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A Portrait of Renewable vs. Non-Renewable Energy in Indonesia's Economic Dynamics

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Abstract

The National Energy Policy has been established in Indonesia since 2014 in government regulation No. 79, after a series of top-down debates since 2010. Although KEN focuses on energy supply, the shift of energy policy to the demand side of energy has not been fully accommodated. This study aims to examine the movement of renewable and non-renewable energy towards Indonesia's economic growth from 1990 to 2023. Quantitative method with Error Correction Model (ECM) statistical test is used in this study which is useful to test the short-term and long-term relationship between variables. The results show that non-renewable energy consumption (CONRE) has a positive and significant impact on economic growth by 6.15%, while renewable energy in the form of electricity (REFE) also has a positive and significant effect of 7.19%. However, renewable energy in water resources (REWR) does not have a significant positive impact in the long run of 0.19%. In the short term, non-renewable energy consumption (CONRE) has a positive and significant effect on economic growth of 6.43%, while both renewable energy (RE) for electricity 0.075% and water 0.071% it is indicated to show no significant impact. From these findings, researchers propose how important it is for the government to optimize the potential of renewable energy to achieve a more environmentally friendly energy policy while still considering aspects outside the variables of this study.

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BACKGROUND

The Indonesian government through the National Energy Council (DEN) has developed a roadmap towards zero emission. The hope is to achieve an energy transition to zero emissions by 2060. Each year will implement a target of increasing the use of renewable energy, starting from 2025 with an initial target of 23%. until 2060 with a target of 66%. The Indonesian government seeks to achieve a target of 23% new renewable energy by 2025, but in reality, the increase in new renewable energy in Indonesia is only 0.55% per year. The target that should be achieved by the government for the achievement of new renewable energy per year is 0.9% (National Energy Council, 2020) . Therefore, more progressive policy planning is needed to achieve this new energy achievement. An analysis is needed regarding how the government observes macroeconomic factors that affect the use of new renewable energy because so far the ratio of the use of new renewable energy to conventional energy such as oil, natural gas and coal is only 10%.

The use of conventional energy is mentioned (Janiszewska, 2019; Jebli & Hakimi, 2023) to still be much greater than the use of new renewable energy. Various efforts to achieve the ideal energy mix, especially the New and Renewable Energy (NRE) mix, as in the government scenario, have not met the expected targets. Some of the problems that often arise in efforts to achieve the achievement of renewable energy in Indonesia include Indonesia's scattered new renewable energy potential, the limited ability of the grid to absorb electricity, some new renewable energy is intermittent, so power plants with large storage are needed. In addition, referring to (Secretariat General of the National Energy Council, 2022a) the limited capability of the domestic industry in terms of technology and market uncertainty are also obstacles that are not increasing in accordance with the target.

In this case, the Indonesian government has sought to increase the productivity of renewable energy procurement with consistent investment efforts in renewable energy. The Directorate of Energy Conservation noted that investment realization in 2017 reached Rp 48 billion, which exceeded the target of Rp 41.4 billion. Throughout 2017, most of the implementation of energy efficiency investments was the result of investment-grade energy audit (IGA) partnerships in 2015 and 2016. (Secretariat General of the National Energy Board, 2022b) mentions that cooperation between central and local governments in the field of energy efficiency is increasingly visible from the emergence of investment from local budgets since 2017.

In general, Indonesia has high hopes for renewable energy for the future and is making the transition from energy change to renewable energy. Several studies (Damodaram et al., 2022; Xu & Wu, 2023; Yalçın Dokumacı et al., 2023) review how the world conditions are a reference for Indonesia in advancing renewable energy and an overview of non-renewable energy is presented by some important findings. Renewable

