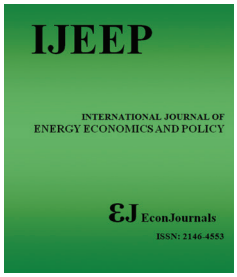

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The Relationship between Primary Energy Consumption, Energy Security Index, Share of Renewable Energy and the Energy Transition in Indonesia

Heru Wahyudi[1]*, Imam Awaluddin[1], Asih Murwiati[1], Tiara Nirmala[1], Sandra Mei Leny[1], Fatkhur Rohman[2]

[1]Faculty of Economics and Business, University of Lampung, Bandar Lampung, Indonesia, [2]Faculty of Teacher Training and Education, University of Lampung, Bandar Lampung, Indonesia. *Email: heru.wahyudi@feb.unila.ac.id

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ABSTRACT

Energy security and the transition to renewable energy are strategic issues in global energy policy, especially for developing countries that still face the challenge of dependence on fossil energy. Indonesia, as one of the countries with high primary energy consumption, has set a target of 23% renewable energy mix by 2025. However, the achievement is still far from the set target, indicating structural barriers in the energy transition. One of the key determinants in the energy transition is the Energy Security Index and primary energy consumption, which may have implications for the share of renewable energy in the national energy mix. Although various studies have explored the relationship between energy security and sustainable energy mix, empirical studies that comprehensively analyse the impact of Energy Security Index and primary energy consumption on the share of renewable energy in Indonesia are still limited. Therefore, this study aims to examine the relationship between the Energy Security Index, primary energy consumption, and the share of renewable energy and evaluate the extent to which the two independent variables affect the energy transition in Indonesia. This study uses a quantitative approach with the robust least squares method to produce more accurate parameter estimates. The results show that the energy security index has a positive and significant effect on the share of renewable energy, with a coefficient of 1.570 (0.0000 < 0.05), indicating that increased energy security contributes to the acceleration of the renewable energy transition. In contrast, primary energy consumption shows a negative impact on the share of renewable energy, with a coefficient of −3.802 (0.0433 < 0.05), indicating that dependence on fossil energy hinders the increase in the share of clean energy. In addition, the F-test shows that the Energy Security Index and primary energy consumption simultaneously have a significant influence on the share of renewable energy (0.0000 < 0.05), with a coefficient of determination R^2 of 89.36%, indicating that the model used is able to explain most of the variability in the share of renewable energy. This finding confirms that improving energy security through energy source diversification and energy efficiency are key factors in accelerating the energy transition. The government needs to reduce dependence on fossil fuels and accelerate incentives for renewable energy so that the renewable energy mix target can be achieved.

Keywords: Energy Security Index, Primary Energy Consumption, Renewable Energy Share, Energy Security, Energy Transition, Robust Least Squares
JEL Classification: Q40, Q41, Q42, Q48, C32

1. INTRODUCTION

Energy security and the transition to clean energy have become central issues in global energy policy. In 2018, dependence on fossil fuels still dominated with global primary energy consumption reaching 13.86 billion tonnes of oil equivalent (Mtoe), of which more than 80% came from fossil fuels (BP, 2019). However, this trend begins to change significantly by 2023 with an increase in the share of new renewable energy (NRE) to 15% of total global energy consumption (IEA, 2023). This surge is influenced by

the acceleration of green energy investment and decarbonisation policies implemented by various countries.

At the global level, primary energy consumption continues to increase from 582 EJ in 2018 to 620 EJ in 2023 (IEA, 2023). The Energy Security Index (ESI) fluctuates across countries with improved energy security in the European region due to diversification of energy sources, while some developing countries still face challenges in energy supply security. Indonesia recorded primary energy consumption of 220 Mtoe in 2023, with the contribution of renewable energy reaching 14.1% of the total national energy mix (Ministry of Energy and Mineral Resources, 2023). This increase in the share of renewable energy is part of the decarbonisation policy set out in the 2015 Paris Agreement and the 2060 Net Zero Emission (NZE) target. G20 countries, including Indonesia, have implemented various policies to improve energy security while reducing carbon emissions, such as carbon tax mechanisms, green energy incentives, and the elimination of fossil fuel subsidies (Wahyudi and Leny, 2025). These energy security strategies are in line with the shift towards a more sustainable energy mix.

Despite the increasing share of renewable energy, energy security remains a major challenge, especially for developing countries that are still dependent on fossil resources. The relationship between the Energy Security Index (ESI), primary energy consumption and the share of renewable energy is still an academic debate. Therefore, this study seeks to examine how the variables of Energy Security Index and primary energy consumption affect the development of renewable energy share as an indicator of energy transition.

