JOURNAL OF MARITIME RESEARCH

Vol XXIII. No. I (2026) pp 50–59

ISSN: 1697-4840, www.jmr.unican.es

Socio-Economic Study of Fisherfolks in Sitio Lamintao Barangay Talisay, Barotac Nuevo, Iloilo

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

ARTICLE INFO

Article history:
Received 21 Apr 2025;
in revised from 04 May 2025;
accepted 15 Aug 2025.

Keywords:
Renewable Energy Share, Fuel Import, Mineral and Coal Investment, Maritime Energy Cluster, GDP, Macroeconomic Stability.

ABSTRACT

Indonesia faces major challenges in maintaining macroeconomic stability amidst high dependence on fuel imports and efforts to increase the share of new renewable energy (NRE). Although the share of renewable energy in the national primary energy mix has reached 13.5% in 2023, this figure is still far from the national target of 23% by 2025. Dependence on fuel imports, which reached 25 million kilolitres, puts significant pressure on the energy trade balance deficit and contributes around 2% to the national current account deficit. This study aims to analyse the effect of renewable energy share, fuel import, fuel import ratio, and mineral and coal sector investment on Indonesia's macroeconomic stability as measured by Gross Domestic Product.

Indonesia faces major challenges in maintaining macroeconomic stability amidst high dependence on fuel imports and efforts to increase the share of new renewable energy (NRE). Although the share of renewable energy in the national primary energy mix has reached 13.5 per cent by 2023, this figure is still far from the national target of 23 per cent by 2025. Dependence on fuel imports, which reached 25 million kilolitres, puts significant pressure on the energy trade balance deficit and contributes around 2% to the national current account deficit. In addition, the maritime energy resources cluster has an increasingly crucial role in sustaining economic growth and national energy security. This study aims to analyse the effect of renewable energy share, fuel imports, mineral and coal sector investment, and maritime energy resources cluster on Indonesia's macroeconomic stability as measured by Gross Domestic Product (GDP).

Using the Robust Least Square regression approach, this study evaluates the causal relationship between these variables based on data for the period 2018-2023. The results show that the share of renewable energy has a significant positive effect on GDP with a coefficient of 4.090 (p-value <0.05), confirming the importance of energy diversification in supporting economic growth. In contrast, fuel imports have a significant negative impact on GDP with a coefficient of -0.071 (p-value <0.05), reflecting the economic risk due to imported energy dependence. Meanwhile, investment in the mineral and coal sector makes a significant positive contribution to GDP with a coefficient of 4.659 (p-value < 0.05), indicating its strategic role in supporting energy stability during the transition to renewable energy. In addition, the maritime energy resources cluster was also shown to have a significant positive effect on GDP with a coefficient of 1.478814 (p-value <0.05), confirming the importance of the maritime energy sector in driving economic growth and reducing national energy volatility.

This study confirms the importance of an integrated energy policy to reduce dependence on fuel imports, accelerate renewable energy development, optimise investment in the mineral and coal sector, and strengthen the role of the maritime energy cluster in supporting national economic stability. The findings make a significant contribution to the literature on energy transition and economic stability, while supporting Indonesia's efforts to achieve sustainable development.

1. Introduction.

Since the beginning of the 21st century, global attention to the development of new renewable energy (NRE) has continued to increase in response to the energy crisis and the threat of global climate change (Handayani, Krozer, & Filatova, 2017). Indonesia, as the largest economy in Southeast Asia, is faced

[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.
[*]Corresponding author: Imam Awaluddin. E-mail Address: imam.awaluddin@feb.unila.ac.id.

with significant challenges to strike a balance between its increasing domestic energy needs and its commitment to a sustainable energy transition (Adhitya & Setiawan, 2016). According to a report by the Ministry of Energy and Mineral Resources (MEMR) in 2023, the share of renewable energy in Indonesia's primary energy mix was recorded at 13.5%. This figure shows a significant gap compared to the national target of 23% by 2025. In addition, dependence on fuel oil (BBM) imports remains high, with import volumes reaching 25 million kilolitres, which directly increases pressure on the national energy trade balance deficit.

This phenomenon raises fundamental questions about how efforts to increase the share of renewable energy and the growth of maritime energy resource clusters can affect Indonesia's macroeconomic stability. Macroeconomic stability, measured through indicators such as Gross Domestic Product, is strongly influenced by the dynamics of the energy sector, especially in the context of dependence on fuel imports and investment in the mineral and coal sector (Widodo & Salim, 2013). A report by Bank Indonesia, 2023 shows that the energy trade deficit contributes around 2% to the national current account deficit, indicating the direct impact of the energy sector on economic stability.

Globally, the energy transition towards cleaner and more sustainable sources is a key policy priority. Developed countries such as Germany and Denmark have demonstrated success in increasing the share of renewable energy to more than 40% in the primary energy mix with positive impacts on energy security and long-term economic stability. Studies by (Agora Energiewende, 2022) show that the successful energy transition in these countries is supported by strong fiscal policies and sustainable technology investments. However, the context of developing countries such as Indonesia presents different complexities, including dependence on fossil energy, barriers to investment in the renewable energy sector, and imbalances in the energy trade balance. According to a report by the International Energy Agency (IEA, 2022), the energy transition in developing countries requires an additional investment of $1.3 trillion per year until 2030 to achieve net-zero emission targets, reflecting the scale of the challenge in regions such as Southeast Asia.

