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ANALYSIS OF ENERGY DEMAND IN INDONESIA

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Abstract

The purpose of this study is to determine the Influence of Energy Supply, Energy Needs and Final Energy on Energy Demand in Indonesia. The study uses Time Series data from 1985-2023. The study uses the Autoregressive Distributed Lag (ARDL) method. The results of the short-term study show that the Energy Supply variable has a negative and insignificant effect on Energy Demand in Indonesia, Energy Needs has a negative and significant effect on energy demand in Indonesia, and the final energy variable has a positive and insignificant effect on Energy Demand in Indonesia. In the long term, the energy supply and energy needs variables have a negative and significant effect on energy demand in Indonesia. The final energy variable has a positive and significant effect on energy demand in Indonesia.

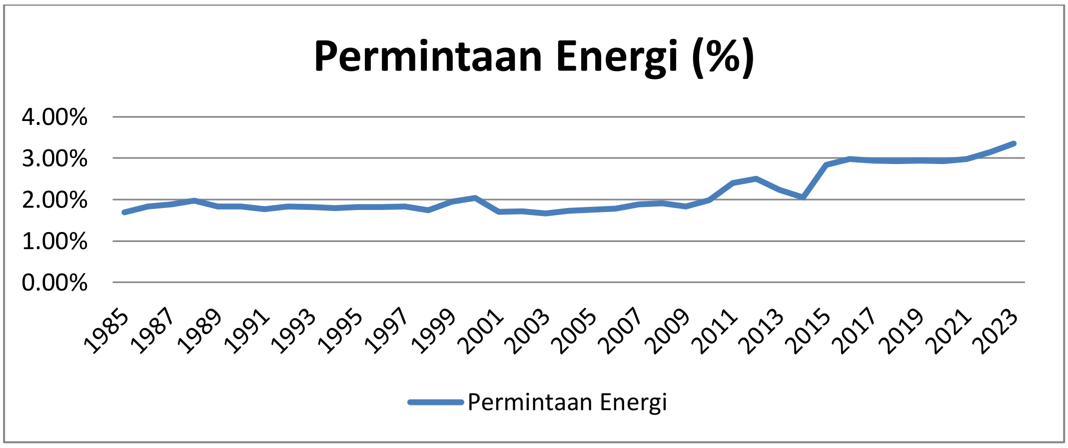
Keywords: ***Energy Supply, Energy Requirements, Final Energy, Energy Demand.***

INTRODUCTION

Energy is the basic capital for the development of a country. Energy plays a strategic role as a pillar of the driving force of the community's economy, both as raw materials for the production sector and as a commodity. Energy plays a major role in improving the macro economy of a country (Aisah & Herdiansyah, 2020). Energy has a very important role in human life, especially in today's increasingly modern era, all human activities cannot be separated from the use of energy. The role of energy is quite large in human life, it cannot be separated from environmental issues and global warming (Harahap, 2019).

Energy has become a very vital need for human life today. Indonesia is no exception, which has various abundant energy in it, both renewable and non-renewable energy. Energy is very much needed in carrying out economic activities, both for consumption needs and production activities in various economic sectors. As a natural resource, energy must be utilized as much as possible for the prosperity of society and its management must refer to the principle of sustainable development (Afriyanti et al., 2018).

Indonesia is a country with a large population and rapid economic growth, so that the demand for energy continues to increase from year to year. In current conditions, the demand for energy supply continues to increase from year to year to meet the needs of the household, transportation, industrial and commercial sectors (Asri, 2018). Strong economic growth and rapid urbanization have driven substantial increases in energy demand. However, over-reliance on fossil fuels, especially coal and oil, raises serious concerns regarding long-term energy security and environmental impacts. In addition, increased energy demand can also have an impact on climate change, if the energy used is not environmentally friendly (Maulidia et al., 2019). In the era of globalization, the demand for energy is increasing rapidly and the dependence of countries on energy shows that energy will be one of the biggest problems in the world in the next century (S. Lilis, H. Siswoyo, 2021).



Data Source: *Ministry of Economic and Mineral Resources (ESDM) 2023*

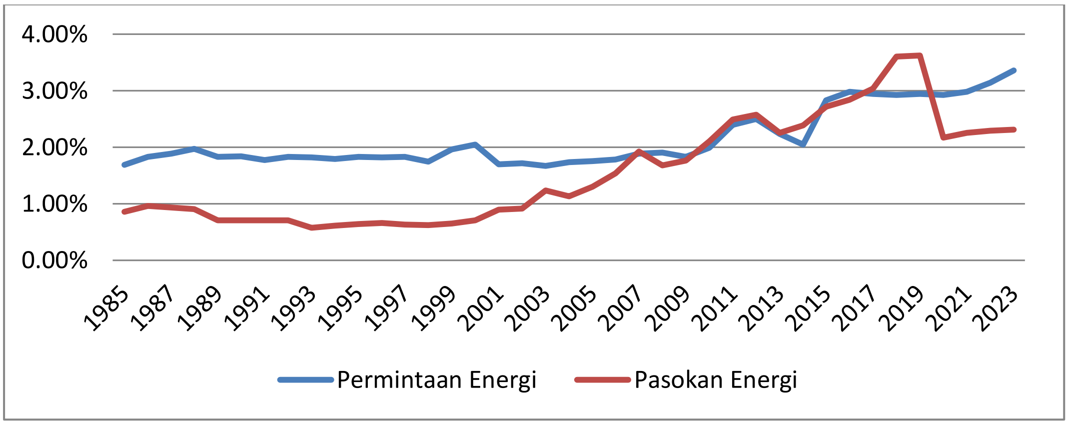
Image 1: Energy Demand in Indonesia

Based on data obtained from the Ministry of Economy and Mineral Resources (ESDM), it can be concluded that Energy demand in Indonesia from 1985 to 2023 continues to fluctuate, increasing and decreasing each year. Fluctuations in energy demand are also present in 2020 due to several factors, especially the Covid-19 pandemic. The impact of the Covid-19 pandemic on the global economy has caused recession in many countries, including Indonesia. This slowed economic growth and reduced energy consumption. In 2021-2023, energy demand in Indonesia again experienced a fairly consistent increase, starting from 2,98% at the beginning of the period to reach 3,36% in the final year.