Various previous studies have examined the relationship between energy security and sustainable energy mix. Research by Sovacool and Mukherjee (2011) highlights the role of policy in improving energy security. Another study by Apergis and Payne (2015) found that primary energy consumption plays a significant role in the growth of renewable energy. In addition, a study by Zhang et al.(2022) showed that energy diversification can significantly improve energy security in developing countries. This research is based on the Energy Transition theory (Rogers, 2003), which explains the shift from fossil energy to renewable energy as part of the evolution of the energy system. In addition, the Resource Dependence theory (Pfeffer and Salancik, 1978) is used to understand how dependence on primary energy can affect the dynamics of renewable energy share. Energy security theory is also a cornerstone in this study to explore how dependence on certain energy resources can affect the stability and sustainability of national energy supply.

Previous research has not explicitly explored the relationship between Energy Security Index, Primary Energy Consumption, and Renewable Energy Share in one comprehensive model, especially in the context of developing countries such as Indonesia. Thus, this study aims to analyse the relationship between the Energy Security Index and the share of new renewable energy, explore the role of primary energy consumption in increasing or inhibiting the renewable energy mix, and provide more effective energy policy recommendations in increasing the share of renewable energy and energy security in Indonesia and other developing countries.

Practically, this research provides insights for policy makers in designing strategies to increase the share of renewable energy while maintaining energy security. From a policy perspective, the results of this study can support the formulation of energy policies that are more adaptive to global challenges, such as climate change and energy market volatility. Academically, this study fills the literature gap in understanding the relationship between energy security, primary energy consumption, and renewable energy share, especially in developing countries. As such, this research is expected to make a significant contribution in supporting the global energy transition towards a more sustainable energy system.

2. LITERATUR REVIEW

2.1. Energy Security Index

The Energy Security Index is an indicator used to measure the extent to which a country can ensure the availability of stable, affordable and sustainable energy. The Energy Security Index covers several key aspects, including energy source diversification, resilience to supply disruptions, energy efficiency, and environmental sustainability in national energy policy (Cherp and Jewell, 2014). In the context of the global energy transition, improving the Energy Security Index is one of the priorities for countries that seek to reduce dependence on fossil fuels and increase the contribution of renewable energy in the national energy mix.

The conceptual framework in this study focuses on the relationship between the Energy Security Index and the share of renewable energy, where the higher the value of a country's Energy Security Index, the more likely the country is able to invest in sustainable energy development. Resource Dependence Theory (Pfeffer and Salancik, 1978) explains that dependence on certain energy resources affects a country's energy stability. In this context, energy diversification is expected to improve national energy security and accelerate the transition to more environmentally friendly energy.

Many previous studies have examined how the Energy Security Index contributes to a country's energy security. The study by Fatahillah et al. (2022) examined Indonesia's national energy security based on the 4AE Energy Security Index from an Islamic economic perspective, which includes availability, affordability, accessibility, acceptability, and energy efficiency. In addition, research by Yana et al. (2021) discusses the main prospects for renewable energy development in ASEAN countries, highlighting the importance of sustainable energy policies to improve energy security and support economic development.

2.2. Primary Energy Consumption

Primary energy consumption is the total amount of energy consumed in a country before being converted into other forms of energy such as electricity or heat. Primary energy consumption reflects a country's level of dependence on certain energy resources, both from fossil fuels and renewable energy (IEA,

2023). Factors that affect primary energy consumption include economic growth, level of industrialisation, energy efficiency, as well as energy policies implemented by the government.

The conceptual framework in this study highlights how primary energy consumption can influence the transition to renewable energy. Based on the Energy Transition theory (Rogers, 2003), the shift from fossil fuels to renewable energy occurs in several stages, starting from increasing energy efficiency to fuel substitution. Countries with high levels of primary energy consumption, but with a heavy reliance on fossil fuels, are likely to experience greater challenges in increasing their share of renewable energy.

Several previous studies have examined the relationship between primary energy consumption and energy transition. Apergis and Payne (2015) used an econometric approach to analyse panel data from several countries in Central America and found that increasing primary energy consumption drives renewable energy growth, but only when supported by appropriate policies. Meanwhile, a study by Wang et al. (2021) revealed that countries that adopt energy efficiency strategies can reduce dependence on fossil fuels while increasing the share of renewable energy.