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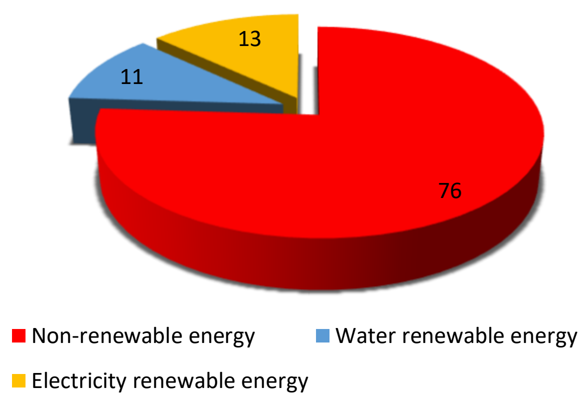
energy use and financial development do not have a strong influence on economic growth (Fareed & Pata, 2022; Hao, 2022) . However, it is concluded that renewable energy use has a positive impact on financial development. Therefore, (S. A. R. Khan et al., 2023) suggested that the use of renewable energy should be encouraged by domestic policy makers. However, it is expressed (Elshimy & El-Aasar, 2020; Joshi & Waghole, 2024; S. A. R. Khan et al., 2023) to understand the main indicators of economic growth, many different factors should be considered. The concept of renewable energy and renewable energy sources, the relationship between renewable energy sources and sustainable energy supply is positively confirmed and consistent with the findings of previous relevant studies.

Moreover, the most important point of the study findings (Amigues et al., 2015; Bukhari et al., 2023; Fadilah et al., 2020; Tipantuña & Hesselbach, 2020) is that sustainable energy supply was found to have a positive impact on sustainable economic growth in the country of Vietnam. (Deka et al., 2024; Ohlan, 2016; Paramati et al., 2018) explained that one of the main components in accelerating economic growth in the energy sector is government support which is one of the main drivers of the positive impact for such energy and significant renewable energy from electricity generated from renewable energy sources, CO 2 emissions, on economic growth. However, the positive and significant impact of carbon dioxide is still a challenge to achieve sustainability. Policies have been identified to develop the energy networks needed in the future. Renewable energy which 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 source of the world and especially Indonesia, in outline renewable energy must be able to 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:

Percentage of energy use in Indonesia during 1990-2023



Source: *World bank*, data processed 2024

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Figure 1 is an illustration of the average consumption/use of renewable and non-renewable energy in Indonesia over the period 1990-2023, where 76% of Indonesia's total energy demand relies on non-renewable energy, 13% is generated by renewable energy electricity, and 11% of renewable energy comes from water resources. Since 2010, Indonesia has gone through a top-down debate process to establish Government Regulation No. 79/2014 on National Energy Policy as a public policy product. Although energy policy has experienced a shift in focus towards energy demand, the Regulation only focuses on energy supply and does not set greenhouse gas mitigation targets. To support the achievement of National Energy Policy (KEN) targets related to the mix of new and renewable energy (EBT), the Government of Indonesia has established various regulations regarding Feed-in Tariffs for electricity selling prices for EBT plants. However, a study (Shahbaz et al., 2020) argues that its implementation is not optimal because the price is higher, thus becoming one of the obstacles in the utilization of renewable energy in Indonesia.

The new energy paradigm states that some countries that are more developed than Indonesia have not been successful and able to develop renewable energy sustainably, even some findings (Klass, 2003; Pishgar-Komleh et al., 2012; Sharif et al., 2019; Yu et al., 2023) found various countries still depend on non-renewable energy. Looking at 99 countries in the world with inclusive energy production functions based on studies (Eisgruber, 2013; Li et al., 2015; S. Z. A. Shah et al., 2020) low, middle, and high income, non-renewable and renewable energy consumption, capital, and labor have a significant positive impact on economic growth. From there it is concluded that although energy consumption has an important role in driving economic growth, too much focus on non-renewable energy causes environmental problems and some countries are still dependent on non-renewable energy, therefore it is recommended to prioritize the renewable energy sector to maintain and create an efficient and friendly environment.

G-20 countries have always been major proponents of the need to end global warming and climate change conditions. However, they continue to fund the production of fossil fuels resulting in a bad scenario, they still depend on non-renewable energy for economic activity (Murshed et al., 2021; Wen et al., 2022) . The problem with renewable energy in Indonesia is that fiscal policy changes are influenced by various political interests of key renewable energy stakeholders, and are accompanied by various key institutional issues. This is also compounded by limited inter-agency communication between Renewable Energy stakeholders. Although the country has established a number of fiscal policies to attract high foreign and domestic investment in infrastructure projects, including for Renewable Energy, political instability and policy uncertainty are two of several key interrelated barriers preventing Indonesia from achieving its ambitious renewable energy aspirations and targets (Heeter & Bird, 2013; Nugroho & Fei-Lu, 2017) . This study will comprehensively examine the impact of renewable and non-renewable energy on the Indonesian economy over 33 years of Indonesian economic activity. What is expected from the findings is to know in detail and with certainty the long-term and short-term effects of renewable and non-renewable energy on the Indonesian economy, and is expected to be an important reference in energy development in Indonesia.