Indonesia's current energy demand includes an imbalance between rapid economic growth and adequate energy supply capabilities. In recent years, energy demand, especially for electricity and transportation fuels, has increased significantly along with urbanization and population growth. However, existing energy infrastructure is often unable to keep up with this surge in demand, resulting in frequent power outages in various regions. On the other hand, although there is great potential for renewable energy development, its implementation is still limited and has not been able to meet the increasing needs.

Adequate energy supply is essential to improve people's living standards, the quality and quantity of human resources, commercial and business activities, environmental sustainability, and the efficiency of government policies in a country (Hasdiana, 2018). Energy supply is a very important factor in driving development. Along with increasing development, especially development in the industrial sector, economic growth and population growth, the need for energy continues to increase. Thus, if the supply of primary energy is lacking, it can have a negative impact on the sustainability of a nation (Hikmayangkara et al., 2012).

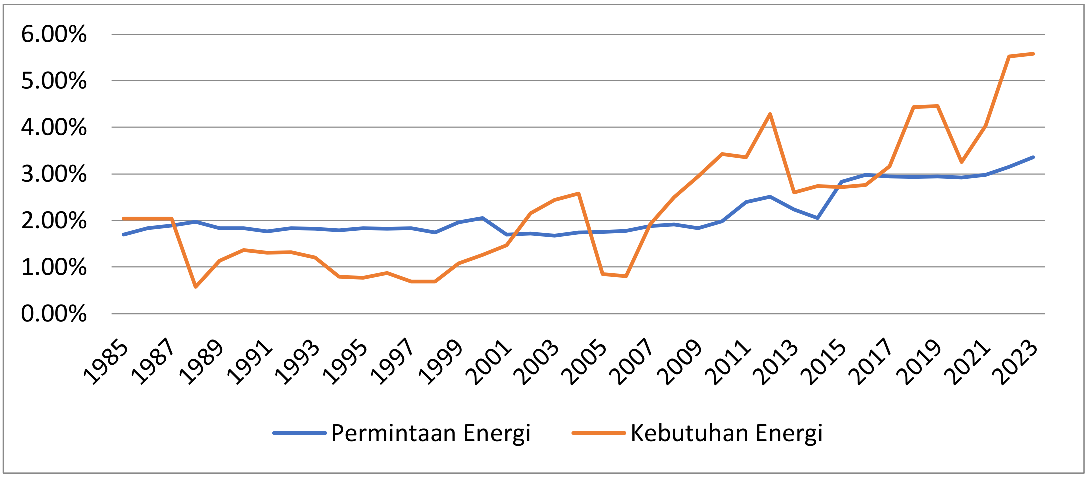
Energy supply in Indonesia is supported by various natural resources including petroleum, natural gas, coal, renewable energy, and others. However, these energy resources have their own challenges in terms of availability, management, and environmental impacts.



Data Source: Ministry of Economic and Mineral Resources (ESDM) 2023

Image 2 : Energy Demand and Energy Supply In Indonesia

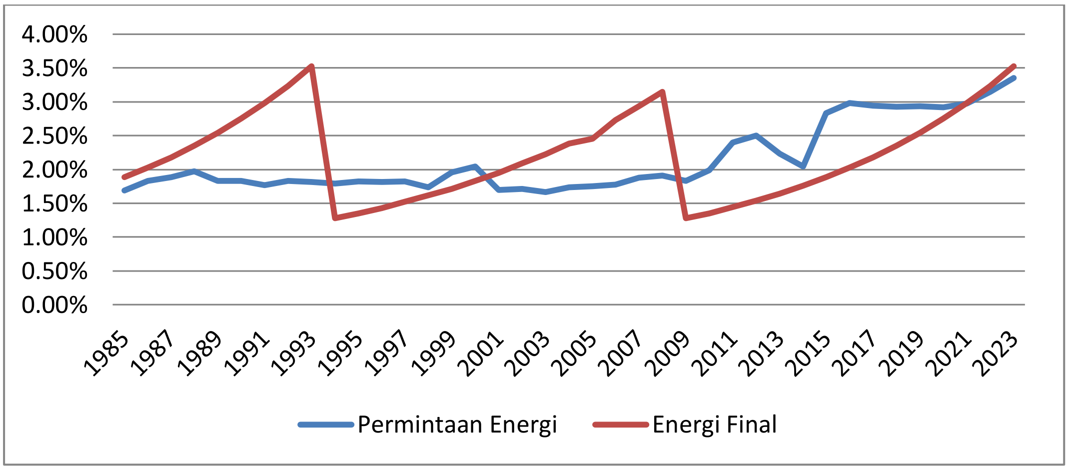
Based on Image 2, it shows that the energy supply in Indonesia from 1985 to 2023 experienced quite significant fluctuations. The energy supply in Indonesia from 1985-2019 continued to fluctuate, where the energy supply in Indonesia was highest in 2019, namely 3.62%. In general, fluctuations in energy demand and supply during this period were influenced by various complex factors, including global economic developments, technological changes, government policies, and geopolitical events. The main challenge that is still faced until 2023 is the high dependence on fossil fuels, where coal still dominates the national energy mix at around 38%. Renewable energy infrastructure still requires large investments, while fossil fuel subsidies are still quite high, which slows down the energy transition. Indonesia, as the world's largest archipelagic country with a population of over 270 million, faces challenges in meeting its growing energy needs. Over the past five decades, Indonesia's energy sector has undergone significant transformation, reflecting dynamic changes in national energy consumption, production and policy patterns (Dutu, 2016). Dependence on energy is very essential for humans. The need for energy is especially related to socio-economic expansion (Mauliza et al., 2023). Energy needs cover important sectors such as industry, transportation, commerce, and households. Economic growth, lifestyle changes, population growth, and urbanization are some of the factors that influence energy needs in Indonesia.