However, in Indonesia, research that specifically examines how primary energy consumption affects the transition to renewable energy is still very limited. Research by Rachmawati et al. (2020) shows that although primary energy consumption is increasing, Indonesia faces major challenges in reducing dependence on fossil energy due to its high dependence on the fossil energy sector. The research also shows that existing policies are not sufficient to support a significant transition to renewable energy. Research by Sari et al. (2021) found that although Indonesia has shown a commitment to energy transition through renewable energy policies, the high level of primary energy consumption, which is still largely fossil-dependent, is slowing down the pace of energy transition. In comparison, European countries such as Germany have successfully reduced dependence on fossil energy by implementing policies that encourage the use of renewable energy and energy efficiency. Research by Bruckner et al. (2021) reveals that in European countries, policies involving increased energy efficiency and primary energy diversification are proven to increase the share of renewable energy.

2.3. Share of New Renewable Energy

The share of new renewable energy (NRE) refers to the proportion of energy derived from renewable resources such as solar, wind, hydro, and biomass in a country's total energy mix. Renewable energy development is high on the agenda of many countries' national energy policies, including Indonesia's, to achieve decarbonisation targets and long-term energy security (Ministry of Energy and Mineral Resources, 2023). The main factors affecting the share of renewable energy include government regulations, fiscal incentives, technology availability, and public environmental awareness.

The conceptual framework in this study highlights how the Energy Security Index and primary energy consumption can affect the share of renewable energy in Indonesia. Based on the Energy Transition theory, the higher a country's energy security and the greater the investment in clean energy, the higher the share of EBT in the national energy mix. In addition, the Resource Dependence approach shows that countries that reduce dependence on fossil fuels are better able to allocate resources for renewable energy development.

Previous research has examined many determinants of the share of renewable energy in various countries. A study by Cherp and Jewell (2011) found that renewable energy subsidy policies significantly increase the share of clean energy in the national energy mix. On the other hand, research conducted by Zhang et al. (2022) shows that developing countries that have strong energy diversification policies tend to have a higher share of renewable energy.

3. RESEARCH METHODOLOGY

3.1. Statistical Analysis

Statistical analysis is a systematic process that includes collecting, organising, interpreting, and presenting quantitative data using statistical techniques to identify patterns, trends, and relationships in the data (Gao et al., 2023). In the context of this study, statistical analysis is used to evaluate the relationship between the share of renewable energy, fuel import, fuel import ratio, mineral and coal investment, and GDP in Indonesia. This study aims to provide deeper empirical insights into the interactions between economic, social, and environmental factors in Indonesia, as well as policy implications that can be taken to achieve inclusive sustainable development.

3.2. Classical Assumptions

The classical assumption test is a series of tests conducted to ensure that the regression model used fulfils the basic assumptions to obtain unbiased, consistent, and efficient estimates of the model parameters by going through tests of normality, multicollinearity, heteroscedasticity, and autocorrelation (Khan et al., 2023).

3.3. Robust Least Square

Robust regression is a method used to overcome the outlier problem (Delaunay and Yurova, 2024). In this study, the Robust Least Squares (RLS) method is applied as an alternative to overcome the limitations inherent in conventional linear regression models, especially regarding sensitivity to outliers. The ordinary least squares (OLS) method tends to produce inaccurate and biased parameter estimates when facing data containing extreme observations. Robust least squares (RLS) offers a more robust approach by introducing a weighting mechanism on the observations, which allows the model to give lower weights to observations with large residuals, thus reducing the impact of outliers on the resulting parameter estimates (Mohamad and Chang, 2023). To evaluate the effectiveness of the resulting model, statistical criteria including Adjusted R-squared, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) are used, which aim to ensure that the model is not only robust to outliers, but also able to provide valid and accurate estimates. By implementing the Robust Least Squares approach,

this study aims to produce a more reliable regression model, which is able to produce consistent and valid parameter estimates, even in the context of data affected by outliers.

3.4. Statistical Test t (Partial Test)

In research, the significance of the influence of the independent variable on the dependent variable is seen through the t statistical test (Widarjono, 2018). In its use, if t-count > t-table or significance is less than (α) 5%, this indicates that there is a partially significant effect between the independent variable and the dependent variable (Gujarati, 2006).

The hypothesis in this test is:

H_0: βi < 0. There is no significant effect between the independent variable and the dependent variable partially.

H_a: βi > 0. There is a significant influence between the independent variables on the dependent variable partially.