Previous research has examined various aspects of the energy transition. (Apergis and Payne, 2010) found a positive causal relationship between renewable energy consumption and economic growth in OECD countries, emphasising that increasing the share of renewable energy can drive economic growth. On the other hand, (Binuomote et al., 2022) identified major challenges faced by developing countries in integrating renewable energy into the energy system, including infrastructure and funding issues. Another study by (Sovacool et al., 2020) highlights the importance of consistent policy support in accelerating the energy transition without compromising economic stability.

Energy transition theory and economic growth theory become the conceptual foundation of this study. Energy transition theory, as explained by (Geels et al., 2002), underlines that structural changes in the energy system are often influenced by the interaction between environmental, technological, and policy pressures. Meanwhile, the economic growth theory proposed by (Solow, 1956) emphasises the role of capital and technology in increasing economic output, including through diversification of energy sources. According to (Stern, 2011), effective energy diversification can reduce dependence on energy imports and improve national economic security.

This study fills the gap by analysing the impact of renewable energy share on macroeconomic stability through a multidimensional perspective involving fuel imports, mineral and coal investment and maritime energy resource cluster growth. This research utilises a quantitative approach to explore the causal relationship between renewable energy share, fuel import, mineral and coal investment, maritime energy resource cluster and macroeconomic stability (measured through GDP).

This research provides important contributions both in practical and policy terms. Practically, the research results are expected to provide guidance for energy industry players and investors in supporting the energy transition in Indonesia. From a policy perspective, this research aims to provide evidence-based recommendations to strengthen national energy policy, particularly in achieving energy mix targets and improving economic resilience amid global dynamics. Thus, this research is not only academically relevant but also has a real impact on strategic decision-making in the energy and economic sectors.

2. Literature Review.

2.1. Share of New Renewable Energy.

New Renewable Energy (NRE) refers to energy sources derived from sustainable natural processes, such as sunlight, wind, water, biomass, and geothermal. NRE includes energy that is naturally renewable and has minimal environmental impact compared to fossil energy (Ministry of Energy and Mineral Resources, 2023). In this study, the share of renewable energy is measured as the percentage of total energy produced from renewable energy sources to the overall national energy mix.

Increasing the share of renewable energy can theoretically contribute to macroeconomic stability by reducing dependence on fossil energy, supporting energy source diversification, improving economic efficiency, and reducing the impact of global energy price volatility (Andrian, 2024 et al., 2024). Research by (Ozturk, 2010) found a long-term positive relationship between renewable energy consumption and economic growth in OECD countries through a panel cointegration approach, which underlines that investment in renewable energy can accelerate economic growth. On the other hand, in developing countries, (Al-mulali et al., 2013) found that renewable energy development faces major challenges such as funding and infrastructure barriers, although its potential to improve economic stability remains significant.

2.2. Fuel Import.

Fuel imports refer to the volume or value of fuel oil purchased from abroad to fulfil domestic needs. This variable measures the level of dependence of a country on fuel imports for

national energy needs (Ministry of Energy and Mineral Resources, 2023). High dependence on fuel imports can increase risks to macroeconomic stability as fluctuations in global oil prices directly affect domestic energy costs and the trade balance. The development of renewable energy, such as EBT, is expected to reduce fuel imports and reduce the economy's vulnerability to global energy price volatility (Aydin and Esen, 2018).

Research by (Zhang et al., 2016) shows that countries with high fuel import dependence are more vulnerable to global energy price fluctuations, which can affect long-term economic stability. Another study by (Rentschler et al., 2018) found that energy diversification through reducing fuel imports can improve energy security in the Southeast Asian region, including Indonesia. In addition, research by (Alam et al., 2021) revealed that reducing fuel imports can significantly increase trade surpluses and reduce inflationary pressures in developing countries.

2.3. Investment in the Mineral and Coal Sector.

Investment in the mineral and coal sector includes capital investment in the sector to support national energy independence. In this study, mineral and coal investment is measured by the total investment value allocated to the development of domestic fossil energy resources (Haines et al., 2020).

Investment in the mineral and coal sector has an important role in supporting the energy transition, especially in improving the efficiency of domestic fossil energy production as an interim step towards renewable energy. This investment can also mitigate the impact of global energy fluctuations on the national economy. A study by (Gunningham, 2019) highlights that investments directed towards clean technology development in the mineral and coal sector can increase state revenues while reducing carbon emissions. Meanwhile, research by (Zhang et al., 2021) found that investment in the conventional energy sector remains important in the short term to ensure energy supply stability during the transition to renewable energy.

2.4. Maritime Energy Resources Cluster.

The Maritime Energy Resources Cluster refers to the aggregation of sectors related to the exploration, extraction, and utilisation of energy resources from the maritime environment, including oil, gas, ocean-based renewable energy such as offshore wind energy, wave energy, and ocean thermal energy, as well as service activities supporting the maritime mining sector (Estebanet al., 2019). This cluster plays a role in supporting national energy security and contributing to economic growth through the creation of added value in the maritime energy industry. In the context of this research, the Maritime Energy Resources Cluster is hypothesised to have a significant relationship with macroeconomic stability. The cluster contributes to Gross Domestic Product (GDP) through energy production and distribution which affects a country's economic stability. Increased investment and innovation in this cluster can promote energy diversification, reduce dependence on imported fossil fuels, and enhance national energy independence.