Data Source: Ministry of Economic and Mineral Resources (ESDM) 2023

Image 3 : Energy Demand and Energy Requirements In Indonesia

Based on Image 3, it shows that energy requirements in Indonesia in the period 1985-2023 experienced fluctuations, it can be seen that there were significant variations in energy needs during the period. There are a number of events and factors that can be identified as the cause of these fluctuations. In 2020, the world was faced with the COVID-19 pandemic which had a major impact on the global economy. The COVID-19 pandemic that hit the world caused a decline in economic activity in various countries, including Indonesia. This decline in economic activity caused a decline in energy demand from various sectors . The following period, from 2021 to 2023, the need and demand for energy in Indonesia continued to increase, where the highest energy demand in 2023 reached 5.58% and energy demand reached 3.36%. One of the factors causing this increase is the increasing need for electricity. The current phenomenon of energy needs in Indonesia reflects the complex challenges caused by rapid population and economic growth. In recent years, energy needs, especially for the industrial and household sectors, have increased significantly. An increasingly urban society and the increasing use of electronic devices have caused a surge in electricity demand that is not in line with the existing energy supply capacity.

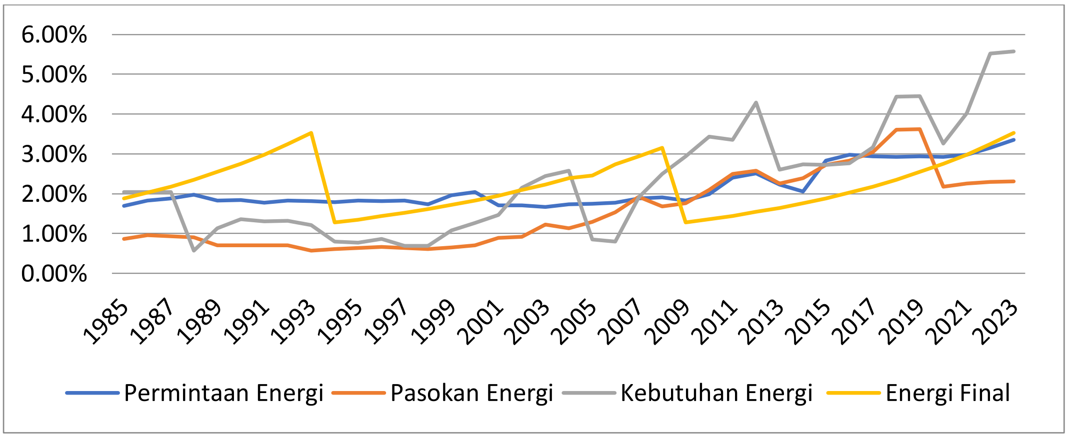


Data Source: Ministry of Economic and Mineral Resources (ESDM) 2023

Image 4 : Energy Demand and Final Energy In Indonesia

Indonesia's final energy consumption from 1985 to 2023 continues to fluctuate with significant increases and decreases each year. The potential increase in final energy consumption in 2023 is driven by stable economic growth and high energy consumption in the industrial and transportation sectors. The government continues to encourage energy efficiency and renewable energy development to mitigate the impact of global energy price fluctuations. A related phenomenon in Indonesia's final energy consumption is the high dependence on fossil fuels, especially in the transportation and industrial sectors. Despite efforts to shift to renewable energy, more than 80% of final energy consumption still comes from oil and coal. This has led to serious air pollution problems in major cities.

A related phenomenon of final energy consumption in Indonesia is the high dependence on fossil fuels, especially in the transportation and industrial sectors. Despite increasing efforts to switch to renewable energy, more than 80% of final energy consumption still comes from oil and coal. This causes serious air pollution problems in big cities, such as Jakarta, where air quality is often at hazardous levels. In addition, many households in remote areas still rely on traditional fuels, such as firewood and kerosene, for their daily needs, resulting in deforestation and health impacts. This unequal access to energy also creates a gap between urban and rural areas, where residents in remote areas often have difficulty meeting their energy needs.



Data Source: Ministry of Economic and Mineral Resources (ESDM) 2023

Image 5 : Energy Demand, Energy Supply, Energy Requirements and Final Energy In Indonesia

Based on Image 5, it shows that energy demand, energy supply, energy requirements, and final energy in Indonesia from 1985 to 2023 have fluctuated. Although Indonesia has great potential in renewable energy, such as geothermal, solar, and hydropower, the implementation and integration of these sources into the national energy mix still face various technical, financial, and regulatory obstacles (Erdiwansyah et al., 2019). Indonesia faces serious challenges in balancing energy supply, energy requirements, and final energy against the increasing energy demand. Rapid economic and population growth has driven a surge in energy demand, while domestic energy supply has not been able to keep up. As a result, Indonesia is increasingly dependent on energy imports, especially petroleum, which burdens the state budget and reduces national energy security. On the other hand, the use of renewable energy is still limited, even though Indonesia has great potential in this regard (Purwanto et al., 2015). Based on this background, the author is interested in examining the energy supply, energy requirements and final energy to energy demand so that the background of the author to take the title "Analysis of Energy Demand in Indonesia".