The test criteria are as follows:

1. If t-statistic > t-table then H_0 is rejected. The independent variable has a significant effect on the dependent variable.
2. If t-statistic < t-table then H_0 is accepted. The independent variable does not have a significant effect on the dependent variable.

3.5. F Statistical Test

The F-statistic test is used to show how the independent variables interact with each other and have an impact on the dependent variable (Wooldridge, 2013). If the F-count exceeds the F-table in the test, then simultaneously the independent variables have a considerable influence on the dependent variable, or the data are consistent with the research hypothesis.

H_0: $\beta_i < 0$. There is no significant effect between the independent variables on the dependent variable together.

H_a: $\beta_i > 0$. There is a significant influence between the independent variables on the dependent variable jointly.

The test criteria are as follows:

1. If F-statistic > F-table then H_0 is rejected. The independent variable on the dependent variable has a statistically significant effect together.
2. If F-statistic < F-table then H_0 is accepted. The independent variable on the dependent variable does not have a statistically significant effect together.

3.6. Test Coefficient of Determination (R^2)

According to Widarjono (2018), the coefficient of determination (R^2) is used to measure the proportion of the contribution of the independent variable in explaining the dependent variable. An R^2 value close to one indicates that the regression model has a good ability to explain data variability, while an R^2 value close to zero indicates limited ability. However, R^2 has the disadvantage that it tends to increase with the addition of independent variables, even though these variables do not necessarily increase the predictive power of the model. Therefore, adjusted R-square is used which corrects for the addition of irrelevant independent variables, so that the adjusted R-square value will not exceed R-square and may decrease or become negative if the addition of independent variables does not improve the quality of the model or if the model shows a low level of fit.

4. RESULTS

4.1. Statistical Analysis

Descriptive statistical analysis serves in the description which includes the mean and median of a set of sorted data. In addition, this analysis includes data distribution such as maximum value, minimum value, and standard deviation value as an indicator of data distribution in the study (Jin et al., 2023).

Based on the results of descriptive statistical analysis in Table 1, it can be seen that the Energy Security Index has an average of 66.05833 with a median of 66.49500 which shows a relatively symmetrical data distribution. The maximum value of the Energy Security Index during the 2018-2023 research period reached 66.87000 while the minimum value was 64.90000, indicating a relatively stable index fluctuation. Furthermore, the Primary Energy Consumption data has an average value of 1,595667 and a median of 1,521500. The data variation for this variable can be seen from the maximum value of 1,855000 and the minimum value of 1,438000, indicating significant fluctuations in total Primary Energy Consumption during the study period. Meanwhile, the Renewable Energy Share data shows an average of 11.10000 with a median of 11.70000. The maximum value achieved is 13.10000, while the minimum value is 8.600000, which reflects the variation in the growth of Renewable Energy Share data during the period 2018 - 2023.

4.2. Classical Asumptions

Based on the normality test shown in Figure 1, the probability value is 0.843525> 0.05. Furthermore, the Jarque-Bera value is less than the Chi-Square critical value, which indicates that the data follows a normal distribution pattern.

Based on the multicollinearity test results presented in Table 2, none of the independent variables exhibit a correlation coefficient exceeding the threshold of 0.8. This indicates the absence of significant multicollinearity among the explanatory variables employed in this study. In other words, the variables do not demonstrate a strong linear relationship or critical interdependence, thereby confirming the reliability of the regression model in terms of multicollinearity assumptions.

Table 1: Statistical analysis

Statistical classifications	X_1	X_2	Y
Mean	66.05833	1.595667	11.10000
Median	66.49500	1.521500	11.70000
Maximum	66.87000	1.855000	13.10000
Minimum	64.90000	1.438000	8.600000

Data analysis results, 2025

Table 2: Multicollinearity test

Correlation coefficient variable	X_1	X_2
X_1	1.000000	0.334104
X_2	0.334104	1.000000

Source: Data Analysis Results, 2025

4.3. Robust Least Square

Based on table 3. shows the results of the regression calculation between the confidence level at 0.5% and then transformed into mathematical form as follows:

$$Y = -98.6893008232 + 1.57018073307*X_1 - 3.80179000194*X_2$$

4.4. Statistical Test t (Partial Test)

The Energy Security Index (X_1) coefficient of 1.570181 indicates that every 1 unit increase in the Energy Security Index will increase the share of renewable energy (Y) by 1.570181 assuming other variables remain constant. The z-statistic value is 4.254109 at the 5% significance level, and the probability value (0.0000) is smaller than 0.05. Therefore, it can be concluded that the Energy Security Index has a positive and significant influence on the share of renewable energy partially.