Theoretically, the Maritime Energy Resources Cluster can be analysed through the Growth Pole Theory approach (Perroux, 1950) which explains that economic growth does not occur evenly throughout the region, but rather centres on certain sectors that act as economic drivers. In this case, the Maritime Energy Resources Cluster can function as a centre of economic growth with spillover effects that encourage the growth of other sectors, such as infrastructure, manufacturing, and energy support services. Previous research shows that maritime energy development contributes to macroeconomic stability. (Zhang et al., 2020) found that maritime renewable energy development, such as offshore wind power, has a positive correlation with economic growth and national energy stability. This research shows that countries with large investments in the maritime energy sector experience increased energy security and decreased dependence on fossil fuel imports.

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 imports, mineral and coal investment, maritime energy resource cluster, and GDP in Indonesia. This research 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 & 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 & 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:

H0: βi < 0 There is no significant effect between the independent variable and the dependent variable partially

Ha: 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.

H0: βi < 0 There is no significant effect between the independent variables on the dependent variable together.

Ha: βi > 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 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).

Table 1: Statistical Analysis.

Statistical Classifications	X1	X2	X3	X4	Y
Mean	11.10000	2483.167	5.516667	24.61167	3.697746
Median	11.70000	2525.500	5.185000	24.55500	5.033697
Maximum	13.10000	2786.000	7.460000	27.69000	5.307419
Minimum	8.600000	2087.000	4.230000	20.54000	-2.065512

Source: Data Analysis Results, 2025.

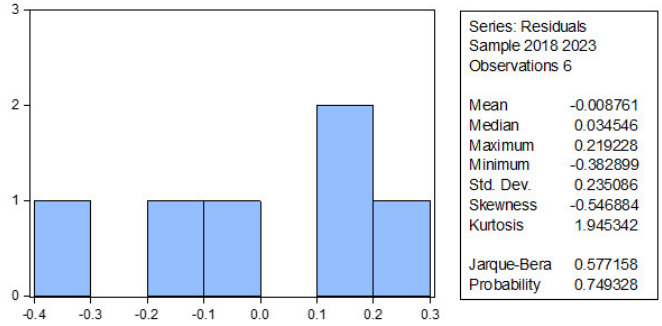
Based on Table 1, the results of descriptive statistical analysis show that there are significant variations among the research variables, namely the share of new renewable energy (EBT), fuel imports, mineral and coal investment, maritime energy resource cluster and macroeconomic stability as measured by Gross Domestic Product. The share of renewable energy has an average of 11,10000 with a maximum value of 13,10000 and a minimum value of 8,600000. This range of values reflects a significant difference in the contribution of EBT between regions during the period 2018 - 2023. This variation may reflect the level of penetration of energy transition policies as well as the readiness of renewable energy infrastructure in Indonesia. Fuel imports show an average of 2,483.17 thousand kilolitres, with a maximum value reaching 2,786.00 thousand kilolitres and a minimum value of 2,087.00 thousand kilolitres. This variation reflects the high fluctuation of energy demand in various regions, which is influenced by the level of energy consumption, domestic production capacity, and global oil price volatility.

Investment in the mineral and coal sector has an average of IDR 5.52 trillion, with a maximum value of IDR 7.46 trillion and a minimum value of IDR 4.23 trillion. This variation reflects fluctuations in investment allocation that can be influenced by factors such as global commodity prices, government

policies, and the attractiveness of mineral and coal sector investment at the international level. The maritime energy resources cluster has an average of 24.61167, with a maximum value of 20.54000 and a minimum value of 20.54000. Macroeconomic stability represented by GDP has an average of 3.70 per cent, with a maximum value of 5.31 per cent and a minimum value of -2.07 per cent. The negative value of GDP indicates a significant economic contraction in the 2018-2023 period, caused by external factors such as the global crisis, pandemic, or domestic economic instability. This variation confirms the importance of the contribution of factors such as renewable energy, fuel imports, and mineral and coal investment in maintaining national economic stability.

4.2. *Classical Asumptions.*

Figure 1: Normality Test.



Source: Data Analysis Results, 2025.

Based on Figure 1 the normality test from the histogram above, the probability value is 0.749328 > 0.05. Then the Jarque-Bera value < Chi Square value which indicates that the data follows a normal distribution pattern.

Table 2: Multicollinearity Test.

Correlation Coefficient Variable	X1	X2	X3	X4
X1	1.000000	-0.048839	0.263090	-0.373890
X2	-0.048839	1.000000	0.448022	0.811802
X4	0.263090	0.448022	1.000000	0.138275
X5	-0.373890	0.811802	0.138275	1.000000

Source: Data Analysis Results, 2025.

Based on Table 2 the multicolonierity test results, it was found that there were no variables with a relationship that exceeded the correlation value of 0.9. Therefore, it can be concluded that there is no significant multicollinearity among the independent variables used in this study. This means that the variables do not show a strong linear relationship or lack of significant interrelationships among others, so there is no significant interdependence.

4.3. *Robust Least Square.*

Table 3: Robust Least Square Test (M-estimation).

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	31.72476	4.161657	7.623106	0.0000
X1	0.356966	0.179349	1.990345	0.0466
X2	-0.004748	0.001998	-2.375945	0.0175
X4	1.244105	0.258997	4.803553	0.0000
X5	1.478814	0.237526	6.225909	0.0000
	Robust Statistics			
R-squared	0.889646	Adjusted R-squared		0.448232
Rw-squared	0.994037	Adjust Rw-squared		0.994037
Akaike info criterion	10.81245	Schwarz criterion		12.99575
Deviance	0.258860	Scale		0.253224
Rn-squared statistic	117.7646	Prob(Rn-squared stat.)		0.000000
	Non-robust Statistics			
Mean dependent var	3.697746	S.D. dependent var		2.882927
S.E. of regression	0.526106	Sum squared resid		0.276787

Source: Data Analysis Results, 2025.