LITERATURE REVIEW

Demand

Demand Theory is a desire accompanied by the willingness and ability to buy an item. A person's or society's demand for an item or service is influenced by several factors because it is needed. An item or service has a price or value because the item is useful and rare. The utility of an item creates a desire, and in turn will require demand (Rahel, 2023). According to everyday understanding, demand is interpreted absolutely, namely indicating the amount of goods needed, while from an economic perspective, demand has meaning if it is supported by consumer purchasing power which is called effective demand. If demand is only based on needs, it is called absolute demand.

Economic theory states that the amount of demand for a good is usually related to its price level. The nature of the relationship between the price level of a good and the amount of demand for that good is called the law of demand. The Law of Demand is the quantity of goods demanded for a good is inversely related to the price of the good, ceteris paribus. So the lower the price of a good or service, the higher the level of demand for the good or service. Conversely, if the price or service is higher, the level of demand for the good or service will be lower. The law of demand applies when in a state of Ceteris Paribus, namely when society is in a state of unchanged. The factors of Ceteris Paribus are that income must remain the same, public tastes do not change, the price of other goods remains the same, there are no substitute goods, and there is no hope for the future (Venny & Asriati, 2022).

Energy

Energy is a quantity that is eternal, meaning that energy cannot be created or destroyed, but can be changed from one form to another without changing the amount or size of energy as a whole. In everyday terms, energy is the ability to move, if an object is able to move, then the object is said to have energy (Waluyo, 2013). Energy is a very abstract concept, energy has no mass, cannot be observed, and cannot be measured directly, but its changes can be felt. The concept of energy form cannot be separated from changes in energy, because what changes is energy (Sunarti, 2018).

According to the Republic of Indonesia Law Number 30 of 2007, Energy is the ability to do work that can be in the form of heat, light, mechanics, and electromagnetics. Energy is one of the basic human needs, one of these energies is petroleum energy, where petroleum energy is the energy most widely used by the community, such as the use of fuel oil, daily cooking needs, and others (Pradani Indah, 2017).

There are several definitions of energy according to experts, namely first, Mitchell, Campbell, and Reece stated that Energy is an ability to rearrange matter. In short, energy is the capacity to be able to carry out work. Second, according to Michael J. Moran, Energy is a basic concept of thermodynamics that is used as an important aspect of engineering analysis. And third according to Robert L. Wolke, Energy is an ability to make something happen.

In physics, energy is a physical property of an object, which can be transferred through fundamental interactions, can be changed in form but cannot be created or destroyed, according to the first law of thermodynamics. The maximum amount that can be used for work is called available energy. Systems such as machines and living things require available energy, not just any energy. Mechanical energy and other forms of energy can be converted directly into heat energy without any particular restrictions.

Energy Supply

Energy supply is the availability of energy resources that can be used to meet human needs in various sectors, such as industry, transportation, and households. In simple terms, energy supply is the amount of energy available for us to use. Energy supply is the foundation of modern life. Understanding the concept of energy supply is essential for designing effective energy policies and building a sustainable future.

Indonesia has abundant energy resources including oil, coal, natural gas, solar, hydro, and geothermal. However, fossil fuel resources are dwindling. Unless new reserves are discovered, Indonesia's oil will run out.

estimated to run out in 12 years, natural gas in 33 years, and coal in 82 years. Meanwhile, the potential for renewable energy is very large, but its utilization is still very lacking (Handayani et al., 2017).

In Government Regulation (PP) No. 79 of 2014 concerning National Energy Policy, Energy sources are anything that can produce energy, either directly or through a conversion or transformation process. In addition, energy sources can be said to be anything around us that can produce energy, either small or large.

Energy Requirements

Energy requirements are the amount of energy required by an individual, group, or system to carry out daily activities at the individual, community, or country level. Simply put, energy needs are how much energy is needed to do things. Energy needs are a very broad concept and cover various aspects of life. Understanding energy needs is essential to managing energy resources efficiently and sustainably.

Final Energy

Final Energy is a term used in a system or process that has reached its final state after undergoing a change or transformation. In various fields, the definition of final energy can be slightly different, but in general, final energy is the amount of energy remaining or available at the end of a process or after all energy transformations have taken place. In energy statistics, final energy is the energy available for use by the final consumer after deducting losses in the transmission and distribution process. This includes energy used by industry, transportation, and housing.

Final energy is a form of energy that has gone through a transformation process from primary energy and is ready to be used by end consumers. This energy includes various forms, such as electricity, liquid fuels, gas, and heat energy, which are used in various sectors, including households, industry, transportation, and commerce. Final energy is different from primary energy, which is a source of energy in raw form such as petroleum, natural gas, coal, and unprocessed renewable energy sources.

In Indonesia, energy needs are divided into several user sectors such as household, transportation, industry, commercial, and other sectors. In the household sector, the final energy used is LPG, natural gas, kerosene, firewood, briquettes and others for cooking activities while other activities use electrical energy (Alqurni & Hadiyanto, 2023).

RESEARCH METHODS

Object of Research

The object of this study is energy demand as the dependent variable, while energy supply, energy needs, and final energy are the independent variables. The location in this research is in Indonesia.