The coefficient of Primary Energy Consumption of −3.801790 indicates that every 1 unit increase in Primary Energy Consumption will reduce the share of renewable energy (Y) by 3.801790 assuming other variables remain constant. The z-statistic value is −2.020722 at the 5% significance level, and the probability value (0.0433) is smaller than 0.05. Therefore, it can be concluded that Primary Energy Consumption has a negative and significant influence on the Partial Renewable Energy Share.

4.5. F Statistical Test

The F test is a statistical test conducted to determine how much influence the independent variables together have on the dependent variable. In the Robust Least Square estimation results, the probability value is 0.0000 and significant at the 5% degree. So it can be concluded that the Energy Security Index (X_1) and Primary Energy Consumption (X_2) together or simultaneously have a significant effect on the Renewable Energy Share (Y).

4.6. Results of the Coefficient of Determination (R2)

The coefficient of determination is used to measure how much variation in the dependent variable can be explained by variations in the independent variables. In this study, the coefficient of determination is carried out to determine how much the percentage of Energy Security Index (X_1) and Primary Energy Consumption (X_2) variables together or simultaneously have a significant effect on the share of renewable energy (Y). Based on the results of the analysis, the value of the coefficient of determination (R^2) is 0.893649. This means that the influence of the variation of the independent variable on the variation of the dependent variable is 89.36% while the remaining 10.64% is explained by variables outside the model.

Table 3: Robust least square test

Variable	Coefficient	SE	z-statistic	P
C	−98.68930	23.55128	−4.190401	0.0000
X_1	1.570181	0.369097	4.254109	0.0000
X_2	−3.801790	1.881402	−2.020722	0.0433
Robust statistics				
R^2	0.893649	Adjusted R-squared		0.822748
Rw-squared	0.919519	Adjust Rw-squared		0.919519
Akaike info criterion	3.111388	Schwarz criterion		6.925800
Deviance	1.335656	Scale		0.928129
Rn-squared statistic	31.43375	Prob (Rn-squared stat.)		0.000000
Non-robust statistics				
Mean dependent var	11.10000	S.D. dependent var		1.817691
S.E. of regression	0.674694	Sum squared resid		1.365635

Source: Data analysis results, 2025. SE: Standard deviation

5. DISCUSSION

In order to understand the trend of the relationship between the Energy Security Index, primary energy consumption, and the share of new renewable energy in Indonesia during the 2018-2023 period, longitudinal analysis is important to see the pattern of changes in these three variables in the context of the national energy transition. The Energy Security Index experienced a fluctuating trend, where in 2018 it was recorded at 64.94, then slightly decreased to 64.9 in 2019, before experiencing a significant increase in 2020 at 66.65. After that, the index value showed relative stability in the range of 66.6 to 66.87 in 2021 and 2022, before experiencing a slight decline to 66.38 in 2023. These fluctuations indicate that despite improvements in energy security, external factors such as global energy price volatility and dependence on fossil fuels are still major challenges.

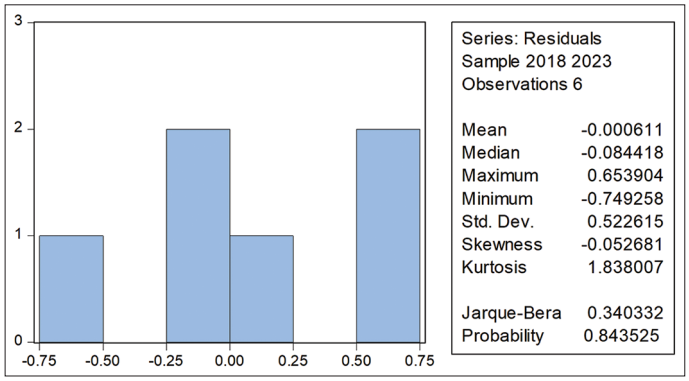
Meanwhile, primary energy consumption shows a significant upward trend, from 1,465 Mtoe in 2018 to 1,855 Mtoe in 2023, with the only decline occurring in 2020 at 1,438 Mtoe, which can be attributed to the economic slowdown due to the COVID-19 pandemic. After this period, energy consumption increased again, reflecting the high domestic energy demand that is still dominated by conventional energy sources (Ministry of Energy and Mineral Resources, 2023).