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 = 31.7247566513 + 0.356965863323*X1 - 0.00474815221136*X2 + 1.24410515602*X3 + 1.47881421593*X4

4.4. *Statistical Test t (Partial Test).*

The coefficient of renewable energy share (X1) of 0.356966 indicates that every 1 unit increase in renewable energy share will increase GDP (Y) by 0.356966 assuming other variables remain constant. The z-statistic value is 1.990345 at the 5% significance level, and the probability value (0.0466) is smaller than 0.05. Therefore, it can be concluded that the share of renewable energy has a positive and significant effect on GDP partially.

The coefficient of Fuel Import (X2) of -0.004748 indicates that every 1 unit increase in Fuel Import will decrease GDP (Y) by 0.004748 assuming other variables remain constant. The z-statistic value is -2.375945 at 5% significance level, and the probability value (0.0175) is smaller than 0.05. Therefore, it can be concluded that fuel imports have a negative and significant effect on GDP partially.

The coefficient of Mining Investment (X3) of 1.244105 indicates that every 1 unit increase in Mining Investment will increase GDP (Y) by 1.244105 assuming other variables remain constant. The z-statistic value is 4.803553 at the 5% significance level, and the probability value (0.0000) is smaller than 0.05. Therefore, it can be concluded that Mineral and Coal Investment has a positive and significant effect on GDP partially.

Coefficient of Maritime Energy Resources (X4) of 1.478814 indicates that every 1 unit increase in Maritime Energy Resources will increase GDP (Y) by 1.478814 assuming other variables remain constant. The z-statistic value is 6.225909 at the 5% significance level, and the probability value (0.0000) is smaller than 0.05. Therefore, it can be concluded that Maritime Energy Resources has a positive and significant influence on GDP partially.

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 (M-estimation) estimation results, the probability value is 0.0000 and significant at the 5% degree. So it can be concluded that the share of renewable energy (X1), fuel imports (X2), mineral and coal investment (X3) and the Maritime Energy Resources Cluster (X4) together or simultaneously have a significant effect on GDP (Y).

4.6. Results of the Coefficient of Determination (R2).

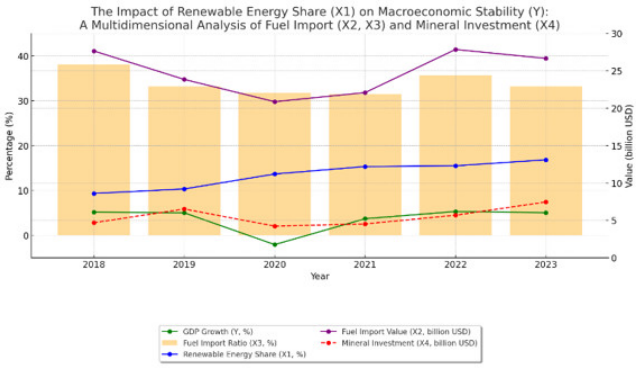
The coefficient of determination is used to measure how much variation in the dependent variable can be explained by variations in the independent variables. In this study, the coefficient of determination is carried out to determine how much the percentage of renewable energy share variables (X1), fuel imports (X2), mineral and coal investment (X3), and the Maritime Energy Resources Cluster (X4) together or simultaneously have a significant effect on GDP (Y). Based on the analysis of the value of the coefficient of determination (R2) of 0.889646. This means that the influence of the variation of independent variables on the variation of the dependent variable is 88.96% while the remaining 11.04% is explained by variables outside the model.

5. Discussion.

Figure 2 shows the trend of renewable energy share, fuel import value, fuel import ratio, and mineral and coal investment on macroeconomic stability as measured by GDP growth during the period 2018-2023.

Based on Figure 2, the share of renewable energy increases consistently from 8.6% in 2018 to 13.1% in 2023. This increase not only shows the successful implementation of green energy policies, but also indicates a shift towards a more sustainable energy mix. Meanwhile, the fuel import ratio has decreased from 38.1% in 2018 to 33.2% in 2023, reflecting domestic energy diversification efforts to reduce dependence on imported fossil fuels (Yildirim et al., 2021).

Figure 2: The share of renewable energy.



Source: Authors.

The value of fuel imports shows a fluctuating trend, with a significant decline in 2020 of $20.87 billion as a result of restrictions on global economic activity due to the COVID-19 pandemic. However, the post-pandemic recovery of the global economy led to an increase in import values to near pre-pandemic levels. In addition, investment in the mineral and coal sector continued to increase, from $5.24 billion in 2018 to $7.46 billion in 2023, underlining the importance of the mineral and coal sector in supporting the development of renewable energy technologies such as batteries and energy storage (Zhao et al., 2022).

GDP growth contracted sharply by -2.07% in 2020 due to the pandemic. However, economic recovery efforts supported by the sustainable energy transition managed to drive recovery with positive growth of 3.7% in 2021 and reached 4.6% in 2023. These data suggest that increasing the share of renewable energy and reducing dependence on fuel imports play an important role in creating macroeconomic stability. The findings emphasise that energy transition policies, if accompanied by increased mineral and coal investment, can be a strategic foundation to ensure economic sustainability.