Data Types and Sources

This study uses a quantitative method because the research data is in the form of numerical data. This study uses secondary data from 1985 to 2023. The author took the data from the Ministry of Energy and Mineral Resources (KESDM).

Method of Collecting Data

The method of data collection in this study is using the documentation method. Data and information collection is carried out by obtaining it from the Ministry of Energy and Mineral Resources (KESDM), journals and articles. Then the data will be tested with a statistical tool, namely eviews 10.

Data Analysis Method

The data analysis method used in this study if it meets the requirements for using the ARDL model, then the author will process the data using the ARDL model. This research uses quantitative analysis methods, namely time series data. By using quantitative data analysis ARDL method in processing data, it can find out how the independent variable (independent variable) can affect the dependent variable (dependent variable). This analysis method is used to determine the effect of the dependent variable and the independent variable in the long or short term. This ARDL model was chosen because this model can overcome research variables/data that have different stationary levels (Siti Afifatul Farichah, 2022).

ARDL is considered effective in determining short-term and long-term relationships between variables that do not have the same integration order where the variables are stationary at level I(0), First Difference I(1) simultaneously.

In general, the steps that will be taken for econometric analysis using this method are as follows: Testing the stationarity of variable data in the research model, both at the level and first difference levels, Classical assumption test, Optimum lag determination test, Cointegration test, ARDL model estimation in the long term and short term, and ARDL Model Stability Test.

Stationery Test

Stationarity is one of the important requirements that must be met. A data is said to be stationary if the mean and variance of the data are constant or do not change systematically over time. One of the formal procedures for stationarity testing is the unit root test. This test was developed by David Dickey and Wayne Fuller and is called the Augmented Dickey-Fuller (ADF) Test. If a time series data is not stationary at the level (zero order, I(0)), then the stationarity of the data can be sought through the next order, namely the first order or I(1) (first difference), or the second order I(2) (second difference). Since this study uses the ARDL method, all variables must be stationary at the level (I(0)) or first order (I(1)).

Classical Assumption Test

Classical assumption tests look for problems in the data collected in this study to determine that it is normally distributed and worthy of further investigation. Classical hypothesis testing is seen based on the normality test, autocorrelation test and heteroscedasticity test.

Normality Test

The normality test is carried out with the aim of testing whether the model to be regressed is normally distributed or not. This study uses the Jarque-Bera (JB) test method to determine whether the regression model is normal or not. By comparing the calculated JB value with an alpha level of 0.05 (5%). If the Jarque Bera (JB) probability value is greater than 5% (0.05), then the data is normally distributed.

Autocorrelation Test

According to Gujarati & Porter (2012) autocorrelation is defined as the correlation between members of a series of observations organized by time (time series data) and by space (cross-section data). Gujarati (2015) to test the presence or absence of aultocorrelation uses two ways, the Dorbin-Watson Test and the Breusch-Godfrey Test. In this study, the Breusch-Godfrey Serial Correlation LM Test method was used. With conditions if:

1.Probability> from $\alpha = 5\%$, it means there is no autocorrelation, and vice versa if
2.The probability value < than $\alpha = 5\%$, means there is autocorrelation.

Heteroskedasticity Test

Heteroscedasticity is a condition where the variation of residuals is not constant. A good regression model is homoscedasticity or no heteroscedasticity. The heteroscedasticity test used in this study is the Breusch-Pagan-Godfrey test. How to detect the Breuschpagan-Godfrey test method by looking at the 0bs * R-squared and Chi-Squares values with conditions if:

1. Obs*R-squared value> Chi Squares value, The probability of the Chi Squares value> 0.05 indicates that there is no heteroscedasticity in the model.
2. If the Obs*R-squared value < Chi Squares value and the probability of the Chi Squares value < 0.05 indicates heteroscedasticity in the model.

Determination of Optimum Lag

Determining the optimal lag is very important in order to obtain the dynamics of the system to be modeled. If the lag is too long, it will result in more parameters that must be estimated so that it can reduce the ability to reject H0 because too many additional parameters will reduce the degree of freedom. Determining the optimal lag length can utilize some information, namely by using the Akaike Information Criterion (AIC). AIC penalizes additional variables (including lag variables) that reduce the degree of freedom. Therefore, the lag will be found in the model specification that gives the minimum AIC value.

Cointegration Bound Test

The cointegration test is a test of whether there is a long-term relationship between the independent and dependent variables, this test is a continuation of the unit root test and the integration test. Cointegration testing is done using the bound test. The decision-making requirement in the cointegration test using the bound test compares the F-statistic value with the critical value of the lower and upwer bounds. If the F-statistic value is higher than the critical value of the upwer bound then Ha is accepted (Ha = there is cointegration between variables), and if the F-statistic value is smaller than the critical value then Ho is accepted (Ho = there is no cointegration between variables).

ARDL Model

The Autogressive Distributed Lag (ARDL) model represents the interaction between X and Y variables over time, including the impact of past values of Y variables on the current value of Y. The Autogressive Distributed Lag (ARDL) model is used in this investigation.