From the perspective of energy transition, the share of new renewable energy (NRE) shows more stable growth but has not been progressive enough compared to the increase in primary energy consumption. The share of renewable energy increases from 8.6% in 2018 to 13.1% in 2023, but the annual growth is relatively moderate, with the largest increase occurring in the 2019-2020 period. This shows that despite the policy push to increase the share of renewable energy, its growth rate is still unable to keep up with the growth of overall energy consumption.

Figure 2 below presents a visualization of the trend of Energy Security Index, primary energy consumption, and renewable energy share from 2018 to 2023.

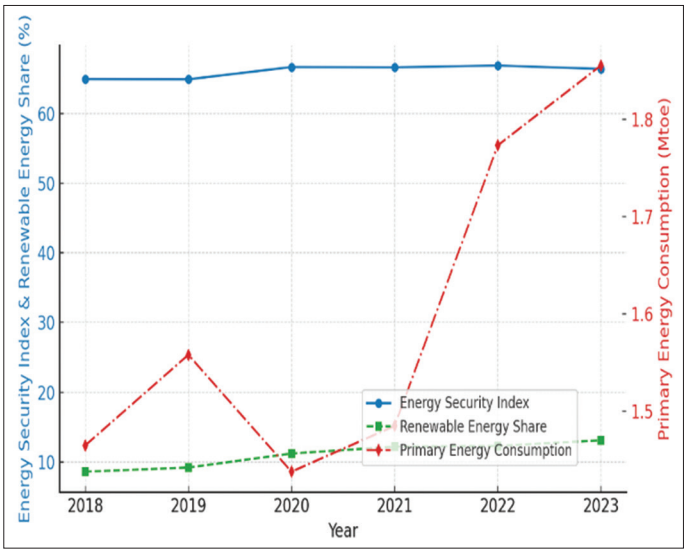
Figure 2 shows that there is a correlation between Energy Security Index and renewable energy share that tends to increase simultaneously, indicating that better energy security can contribute to the acceleration of renewable energy transition. The increase in Energy Security Index, although relatively small, goes hand in hand with the growth of renewable energy share, especially in 2020-2023. However, the increase in primary energy consumption shows the opposite trend, where the surge in energy consumption in 2022 and 2023 is not followed by a significant increase in the share of EBT. This indicates that the increase in energy consumption is still dominated by fossil energy sources, which hinders the optimization of clean energy transition (Alam

Figure 1: Normality test



Source: Data Analysis Results, 2025

Figure 2: Trends in energy security index, primary energy consumption, and renewable energy share (2018-2023)



et al., 2024). This result is in line with the regression findings in this study, which show a positive and significant effect of the Energy Security Index on the share of renewable energy, as well as a negative impact of primary energy consumption on the renewable energy mix. Thus, more assertive policies are needed to improve energy efficiency and accelerate investment in renewable energy to achieve Indonesia's energy transition target.

5.1. Energy Security Index and its Implication on Renewable Energy Share

The relationship between the Energy Security Index and the share of renewable energy is an important aspect of the global energy transition (Trifonov et al., 2021). The Energy Security Index reflects a country's resilience in ensuring a stable and affordable energy supply, while the share of renewable energy shows the contribution of clean energy in the national energy mix. The relationship between the Energy Security Index and the share of renewable energy can be analysed through the Energy Transition theory (Rogers, 2003) which explains that the energy transition is not only influenced by technological innovation, but also by energy security that enables sustainable investment in renewable energy. In the Resource Dependence Theory approach (Pfeffer and Salancik, 1978), countries with higher levels of energy security tend to have greater flexibility in developing green energy due to more controllable supply risks.

Empirical studies confirm the positive relationship between Energy Security Index and renewable energy share. Research by Ang et al. (2015) found that countries with high energy security index tend to have better capacity in building clean energy infrastructure and accelerating the transition to renewable energy. This is reinforced by the findings of Bhattacharya et al. (2016) which show that energy diversification and mature energy security planning contribute significantly to increasing the share of renewable energy in the national energy mix.

