic resilience. While the transition from non-renewable to renewable energy sources presents challenges, it also presents opportunities for innovation and economic diversification. As the nation strives to meet its energy demands sustainably, collaboration among stakeholders and innovative policy frameworks will be instrumental in realizing Indonesia's vision for a greener and more prosperous future.

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