In general, the ARDL model equation can be written as follows:

$$\Delta Yt = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta Y_{t-1} + \sum_{i=1}^{n} \delta_1 \Delta X_{t-1} + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-1} + \mu t$$

Description:

β_1, δ_1 : Short-term coefficient

φ1, φ2 : Long run coefficient

μt : Disturbance error (whitenoise)

The following is the general model of ARDL:

$$\Delta PRE_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta PRE_{t-1} + \sum_{i=0}^{n} \delta_1 \Delta PE_{t-1} + \sum_{i=0}^{n} \delta_2 \Delta KE_{t-1} + \sum_{i=0}^{n} \delta_2 \Delta EF_{t-1} + \varphi_1 PRE_{t-1} + \varphi_2 PE_{t-1} + \varphi_3 KE_{t-1} + \varphi_4 EF_{t-1} + \mu_t.$$

Description:

β_1, δ_1 = Short-term coefficient

φ1, φ2 = Long run ARDL coefficients

PRE = Energy Demand

PE = Energy Supply

KE = Energy Requirements

EF = Final Energy

μt = Disturbance error (whitenoise)

The estimation method used is the Autoregressive Distributed Lag (ARDL) approach. The ARDL model was chosen because using ARDL will be able to see the effect of Y and X over time, as well as the effect of past Y variables on present Y.

Model Stability Test

The ARDL model stability test in this study uses the cusum test where the cusum test is carried out by looking at the 95% confidence level. The Cusum test results for the ARDL model in this study are determined by the position of the blue Cusum line between the two red 5% significance lines. For the ARDL model, the Cusum line is between the significance lines which proves that the ARDL model is stable.

RESULTS AND DISCUSSION

Data Stationery Test

To determine the stationarity of the data, the Augmented Dicky-Fuller (ADF) Test or the Phillips-Perron (PP) Test is used (Faudzi & Asmara, 2023). Stationary or not will be seen from the probability value (Critical Value) which is compared at the alpha level (1%, 5%, or 10%).

Table 1 Stationarity Test Using Augmented Dickey-Fuller (ADF)

Variabel	Unit Root Test	ADF Test Statistik	Critical Value 5%	Prob	Keterangan
PRE	Level	-7,813998	-2,941145	0,0000	**Stasioner**
PE	First Diff	-7,037778	-2,951125	0,0000	**Stasioner**
KE	First Diff	-6,139437	-2,94840	0,0000	**Stasioner**
EF	First Diff	-6,209865	-2,94343	0,0000	**Stasioner**

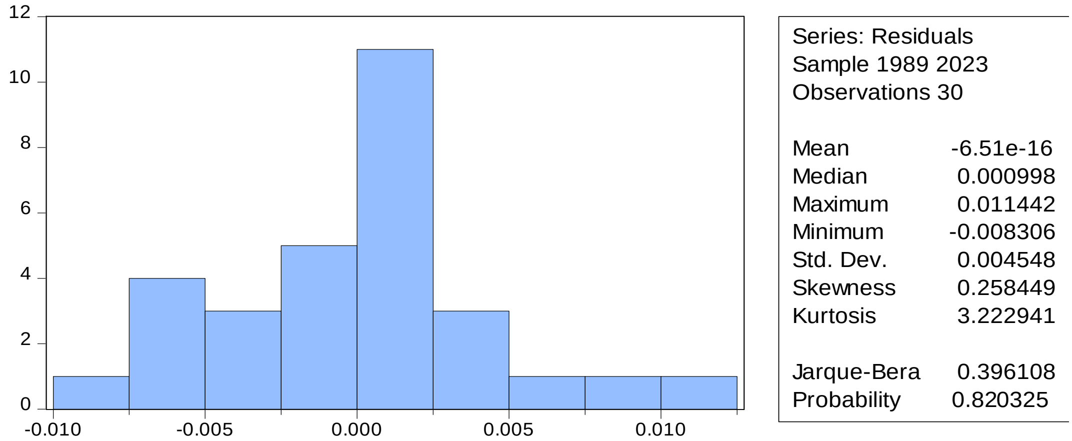
Source: Processed data, eviews10 output results (2024)

Based on table 1, it can be seen that the results of the stationarity test with Augmented Dickey-Fuller (ADF) on the energy demand variable are significant or said to be stationary at the level level with α: 5%. While the variables of energy supply, energy demand, and final energy are not stationary at the level. Therefore, it is necessary to do a differencing process at the 1st difference to find out whether the other variables are stationary or not. Based on table 1, it can be seen that the variables of energy supply, energy demand, and final energy are significant or stationary at 1st difference with α: 5%. From the stationarity test results, the Auto Regressive Distributed Lag (ARDL) model is a suitable method used in this study.

Classical Assumption Test

The classical assumption test looks for confounding issues in the data collected for this study to determine that it is normally distributed and worthy of further investigation. Multicollinearity test, autocorrelation test and heteroscedasticity test are some examples of traditional assumptions in this subject. The findings of the study's classical assumption tests are as follows:

Normality Test Result



Source: Processed data, eviews10 output results (2024)

Image 6 Normality Test Result

Based on Image 6 shows the results of the normality test using the Jarque Bera (JB-Test) method. The test results resulted in a probability value of 0.820325> 0.05. Based on these results, it can be concluded that the data is normally distributed.

Autocorrelation Test Result

Table 2
Autocorrelation Test Results

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.118568	Prob. F(1,3)	0.7533
Obs*R-squared	1.026542	Prob. Chi-Square(1)	0.3110

Source: Data processed from Eviews output (2024)

Based on Table 2 shows the results of the autocorrelation test, the value of Prob. Chi-Square (2) which is the p value of the Breusch-Godfrey Serial Correlation LM test of 0.3110. The Prob value. Chi-Square (2) is greater than the 5% or 0.05 significant level so it can be concluded that there is no autocorrelation problem.