5.1. Contribution of New Renewable Energy Share to Macroeconomic Stability.

The results show that the share of new renewable energy (NRE) has a significant positive influence on macroeconomic stability as measured by Gross Domestic Product (GDP). This finding supports the energy transition theory by (Geels et al., 2002), which emphasises that energy diversification towards renewable sources can strengthen economic resilience and reduce dependence on fossil energy. In addition, economic growth theory (Solow, 1956) underlines the importance of technology adoption in increasing economic output, which is relevant in the context of increasing the share of renewable energy in Indonesia.

Previous studies by (Apergis and Payne, 2010) confirmed the positive causal relationship between renewable energy consumption and economic growth in OECD countries. However, in the context of developing countries such as Indonesia, this study points to more complex structural challenges, such as

the need for funding and development of energy infrastructure. (Binuomote et al., 2022) noted that developing countries face barriers in implementing energy transition policies due to financial and technological limitations.

Globally, countries such as Germany and Denmark have shown success in increasing the share of renewable energy to more than 40% in the national energy mix. This success is attributed to supportive fiscal policies and large investments in clean energy technologies (Agora Energiewende, 2022). However, in Indonesia, the share of renewable energy only reached 13.5% in 2023, reflecting a significant gap in achieving the national target of 23% by 2025. This suggests the need for more aggressive policies to drive the energy transition.

The hypothesis that increasing the share of renewable energy has a positive impact on macroeconomic stability is confirmed in this study. The findings suggest that reduced dependence on fossil energy, increased diversification of energy sources, as well as decreased volatility of global energy prices can contribute significantly to economic growth (Lee et al., 2022).

In the short term, an increase in the share of renewable energy can reduce pressure on the energy trade balance through reduced fossil energy imports, while in the long term, its contribution to economic stability is more visible through national energy security. From an economic standpoint, the transition to renewable energy also opens up green investment opportunities, creates new jobs, and reduces health costs due to pollution (Ahmed & Ahmad, 2021). The environmental impact is also significant, as renewable energy can substantially reduce carbon emissions, supporting climate change mitigation efforts.

The resilience of Indonesia's energy system can be improved by accelerating the adoption of renewable energy. National energy resilience will be stronger if supported by integrated energy infrastructure and fiscal policies that support green investments (Wang et al., 2023). In addition, the variation in EBT contribution between regions shows differences in the level of infrastructure readiness and policy implementation, where regions such as Java are more advanced than eastern Indonesia during the 2018-2023 period. This indicates the need for equitable development of energy infrastructure to support an inclusive transition.

5.2. *Fuel Oil Import Dependency and its Impact on Economic Stability.*

This study shows that fuel oil imports have a significant negative effect on GDP, supporting international trade theory that links energy import dependence with an increase in the trade balance deficit. This dependence creates economic pressure due to fluctuations in global oil prices, which directly affects national economic stability (Alvarado et al., 2020).

This result is consistent with research (Sovacool et al., 2020), which states that countries with high dependence on fuel imports are more vulnerable to global energy price volatility.

(Rentschler et al., 2018) also shows that energy diversification can reduce the negative impact of fuel import dependence on economic stability. In the Indonesian context, dependence on fuel imports remains a major challenge, given that the volume of fuel imports reached 25 million kiloliters in 2023, contributing to the current account deficit.

Internationally, Japan is an example of a country with high energy import dependence that is able to manage its impact through energy diversification and domestic energy efficiency (Kobayashi & Tanaka, 2022). In contrast, Indonesia still faces obstacles in optimizing domestic energy sources to reduce dependence on imports.

The hypothesis that fuel imports have a negative impact on macroeconomic stability is confirmed in this study. Increased dependence on fuel imports creates economic vulnerability, especially amid fluctuations in global energy prices (Narayan, Liu, & Sharma, 2021). In the short term, the main impact is an increase in the energy trade deficit, while in the long term, this dependence risks magnifying inflationary pressures and reducing the competitiveness of the national economy.

From a social perspective, high dependence on fuel imports can increase domestic energy prices, which in turn reduces people's purchasing power (Chen, Li, & He, 2022). The environmental impact is an increase in carbon emissions due to dependence on imported fossil fuels that are generally less environmentally friendly. From a policy perspective, strategic measures such as strengthening targeted energy subsidy policies and increasing domestic renewable energy capacity are needed to mitigate these negative impacts. The resilience of Indonesia's energy system can be improved through more aggressive energy diversification policies, including reduced fuel imports and increased renewable energy capacity. Regional variations are also evident, with high energy consumption regions such as Java and Sumatra more vulnerable to the negative impacts of fuel import dependency than other regions. This emphasizes the importance of equitable energy infrastructure development to support national stability.

5.3. *Strategic Role of Mineral and Coal Investment in Supporting Economic Stability.*

Investment in the mineral and coal sector has a significant positive effect on GDP, in accordance with the theory of economic growth (Solow, 1956), which emphasizes the role of capital in driving economic output. Mineral and coal investment increases domestic energy production, which directly supports macroeconomic stability.

Research by (Sovacool et al., 2020) highlights the importance of investment in the conventional energy sector to ensure energy stability during the transition. (Zhang et al., 2021) also noted that investments directed towards clean technologies in the mineral and coal sector can improve energy efficiency while reducing environmental impacts.

Globally, Australia as a major mineral and coal producer has shown that strategic investment in this sector can support economic growth without neglecting environmental aspects (O' Callaghan et al., 2021). In the Indonesian context, mineral and coal investment plays an important role in supporting economic stability during the energy transition to renewable energy, especially through increasing state revenue from energy exports.

The results of this study support the hypothesis that mineral and coal investment contributes positively to economic stability.