METHODOLOGY

This research adopts a descriptive quantitative approach by analyzing secondary data related to economic growth and energy consumption in Indonesia over 33 years (1990-2023). The data is sourced from official platforms such as the World Bank and includes variables such as economic growth (GDP), fossil fuel consumption, renewable water resources, and renewable electricity generation. The study aims to understand the relationship between energy consumption and economic growth through various data analysis methods. The analysis involves testing data stationarity using the Augmented Dickey-Fuller (ADF) test and examining cointegration with the Eagle-Granger (EG) method. If the data is non-stationary at the level but becomes stationary at the first difference, the Error Correction Model (ECM) is applied to observe short- and long-term relationships between variables. The Ordinary Least Squares (OLS) regression model is also used to measure the impact of independent variables on economic growth. Additionally, this study conducts a multicollinearity test using the Variance Inflation Factor (VIF), a heteroscedasticity test to assess variance stability, and an autocorrelation test using the Durbin-Watson and Breusch-Godfrey methods. These tests ensure the validity of the regression model, making the findings more accurate and applicable to energy and economic policy analysis in Indonesia

.RESULTS AND DISCUSSION

1. Stationary test results

Stationarity testing in this study uses the *Augmented Dickey-Fuller Test* (ADF) method. This method is used to determine whether a time series is stationary or not. In the ADF test, we test (H0) that the time series has a unit root, which indicates that the time series is not stationary. If the absolute t-count value (test statistic value) is greater than the MacKinnon absolute critical value corresponding to the set significance level, then we reject (H0). This means that the time series data is stationary. Conversely, if the t-count value does not exceed the MacKinnon critical value, then we fail to reject H0, indicating that the time series data is not stationary. When the t-count value is negative, we also perform a similar analysis. If the t-count value is smaller than the MacKinnon critical value, then we reject H0, indicating that the time series data is stationary. Conversely, if the t-count value does not exceed the MacKinnon critical value, we fail to reject H0, indicating that the time series data is not stationary

Table 1.

Unit Root Test Results

Variables	ADF t-Statistic	Prob	Result	Ket.
EG	-1.6368	0.3143	H0 accepted	Not stationary
CONRE	-4.9437	0.0006	H0 rejected	Stationer
REFE	-3.7648	0.0786	H0 accepted	Not stationary
REWR	-2.4153	0.6174	H0 rejected	Not stationary

Based on Table 1.0, by conducting unit root tests and comparing the t-count values with the corresponding critical values for each significance level α, including 1 percent, 5 percent, and 10 percent, it can be concluded that none of the variables show stationarity at a significant level. Therefore, a retest will be conducted using the unit root test at the first difference level for each variable, with the results presented in the next table.

Table 2.

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Root test results at the first level of difference

Variables	ADF t-Statistic	Prob	Result	Ket.
EG	-7.1476	0.0000	H0 accepted	Stationer
CONRE	-5.7468	0.0112	H0 accepted	Stationer
REFE	-7.3448	0.0000	H0 accepted	Stationer
REWR	-6.8053	0.0000	H0 accepted	Stationer

In Table 1.2, the *root test* results at the first difference level for all variables show that all variables are stationary. This indicates that the data used in this study is integrated at order one, or can be abbreviated as I(1), and therefore free from pseudo regression problems. Thus, the stationarity requirement has been met, and allows for processing in the next stage of the data analysis conducted.

2. Cointegration test results

The purpose of the cointegration test is to see if there is a long-term relationship between the independent variable and the dependent variable. Cointegration testing is conducted using the Engel-Granger (EG) cointegration testing method. If the t-count value in absolute value exceeds the critical value in MacKinnon's absolute value, this indicates residual cointegration, indicating the existence of a long-run relationship between the independent variable and the dependent variable. Conversely, if the t-count value is negative, if the t-count value is less than the MacKinnon critical value, this indicates the presence of residual dichroism, indicating the existence of a long-run relationship between the independent variable and the dependent variable.

Table 3.