Heteroskedasticity Test Result

Table 3
Heteroscedasticity Test Results

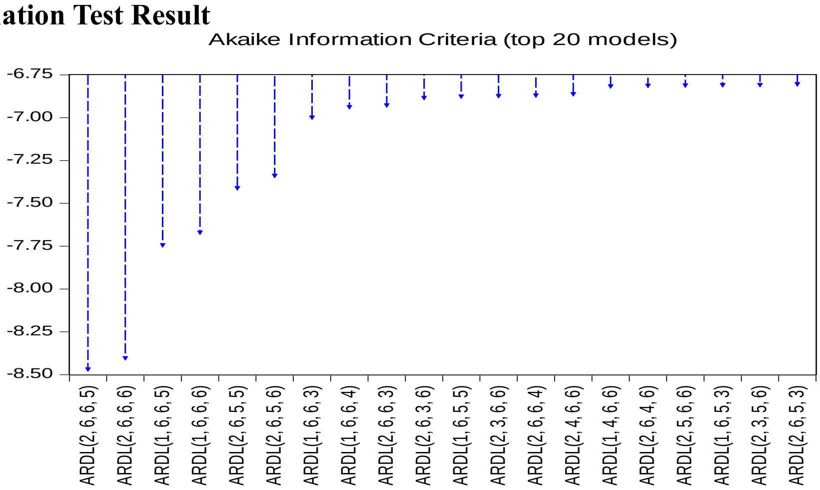
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.623699	Prob. F(17,12)	0.8183
Obs*R-squared	14.07283	Prob. Chi-Square(17)	0.6619
Scaled explained SS	2.502646	Prob. Chi-Square(17)	1.0000

Source: Data processed from Eviews output (2024)

Based on Table 3 shows the results of the heteroscedasticity test, the p value is indicated by the Prob value. Chi-Square has a value greater than the 5% or 0.05 significant level (0.6619> 0.05). It can be concluded that there is no heteroscedasticity problem.

Optimum Lag Determination Test Result



Source: Processed data, eviews10 output results (2024)
Image 7 Akaike Information Criteria

Based on the image shows the estimation results of lag selection criteria by looking at the smallest Akaike Information Criteria (AIC) value of the 20 best models. The best criterion is ARDL (2,6,5,3) which means that Y or Energy demand is 2 lags, X1 or Energy Supply is 6 lags, X2 or Energy Demand is 5 lags, and X3 or Final Energy is 3 lags.

Bound Test Cointegration Result

Table 4
Bound Test Cointegration Results

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	14.71723	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
			Finite Sample: n=35	
Actual Sample Size	27			
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816
			Finite Sample: n=30	
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

Source: Data processed from Eviews output (2024)

Based on the table, the cointegration test results based on the Bound Test Technique show that the F-statistic value of 14.71723 is higher than the bound value of I0. F-statistic > I0 Bound is considered positive at 10%, 5%, 2.5%, or 1% confidence level. Therefore, the tested model has cointegrating variables, resulting in a balance between the long-run and short-run.

ARDL Model Estimation

The data is further checked for cointegration using ARDL analysis following the stationarity test. There are two types of processing viz: short-run processing and long-run processing.

Short-Term Test Results of ARDL Model

Table 5
Short-Term Coefficient Estimation Results of ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LPRE(-1))	0.467934	0.124271	3.765433	0.0197
D(LPE)	-0.009904	0.008586	-1.153444	0.3130
D(LPE(-1))	0.018410	0.009540	1.929840	0.1258
D(LPE(-2))	0.061740	0.006695	9.222310	0.0008
D(LPE(-3))	0.010403	0.010398	1.000546	0.3737

D(LPE(-4))	0.010920	0.009276	1.177227	0.3044
D(LPE(-5))	0.072802	0.009337	7.797028	0.0015
D(LKE)	-0.008046	0.001078	-7.467081	0.0017
D(LKE(-1))	0.022949	0.002195	10.45331	0.0005
D(LKE(-2))	0.020390	0.001829	11.14760	0.0004
D(LKE(-3))	0.012511	0.001919	6.520602	0.0029
D(LKE(-4))	0.011053	0.001423	7.768327	0.0015
D(LKE(-5))	0.005878	0.001229	4.784317	0.0087
D(LEF)	0.002690	0.003368	0.798813	0.4691
D(LEF(-1))	-0.027159	0.003881	-6.997292	0.0022
D(LEF(-2))	-0.023211	0.003388	-6.850584	0.0024
D(LEF(-3))	-0.011522	0.003610	-3.192015	0.0332
D(LEF(-4))	-0.030106	0.004471	-6.733932	0.0025
CointEq(-1)*	-1.765589	0.145538	-12.13146	0.0003

R-squared	0.991238
Adjusted R-squared	0.971523

Source: Data processed from Eviews output (2024)

$$\Delta PRE_t = 0{,}467934\Delta LPRE_{(-1)} - 0.009904\Delta LPE + 0.018410\Delta LPE_{(-1)} + 0.061740\Delta LPE_{(-2)} + 0.010403\Delta LPE_{(-3)} + 0.010920\Delta LPE_{(-4)} + 0.072802\Delta LPE_{(-5)} - 0.008046\Delta LKE + 0.022949\Delta LKE_{(-1)} + 0.020390\Delta LKE_{(-2)} + 0.012511\Delta LKE_{(-3)} + 0.011053\Delta LKE_{(-4)} + 0.005878\Delta LKE_{(-5)} + 0.002690\Delta LEF - 0.027159\Delta LEF_{(-1)} - 0.023211\Delta LEF_{(-2)} - 0.011522\Delta LEF_{(-3)} - 0.030106\Delta LEF_{(-4)} - 1.765589\Delta ECT_{(-1)}$$

Based on the model above, it can be seen that the CointEq (-1) value in the ARDL short-term model indicates how much the error will be corrected in each time period. In order to meet the requirements, the value must be negative and significant. The model estimation results above show the CointEq(-1) value of -1.765589 with a probability of 0.0003. This shows that with an Ect value of 176.6%, it can be applied, if there is a shock in the economy, the economy will return to the equilibrium point at a rate of 176.6% per year or in other words, it will return to the equilibrium point within a period of 1 year 9 months and 5 days.