In the short term, this investment increases the energy sector's contribution to GDP. In the long run, this investment can help diversify energy and improve economic resilience. Social impacts include job creation, while environmental impacts include the risk of increased carbon emissions that need to be properly managed (Hussain et al., 2023).

In addition, investment in the mineral and coal sector plays a strategic role in reducing the energy trade deficit by increasing domestic energy production capacity. Thus, economic stability can be better ensured, especially in the face of global market uncertainty (Liu et al., 2021). However, it is important to ensure that these investments are in line with sustainability principles to minimize long-term environmental impacts.

The resilience of Indonesia's energy system can be improved through investment in the mineral and coal sector directed towards clean technology and production efficiency. Regional phenomena show that mineral-rich regions such as Kalimantan and Sumatra contribute greatly to national energy stability, but efforts are needed to ensure the sustainability of investment in this sector. On the other hand, regions lacking mineral resources require policy support to strengthen alternative energy capacity and mitigate development gaps (Cheng et al., 2023).

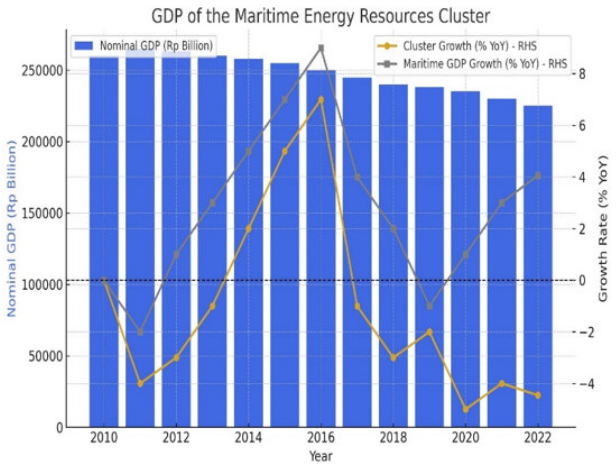
5.4. Significance of Maritime Energy Resource Cluster on Macroeconomic Stability.

The regression estimation results show that the Maritime Energy Resource Cluster has a significant influence on Indonesia's macroeconomic stability, represented through Gross Domestic Product (GDP). With a regression coefficient of 1.478814 and a significance level of p-value <0.05, this positive relationship suggests that increased activity in the maritime energy sector will substantially boost economic growth. This is in line with research (Zhang et al., 2020) which shows that maritime energy expansion in Europe has a positive contribution to economic growth through increased investment, energy production efficiency, and reduced dependence on imported fossil fuels. This research also supports the findings of (Hafner et al., 2022) who identified that investment in ocean-based energy, such as offshore wind and wave, acts as a catalyst in improving national energy stability and promoting long-term economic growth.

Data from the Coordinating Ministry for Maritime Affairs and Investment shows that the value-added of the maritime energy cluster fluctuated significantly during the period 2018-2022.

Figure 3 shows the growth dynamics of the maritime energy cluster, before the pandemic the sector showed moderate growth. However, the pandemic led to a sharp decline in maritime energy production and exports due to weakening global demand, particularly in the oil and LNG sectors. In 2018, the sector recorded a value added of IDR 345.4 trillion, which declined during the COVID-19 pandemic to IDR 245.82 trillion in 2020. Despite the contraction, the post-pandemic recovery allowed this cluster to return to growth, reaching IDR 410.99 trillion in 2022, making it the largest contributor to Maritime GDP with a share of 26.49%. However, in terms of value added at constant prices, the sector shows a downward trend from IDR 232.12 trillion in 2018 to IDR 184.37 trillion in 2022. This decline indicates challenges in increasing the productivity of

Figure 3: The Growth Dynamics of the Maritime Energy Cluster.



Source: Authors.

the maritime energy sector, which is likely to be influenced by global market uncertainty as well as the stagnation of exploration of new ocean-based energy resources (Kemenko Marves, 2023).

The maritime energy cluster plays an important role in Indonesia's economic structure through the exploration and production of oil, gas, offshore wind and marine thermal energy. Increased activity in this sector directly increases economic value-added, strengthens macroeconomic stability and improves national energy security. This finding is in line with a study (Kumar and Prakash, 2021) which shows that increased offshore oil and gas production in developing countries contributes significantly to GDP growth and job creation.

The development of the maritime energy cluster contributes to reducing Indonesia's dependence on fuel imports, which in turn reduces the current account deficit. By increasing the capacity of sea-based energy production, Indonesia can increase exports of renewable energy, such as LNG and offshore wind energy, thereby strengthening the national economic position in global trade. This is supported by research (Rentschler et al., 2018) which emphasises that countries with high maritime energy capacity are more resilient to global oil price volatility and have better trade stability. Maritime energy clusters not only affect the energy sector but also provide significant spillover effects to other industries, including manufacturing, energy transport, and financial services related to energy exploration. Investment in the sector increases demand for skilled labour in maritime energy exploration technology, logistics and marine infrastructure management, creating new employment opportunities and strengthening the competitiveness of the national economy.