Engel Granger cointegration test results

Variable	ADF T-Statistic	Prob	Result	Ket
Ect(-1)	-42.732	0.002	H0 rejected	Stationer

Based on Table 1.3, the results of cointegration testing with the Engel-Granger method show that the residuals (resid01) show stationary properties at the observable level, characterized by a *t-count* value that exceeds the MacKinnon critical value at the 5% and 10% significance levels. This indicates the presence of cointegration in the residuals, suggesting that there is a long-run relationship between the independent variable and the dependent variable.

3. Ordinary Last Square (OLS) and Error Correction Model

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

Table 4.

Ordinary least square (OLS) results

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 $\alpha=0.01$. **Significant at $\alpha=0.05$, *Significant at $\alpha=0.10$

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EG_t = -68.862 + 6.1527 $CONRE_t$ + 0.1936$REWR_t$ + 0.0469$REFE_{(t)}$ + *et* (-3.1964) (3.6543) (2.7165) (1.4629)

In the long-term model results, it is seen that there is a positive and significant effect between non-renewable energy consumption (CONRE) and renewable electricity (REFE) on Indonesia's Economic Growth, while Renewable Water Resources (REWR) has no effect on Indonesia's economic growth in 1990-2023. The short-run model is formed because the model fulfills the conditions that include adjustments to make corrections for imbalances called *Error Correction Model* (ECM) in calculating the effects in the short-run and is presented as follows:

Table 5.

ECM short term estimation results

Variable	Coefficient	Standard error	t-Statistic	Prob.
CONRE)	6.432571	46.45872	0.254464	0.0092
REFE)	0.075328	0.076328	0.768936	0.4432
RIWR)	0.071463	0.058325	2.888263	0.2876
T (-1)	0-.043226	0.047732	2.834672	0.0454
	0.035264	0.386355	0.635834	0.7853

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

In Table 5, all variables are differenced in the ECM model to determine the short-run relationship. The short-run equation obtained is:

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 sign (-) on the ECT coefficient indicates the validity of the model specification. The short-term ECM estimation results show a negative ECT coefficient value, which is -0.043226 and significant at the 0.05 significance level. This means that the conditions for short-term estimation of the ECM are met and the ECM model is declared valid. *short-term balance fluctuations* (disequilibrium) towards *long-term balance* will be corrected, where 43.22% of the adjustment process occurs within the first year, while the remaining 56.78% of the adjustment process occurs within the following year. The speed of adjustment from short-term to long-term takes 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 about 25.6 months/1 year 2 months 33 days.

4. Multicollinearity test

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

Table 6.

Multicollinearity Test Results

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

Based on Table 6 of the data processing in the table, the VIF value is< 10 for each independent variable, so it can be concluded that there is no multicollinearity problem.

1. Heteroscedasticity test

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

Table 7.

Heteroscedasticity Test Results

Short term equation	
tatistic	2.073281
s*R-squared	6.568313
ıled explained SS	4.361372
ıb. F (3,28)	0.4763
ıb. Chi-square (3)	0.4636
ıb. Chi-Square (3)	0.4743

Based on Table 7, it can be seen that the Chi-square value of Obs*R-squared in the short-term equation is 6.568313 or ≥5% of the equation, there is no heteroscedasticity problem.

2. Autocorrelation test

In this study, the test was carried out using the Bruesche-Godfrey Serial Correlation LM Test, which is presented as follows:

Table 8

Autocorrelation Test Results

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

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

Discussion

Indonesia's renewable energy potential, including ocean energy, geothermal, bioenergy, wind, water and sunlight, has significant dimensions. This potential indicates an urgent need for further development. The energy policy implemented in Indonesia is in line with international policy directions in reducing greenhouse gas emissions, moving towards renewable energy, and promoting sustainable economic growth based on environmentally friendly technologies. Indonesia's commitment in supporting international energy policy includes increasing the adoption of new and renewable energy, reducing dependence on fossil energy, increasing access to electricity in various sectors such as households, industry, and transportation, as well as the use of carbon capture and storage technology (Ministry of Energy and Mineral Resources, 2019)

This is in accordance with the study (Chakraborty et al., 2019) that renewable energy in Indonesia has great potential that has not been fully utilized. For example, the potential of solar energy in Indonesia is estimated at 2,898 GW, but only about 0.2 GW is installed, Indonesia's energy policy is in line with international policy directions to reduce greenhouse gas emissions and switch to renewable energy (Data Books, 2022) . This can be seen from Indonesia's commitment to increase the adoption of new and renewable energy, and reduce dependence on fossil energy (Ministry of Energy and Mineral Resources, 20)21 . Indonesia is also working to improve access to electricity in various sectors, including households, industry, and transportation, through the development of renewable energy infrastructure.