In the context of Indonesia, data from the International Energy Agency and the Ministry of Energy and Mineral Resources show that Indonesia's Energy Security Index in the period 2018-2023 is in the range of 62-65 on a scale of 100, reflecting challenges in energy supply reliability as well as limitations in diversifying energy sources. On the other hand, the share of renewable energy increased from 11% in 2018 to 14.1% in 2023, although this figure is still far from the 2025 National Energy General Plan target of 23%. The main challenge in growing the share of renewable energy in Indonesia is the dominance of fossil fuels in the national energy mix, which is exacerbated by dependence on energy imports and the slow development of green energy infrastructure (Setiawan and Nugroho, 2021). To address this challenge, carbon tax policy has been introduced as an instrument to reduce dependence on fossil energy, but its implementation is still limited. When compared to countries with high Energy Security Index such as Germany and the UK, there are significant disparities in energy policy approaches. Germany, with its Energiewende policy, has managed to increase its share of renewable energy to more than 42% by 2023 through strong fiscal incentives and subsidies for green energy projects. The UK has also reduced its dependence on fossil fuels through an effective carbon trading system and strict regulation of renewable energy development.

In terms of fiscal incentives, Japan has heavily subsidised renewable energy development, while Indonesia still allocates more subsidies to fossil fuels, which discourages investment in the green energy sector (Yamaguchi et al., 2023). In terms of carbon tax policy, Canada has adopted a more progressive mechanism with a gradually increasing carbon price scheme to encourage more effective emission reductions. In contrast, the implementation of carbon tax in Indonesia is still limited, especially in the coal-based power generation sector (Smith et al., 2022).

In addition to fiscal incentives and carbon tax regulations, grid capacity is also a determining factor in increasing the share of renewable energy. Indonesia still faces limitations in the integration of intermittent renewable energy, such as solar and wind power, which require further investment in transmission infrastructure and energy storage technology. Without increased investment in this sector, renewable energy penetration will remain limited and suboptimal in the national energy mix (Santoso, 2023).

Based on these findings, some policy recommendations that can be implemented to increase the share of renewable energy through

an increase in the Energy Security Index include increasing investment incentives in green energy through tax breaks and direct subsidies for renewable energy projects, reducing dependence on fossil fuels through the implementation of a firmer and more gradual energy transition policy and increasing the capacity of the electricity grid and developing green energy infrastructure to be more optimal in accommodating clean energy sources. In addition, international collaboration should be strengthened to improve technology transfer and renewable energy production capacity in the country. With policies that are more strategic, data-driven, and aligned with international best practices, Indonesia has great potential to accelerate the energy transition to a more sustainable, resilient energy system and support the 2060 Net Zero Emission target (Zhang and Lee, 2021).

5.2. Primary Energy Consumption and its Implication for the Share of New Renewable Energy

Primary energy consumption is a fundamental aspect of a country's energy structure that has direct implications for the national energy mix, including the share of new renewable energy (Lahope, 2023). Based on the Energy Transition Theory by Rogers (2003), the shift from fossil fuel dominance to renewable energy occurs through a series of stages that include technological innovation, initial diffusion, to large-scale implementation. However, in Indonesia, the increasing trend of primary energy consumption, which is still dependent on fossil fuels, hinders the acceleration of the energy transition. Resource dependence theory by Pfeffer and Salancik (1978) explains that high dependence on certain energy resources, such as coal, oil and natural gas, has the potential to reduce economic flexibility and slow down green energy innovation. This phenomenon occurs in Indonesia, where the dominance of fossil energy in primary energy consumption has significantly limited the growth rate of renewable energy share.

Based on the Ministry of Energy and Mineral Resources report, primary energy consumption in Indonesia increased from 200 Mtoe in 2018 to 220 Mtoe in 2023, with the dominant composition coming from fossil fuels which reached 85% of the total national energy consumption. Although the share of renewable energy has increased from 11% in 2018 to 14.1% in 2023, this achievement is still far from the 23% target as stated in the 2025 National Energy General Plan. The imbalance between the increase in primary energy consumption and the development of renewable energy is an indicator that the growth of Indonesia's energy sector is still dependent on conventional energy sources. The 60% dependence on coal as the main source of national electricity generation further exacerbates the slow energy transition. Other major obstacles include limited electricity grid infrastructure to accommodate renewable energy, as well as the lack of investment incentives for green energy projects (Hidayat and Widodo, 2023).

The phenomenon in Indonesia further reinforces the negative relationship between primary energy consumption and the share of renewable energy. Dependence on coal-based steam power plants still dominates, contributing more than 55% to total national electricity production. Although the government has launched a program to phase out old power plants and replace them with renewable energy-based power plants, implementation in the field still faces obstacles, especially in terms of funding and infrastructure readiness. In addition, palm oil-based biodiesel programs such as B30 that aim to reduce dependence on fossil fuels face technical and economic constraints on raw materials. Fluctuations in global coal prices are also a factor that further strengthens dependence on fossil energy, as when coal prices spike, the government tends to allocate more subsidies to keep electricity tariffs stable, which in turn discourages investment in the renewable energy sector (Widyawati and Ardiansyah, 2022).