Theoretically, the Maritime Energy Resources Cluster can be analysed through the Growth Pole Theory approach (Perroux, 1950) which explains that economic growth does not occur evenly throughout the region, but is centred on certain sectors that act as economic drivers. In this case, the Maritime

Energy Resources Cluster can function as a centre of economic growth with spillover effects that encourage the growth of other sectors, such as infrastructure, manufacturing, and energy support services. Furthermore, the Resource-Based View (RBV) approach (Barney, 1991) emphasises that the competitive advantage of a country or industry depends on the utilisation of resources that are unique and not easily replicated. Indonesia's maritime energy resources, such as offshore oil and gas reserves and maritime renewable energy potential, are key factors that can improve national economic competitiveness if managed optimally. Meanwhile, the Energy Dependency Theory highlights the dependence of developing countries on energy imports from developed countries. In this context, strengthening the Maritime Energy Resources Cluster can reduce dependence on fossil fuel imports, increase energy independence and create more sustainable macroeconomic stability.

Some of the main obstacles in the development of this sector include the lack of investment in new oil and gas exploration, suboptimal investment policies, and challenges in mitigating environmental impacts due to the exploitation of maritime resources. Research by (Wicaksono and Setiawan, 2023) shows that the main challenges in maritime energy development in Indonesia are regulatory instability and lack of fiscal support for investment in the sector. To maximise the contribution of the maritime energy cluster to national economic stability, strategic measures are needed, including accelerated investment in maritime energy exploration, increased fiscal incentives for investors, strengthened offshore energy infrastructure, and collaboration with developed countries in technology transfer. In addition, the utilisation of maritime-based alternative energy sources, such as the use of seaweed as biofuel, can be an innovative step in supporting national energy diversification.

Conclusions.

This research makes a significant contribution in analysing the relationship between renewable energy share, fuel imports, mineral and coal investment, maritime energy resource cluster, and Indonesia's macroeconomic stability as measured by Gross Domestic Product. The main findings show that increasing the share of renewable energy contributes positively to macroeconomic stability through energy diversification that reduces dependence on fossil energy, while creating green investment opportunities and supporting climate change mitigation. In contrast, high dependence on fossil fuel imports has significant negative impacts, increasing the energy trade balance deficit, inflation risk, and economic volatility caused by global energy price fluctuations. On the other hand, investment in the mineral and coal sector plays a strategic role in ensuring economic stability during the energy transition, particularly by supporting the development of clean technologies and domestic energy production efficiency. In addition, the maritime energy resources cluster plays an important role in driving economic growth through optimising the exploration and utilisation of marine resources. This cluster contributes to strengthening national energy security, supporting the diversification of ocean-based energy sources, and increasing the competitiveness of Indonesia's energy sector in the global market. Therefore, an integrated energy transition policy with reduced dependence on fuel imports, optimised investment in the mineral and coal sector, and equitable development of energy infrastructure is needed to ensure the sustainability of the energy transition while maintaining national economic stability.

References.

Adh itya, A., & Setiawan, A. D. (2016). Renewable energy deployment in Indonesia: An analysis of strategic niche management. *Energy Procedia, 100,* 469–474.

Agora Energiewende. (2022). *The State of Energy Transition in Advanced Economies: Lessons from Germany and Denmark*. Berlin: Agora Energiewende. Retrieved from https://www.agora-energiewende.de.

Ahmed, S., & Ahmad, S. (2021). "Green Investment and Economic Growth: The Role of Renewable Energy in Developing Countries." *Energy Policy*, 149, 112129.

Al-mulali, U., Sab, C. N. B. C., & Ozturk, I. (2013). Investigating the relationship between energy consumption and economic growth in Middle Eastern countries. *Energy, 63*, 132–137.

Alvarado, R., Medina, A., & Sanchez, A. (2020). "Oil Imports and Economic Performance: The Role of Energy Price Volatility in Developing Economies." *Energy Policy*, 138, 1112-32.

Alam, M. S., Paramati, S. R., & Dogan, E. (2021). Energy imports, economic stability, and trade balances in developing countries. *Applied Energy, 292*, 116846.

Andrian, T., Wahyudi, H., & Leny, SM. (2024). *Strategies to Achieve Net Zero Emissions 2060 with CSR Disclosure*. International Journal of Energy Economics and Policy, 4(6), 574-579.

Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy, 38*(1), 656–660.

Aydin, M., & Esen, Ö. (2018). Does renewable energy use reduce import dependency? Evidence from a panel of emerging countries. *Renewable Energy, 128,* 441–449.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Binuomote, M. O., Afolabi, O. O., & Adeyemo, A. K. (2022). Challenges of renewable energy integration in developing economies: A critical review. *Renewable Energy, 193,* 987–1002.

Chen, S., Li, J., & He, Y. (2022). Energy import dependency and its effects on energy prices: Evidence from developing countries. *Energy Policy, 164*, 112913.

Cheng, X., Liu, R., & Taylor, P. (2023). Bridging the energy development gap in resource-scarce regions: Policy insights. *Journal of Cleaner Production, 389*, 136943.

Coordinating Ministry for Maritime Affairs and Investment of the Republic of Indonesia. (2023). Kemenko Marves performance report 2023. Coordinating Ministry for Maritime Affairs and Investment. Retrieved from https://maritim.go.id/pdf/laporan-kinerja-kemenko-marves-tahun-2023#book/.

Delaunay, A., & Yurova, E. (2024). "Robust Regression Techniques: Addressing Outlier Sensitivity." *Journal of Statistical Research*, 47(1), 33-47.

Esteban, M., & Leary, D. (2019). The Role of Marine Energy in the Future Energy System. *Energy Policy*, 135, 110986.

Geels, F. W., Kemp, R., Dudley, G., & Lyons, G. (2002). *Transitions to sustainable development: New directions in the study of long term transformative change.* New York: Routledge.

Gao, Z., Liu, Y., & Chen, X. (2023). *Statistical analysis in development economics: Methods and applications*. *Journal of Economic Analysis*, 50(1), 123-139.