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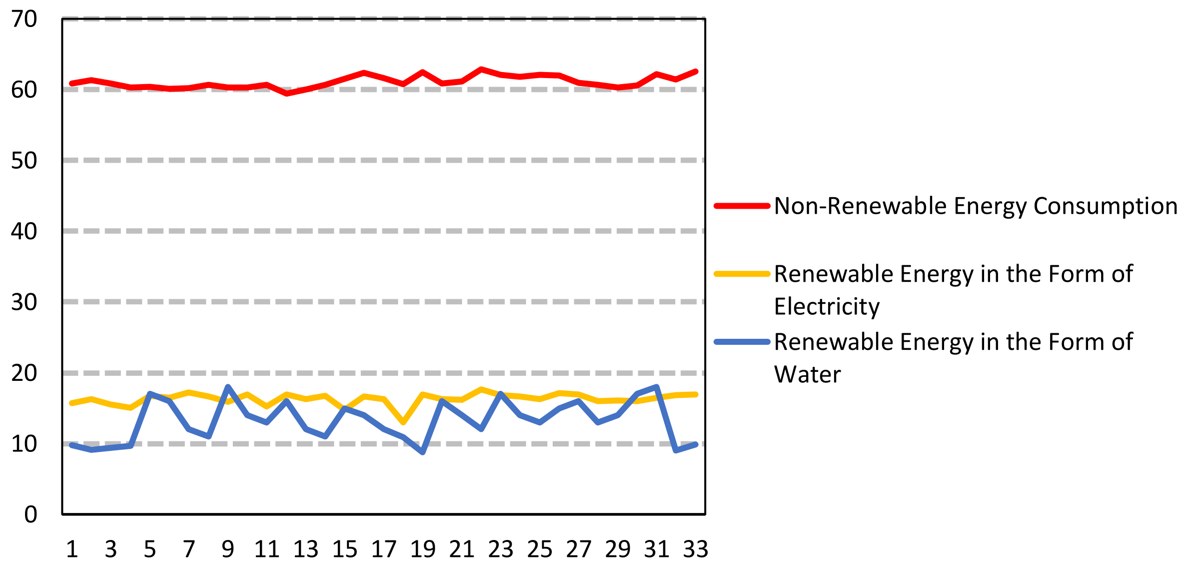
The statistical results explain how renewable and non-renewable energy in Indonesia during 1990-2023, which found the results in the long run Non-renewable energy consumption (CONRE) has a positive influence with a coefficient value of 6.1527 and significant where every 1% increase in total consumption, will be able to increase economic growth by 6.15%. Renewable energy in the form of electricity (REFE) has a positive influence with a coefficient value of 7.1936 and significant where every 1% increase in total consumption will be able to increase economic growth by 7.19%, while renewable energy yield through water resources (RIF) does not have a significant positive effect on Indonesia's economic growth. In the short-term *error corection model* (ECM) results, non-renewable energy consumption (CFE) has a positive influence with a coefficient value of 6.432571 and is significant where every 1% increase in total consumption will be able to increase economic growth by 6.43%. While renewable energy output in the form of electricity (RE) and renewable energy through water resources (RIF) do not have a significant positive impact on Indonesia's economic growth during 1990-2023.

Renewable energy development in Indonesia faces a multi-faceted agent-principal problem (Zainudina et al., 2019) . Indonesia experiences a multi-faceted *principal-agent* problem between PT PLN, the agent that has the sole authority to manage electricity transmission, and various principals, namely the Ministry of State-Owned Enterprises (SOEs), the Ministry of Energy and Mineral Resources, the Ministry of Industry as an intermediary between domestic and foreign EBT industries, and the Ministry of Finance. While the Ministry of Energy and Mineral Resources' *feed-in-tariff* (FiT) policy changes signal an uncertain policy, the Ministry of Finance's fiscal incentive policies other than FiT to encourage EBT development in Indonesia remain suboptimal.