When compared to countries that have successfully increased the share of renewable energy along with primary energy consumption, Indonesia is still experiencing delays in implementing energy transition policies. For example, Germany, with primary energy consumption of 305 Mtoe, is able to increase the share of renewable energy to 42% through fiscal incentive policies, feed-in tariff mechanisms, and strict regulations on carbon emissions. China, as the country with the largest primary energy consumption in the world, reached 3,000 Mtoe in 2023, but managed to increase the share of renewable energy to 30% through an aggressive investment strategy in the solar and wind power sectors. Scandinavian countries such as Sweden and Norway also show that energy efficiency and strong incentive policies play an important role in accelerating the shift from fossil energy to green energy (Liu and Li, 2023).

The results of this study are in line with the findings of (Uzar, 2020) which show that high primary energy consumption will only have a positive impact on the share of renewable energy if supported by the right energy policy. However, in the context of Indonesia, the increasing primary energy consumption without a firm energy transition strategy actually contributes to the slow growth of the share of EBT. Studies by Sadorsky (2009) also reveal that countries with high primary energy consumption but without clear energy transition regulations tend to experience stagnation in the development of the green energy sector. Thus, the conditions that occur in Indonesia indicate a negative relationship between primary energy consumption and the share of renewable energy, where an increase in fossil-based primary energy consumption actually slows down the shift to clean energy.

Indonesia has had limited success in developing renewable energy, despite an increase in solar energy capacity to 1.6 GW by 2023 and the construction of a Bayu Power Plant in South Sulawesi (Sianipar et al., 2024). The carbon tax policy that has been in place since 2022 has also yet to have a significant impact on reducing fossil-based energy consumption, given that its implementation is still limited to the coal-based power generation sector. Other challenges include unprepared grid infrastructure to support widespread renewable energy integration, fossil energy subsidies that remain high (more than USD 8 billion/year), and industry resistance in adopting low-carbon technologies due to high initial investment costs. For example, heavy industry sectors such as cement and steel, which are the largest energy users in Indonesia, still face obstacles in transitioning to clean energy due to technological limitations and lack of fiscal incentives that support the development of low-emission technologies (Mudhoffar and Magriasti, 2024).

G20 countries such as Canada and the UK have successfully reduced fossil-based primary energy consumption by implementing progressive carbon tax schemes and green energy incentives. In contrast, Indonesia's energy policy is still not fully supportive of accelerating the energy transition, as dominant fossil fuel subsidies hinder the development of investment in the renewable energy sector. To accelerate the energy transition, the Indonesian government needs to implement policies to improve energy efficiency in the industrial and transportation sectors by adopting energy-efficient technologies, strengthen regulations to reduce fossil fuel consumption through wider application of carbon tax mechanisms, and develop incentives for investors in the green energy sector, such as zero tax schemes for renewable energy projects. In addition, increased investment in green energy infrastructure, especially in smart grids, is a key factor in accommodating higher penetration of renewable energy (Sianipar et al., 2024). Based on the estimated economic impact, a 10% reduction in fossil-based primary energy consumption can increase the share of renewable energy to 20% by 2030, which in turn will strengthen national energy security and support the 2060 Net Zero Emission target.

6. CONCLUSION

This study examines the relationship between the Energy Security Index, primary energy consumption, and the share of new renewable energy in the context of Indonesia's energy transition. The analysis shows that the Energy Security Index has a positive and significant effect on the share of renewable energy, indicating that improving energy security contributes to accelerating the adoption of renewable energy. In contrast, fossil-based primary energy consumption has a negative impact on the share of renewable energy, which indicates that dependence on conventional energy sources is still a major obstacle in the transition to sustainable energy. The estimation model used has a coefficient of determination (R^2) of 89.36%, which indicates that the independent variables significantly explain the variability of the share of renewable energy in Indonesia.

From a policy perspective, the results of this study indicate that improving energy security should be followed by a comprehensive strategy, including the reduction of fossil fuel subsidies, expansion of renewable energy investment incentives, and strengthening regulations related to carbon taxes to reduce fossil-based energy consumption. The findings confirm that energy security and primary energy consumption play a significant role in shaping Indonesia's energy transition. With the right policies and targeted mitigation strategies against fossil energy dependence, an accelerated energy transition can be achieved, supporting national energy sustainability and contributing to the Net Zero Emission 2060 target.

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