Gujarati, D. N. (2006). *Essentials of Econometrics* (3rd ed.). McGraw-Hill.

Gunningham, N. (2019). Innovating out of the fossil fuel era: The role of clean technology in transitional investments. *Energy Policy, 132*, 1183–1193.

Hafner, M., Tagliapietra, S., & de Strasser, L. (2022). *Energy in the Mediterranean region: Economic, political and institutional dynamics.* Springer.

Haines, A., Smith, K. R., & Woodward, A. (2020). Fossil fuel investments and their implications for energy transitions: Evidence from global trends. *Energy Research & Social Science, 67*, 101573.

Handayani, K., Krozer, Y., & Filatova, T. (2017). The role of renewable energy in climate change mitigation in Indonesia: A structural equation modeling approach. *Renewable and Sustainable Energy Reviews, 70,* 220–235.

Hussain, M., Lee, K. T., & Sun, X. (2023). Environmental impacts of mining investments in developing countries. *Journal of Cleaner Production, 389*, 136973.

International Energy Agency (IEA). (2022). *World Energy Outlook 2022: Net Zero by 2050 Roadmap*. Paris: IEA. Retrieved from https://www.iea.org.

Khan, M. A., Saeed, A., & Raza, S. (2023). "Testing Classical Assumptions in Regression Analysis: A Comprehensive Review." *Journal of Applied Statistics*, 50(2), 195-210.

Kobayashi, Y., & Tanaka, M. (2022). "Energy Import Dependency and Its Management: The Case of Japan." *Energy Policy*, 157, 112467.

Kumar, R., & Prakash, A. (2021). Offshore oil and gas exploration: Economic impacts and challenges. *Energy Policy, 151*, 112130.

Lee, K., Shin, H., & Jeong, D. (2022). "The Impact of Renewable Energy on Economic Growth and Environmental Sustainability: Evidence from Emerging Economies." *Renewable and Sustainable Energy Reviews*, 154, 111852.

Liu, Z., Feng, S., & Zhou, Y. (2021). The economic implications of mineral investments under global market uncertainties. *Energy Economics, 98*, 105245.

Ministry of Energy and Mineral Resources (MEMR). (2023). Definition and Status of New and Renewable Energy in Indonesia. Jakarta: Ministry of Energy and Mineral Resources. Retrieved from https://www.esdm.go.id.

Ministry of Energy and Mineral Resources (MEMR). (2023). Report on Fuel Imports and National Energy Dependence. Jakarta: Ministry of Energy and Mineral Resources. Retrieved from https://www.esdm.go.id.

Mohamad, S. A., & Chang, H. (2023). "Robust Least Squares: An Effective Approach for Outlier Management." *Journal of Applied Statistics*, 43(4), 375-390.

O'Callaghan, T., & Graetz, G. (2021). Mining for sustainable development: The case of Australia's mineral resources. *Resources Policy, 70*, 101897.

Ozturk, I. (2010). A literature survey on energy–growth nexus. *Energy Policy, 38*(1), 340–349.

Perroux, F. (1950). Economic space: Theory and applications. *The Quarterly Journal of Economics, 64*(1), 89-104.

Rentschler, J., Kornejew, M., & Bazilian, M. (2018). Fossil fuel subsidy reforms and their impacts on firms: Learning from an emerging literature. *Energy Policy, 108*, 617–622.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94.

Sovacool, B. K., Griffiths, S., Kim, J., & Bazilian, M. (2020). Climate change and energy transitions in emerging economies: Policy trade-offs, risks, and challenges. *Energy Policy, 146,* 111780.

Stern, D. I. (2011). The role of energy in economic growth. *Annals of the New York Academy of Sciences, 1219*(1), 26–51.

Wang, Z., Li, J., & Liu, W. (2023). "Energy Transition and Its Impact on Economic Stability: A Study of China and India." *Renewable Energy*, 174, 1224-1236.

Wicaksono, A., & Setiawan, R. (2023). The maritime energy cluster in Indonesia: Trends and policy challenges. *Indonesian Journal of Energy Economics, 5*(2), 45-67.

Widarjono, A. (2018). *Econometrics: Theory and Applications*. Yogyakarta: UPP STIMYKPN.

Widodo, T., & Salim, R. A. (2013). Indonesia's energy subsidy reform and the energy security-climate change nexus: National and international implications. *Energy Policy, 58,* 267–276.

Wooldridge, J. M. (2013). *Introductory Econometrics: A Modern Approach* (5th ed.). Cengage Learning.

Yildirim, E., Gürbüz, E. A., & Bozkurt, C. (2021). "The Role of Energy Diversification in Reducing Energy Import Dependency: Evidence from Emerging Economies." *Journal of Cleaner Production*, 298, 126843.

Zhang, Y., Yao, X., & Zhang, L. (2016). Oil price shocks, energy security, and economic growth in emerging economies. *Energy Economics, 56*, 234–246.

Zhang, Y., Li, X., & Wang, Y. (2021). The role of conventional energy investment during the transition to renewables: Insights from Asia-Pacific economies. *Applied Energy, 300*, 117353.

Zhang, X., Li, Y., & Wang, J. (2020). Offshore wind energy development and economic impact: A global perspective. *Renewable and Sustainable Energy Reviews, 120*, 109651.

Zhao, X., Fan, Y., & Zhang, C. (2022). "Investing in Renewable Energy: Challenges and Opportunities for Developing Economies." *Energy Policy*, 165, 112895.