New and renewable energy consumption shows a positive relationship but does not have a significant effect on gross domestic product in Indonesia, as attention has not been maximized in the development process, it is also related to regulation and Indonesia is currently still meeting its energy demand from non-renewable sources. Electricity consumption has a higher and more significant impact in the short term. However, in the long term, the impact of electricity consumption on economic growth is not significant in Indonesia, as it is still dependent on non-renewable energy. In the long term, throughout 1990-2023, according to the results of the long-term model, Indonesia's energy consumption is highly dependent on non-renewable energy such as oil, coal, natural gas, and electricity consumption. When viewed from the energy model for the Indonesian economy, only non-renewable energy has an impact on Indonesia's economic activity. A graph of energy consumption over the past 33 years is presented below:

Chart 1
Average Energy Consumption
Indonesia's Renewable and Non-Renewable in 1990-2023



Source: *World bank*, processed 2024

In Figure 1, Indonesia for 33 years has an average non-renewable energy consumption of 61.09%, as seen in the graph, the trend of non-renewable energy use throughout the years continues to increase. In

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electricity renewable energy, the average consumption is 16.31%, the consumption is not so large and fluctuates, while renewable energy from water resources has an average consumption of 13.22%, it is still minimal and moves in fluctuations, experiencing significant increases and decreases This is due to the geographical factor that Indonesia has a diverse topography, with many rivers and other water sources. However, not all regions have the same potential for hydroelectric energy development due to differences in geographical and hydrological circumstances (World Bank, 2023) . However, a study (Keshavarzian & Tabatabaienasab, 2021) considers that Indonesia's potential in energy transition can also be prioritized by consuming renewable electricity that is more environmentally friendly.

The potential of renewable energy in Indonesia can be utilized and can replace conventional energy for decades. Utilization of renewable energy for power generation can be done by using government policies that support investors as implementers of new renewable energy development (EBT). The selling price of electricity generated from EBT is cheaper than electricity generated from fossil fuels, this makes the economy more affordable (Erdiwansyah et al., 2021). From various studies on renewable and non-renewable energy consumption in Indonesia, the same results were obtained in the study (Wu et al., 2020) . The results of the study (Nepal & Musibau, 2021; Smaili & Gam, 2023; Zhao et al., 2023) show that all inflation, poverty, and debt significantly cause an increase in non-renewable energy consumption in both short-term and long-term analysis. Non-renewable energy is consumed due to high inflation, debt and poverty in Indonesia. The model shows that increasing renewable energy consumption reduces environmental degradation while increasing non-renewable energy consumption increases CO_2 emission levels. GDP has a negative impact while the square of GDP has a positive impact on CO_2 emission levels. Assumptions in (Caldararu et al., 2011; Tateishi et al., 2020) The high consumption of non-renewable energy in Indonesia should immediately switch to renewable energy, encourage industries to adopt clean technology and renewable energy, and increase public awareness on how to consume energy in a healthy way.

Although in (Soonmin et al., 2019) it is also mentioned that non-renewable energy consumption has an increasing impact and will drive the economies of various countries, but Indonesia, Malaysia, and Colombia are all located on the equator, so the potential for solar energy is quite high with an average of 6-7 hours of radiation per day (World Bank Climate Change Knowledge Portal, 2020). Therefore, the government has actually committed to building solar power plants for various applications. However, it is important to understand that we cannot continue to rely on fossil fuels in the future as the need for electricity increases along with economic and population growth.

CONCLUSION

During the period 1990-2023, non-renewable energy consumption in Indonesia reached 63.72%. This can also be seen from the role of non-renewable energy in the long and short term in the Indonesian economy which has a positive and significant impact. Meanwhile, from the point of view of renewable energy, Indonesia temporarily has the potential to switch to renewable energy early where its consumption and use on average is 29.53%. Electricity also has a positive and significant impact on Indonesia's long-term economy, while renewable energy from water resources is still unable to significantly help the economy in both the short and long term

Indonesia's energy policy should focus on one stable and potentially energy-contributing side, such as electricity and water, in order to move towards a renewable energy transition. The Indonesian government should be able to develop the potential of hydropower first as Indonesia has many large and potential rivers for hydropower generation. With more than 17,000 islands and a network of rivers crossing its territory, Indonesia has abundant natural resources to generate electricity from water energy, as well as various other plants such as development in each region of Indonesia into hydropower plants (PLTA), steam power plants (PLTU), solar power plants (PLTS), geothermal power plants (PLTP), and wind power plants (PLTB). Development should be carried out in all provinces according to the potential of renewable resources in order to achieve a slow transition and reduce the generation of non-renewable energy.

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