The PRE variable in the previous 1 year has a coefficient value of 0.468 with a probability value of 0.0197. This means that the PRE variable has a positive and significant effect. This can be seen from the probability value <0.05.

The PE variable in the current year has a coefficient value of -0.009904 which means that a change in energy supply increased by 1% will reduce energy demand by 0.009 million BOE. This variable is not significant at the 5% level because the probability of 0.3130> 0.05 so that the energy supply variable has a negative and insignificant effect on energy demand.

The variable PE (-1) has a coefficient value of 0.018410 which means that a change in energy supply in the previous 1 year increased by 1% will increase energy demand by 0.018 million BOE. This variable is not significant at the 5% level because the probability of 0.1258> 0.05 so that the energy supply in the previous year has a positive and insignificant effect on energy demand.

The variable PE (-2) has a coefficient value of 0.061740 which means that a change in energy supply in the previous 2 years increased by 1% will increase energy demand by 0.061 million BOE. This variable is significant at the 5% level because the probability of 0.0008 <0.05 so that energy supply in the previous two years has a positive and significant effect on energy demand.

The variable PE (-3) has a coefficient value of 0.010403 which means that a change in energy supply in the previous 3 years increased by 1% will increase energy demand by 0.0104 million BOE. This variable is not significant at the 5% level because the probability of 0.3737> 0.05 so that the energy supply in the previous three years has a positive and insignificant effect on energy demand.

The variable PE (-4) has a coefficient value of 0.010920 which means that a change in energy supply in the previous 4 years increased by 1% will increase energy demand by 0.0109 million BOE. This variable is not significant at the 5% level because the probability of 0.3044> 0.05 so that energy supply in the previous four years has a positive and insignificant effect on energy demand.

The variable PE (-5) has a coefficient value of 0.072802 which means that a change in energy supply in the previous 5 years increased by 1% will increase energy demand by 0.072 million BOE. This variable is significant at the 5% level because the probability of 0.0015 <0.05 so that energy supply in the previous five years has a positive and significant effect on energy demand.

The current year KE variable has a coefficient value of -0.008046 which means that a change in energy requirements in the current year increases by 1%, it will reduce energy demand by 0.0080 million BOE. This variable is significant at the 5% level because the probability of 0.0017 <0.05 so that energy requirements in the current year has a negative and significant effect on energy demand.

The variable KE (-1) has a coefficient value of 0.022949 which means that a change in energy requirements in the previous 1 year increased by 1% will increase energy demand by 0.022 million BOE. This variable is significant at the 5% level because the probability of 0.0005 <0.05 so that energy requirements in the previous year has a positive and significant effect on energy demand.

The variable KE (-2) has a coefficient value of 0.020390 which means that a change in energy requirements in the previous 2 years increased by 1% will increase energy demand by 0.0203 million BOE. This variable is significant at the 5% level because the probability of 0.0004 <0.05 so that energy requirements in the previous two years has a positive and significant effect on energy demand.

The variable KE (-3) has a coefficient value of 0.012511 which means that a change in energy requirements in the previous 3 years increased by 1% will increase energy demand by 0.0125 million BOE. This variable is significant at the 5% level because the probability of 0.0029 <0.05 so that energy requirements in the previous three years has a positive and significant effect on energy demand.

The variable KE (-4) has a coefficient value of 0.011053 which means that a change in energy requirements in the previous 4 years increased by 1% will increase energy demand by 0.0110 million BOE. This variable is significant at the 5% level because the probability of 0.0015 <0.05 so that energy requirements in the previous four years has a positive and significant effect on energy demand.

The variable KE (-5) has a coefficient value of 0.005878 which means that a change in energy requirements in the previous 5 years increased by 1% will increase energy demand by 0.0058 million BOE. This variable is significant at the 5% level because the probability of 0.0087 <0.05 so that energy requirements in the previous five years has a positive and significant effect on energy demand.

The EF variable in the current year has a coefficient value of 0.002690 which means that the change in final energy in the current year increases by 1%, it will increase energy demand by 0.0026 million BOE. This variable is not significant at the 5% level because the probability of 0.4691> 0.05 so that the final energy in the current year has a positive and insignificant effect on energy demand.

The EF (-1) variable has a coefficient value of -0.027159 which means that a change in final energy in the previous 1 year increases by 1% and will reduce energy demand by 0.0271 Million BOE. This variable is significant at the 5% level because the probability of 0.0022 <0.05 so that the final energy in the previous year has a negative and significant effect on energy demand.

The variable EF (-2) has a coefficient value of -0.023211 which means that the change in final energy in the previous 2 years increases by 1%, it will reduce energy demand by 0.0232 Million BOE. This variable is significant at the 5% level because the probability of 0.0024 <0.05 so that the final energy in the previous two years has a negative and significant effect on energy demand.

The variable EF (-3) has a coefficient value of -0.011522 which means that a change in final energy in the previous 3 years increases by 1% and will reduce energy demand by 0.0115 Million BOE. This variable is significant at the 5% level because the probability of 0.0332 <0.05 so that the final energy in the previous three years has a negative and significant effect on energy demand.

The variable EF (-4) has a coefficient value of -0.030106 which means that a change in final energy in the previous 4 years increased by 1%, it will reduce energy demand by 0.0301 Million BOE. This variable is significant at the 5% level because the probability of 0.0025 <0.05 so that the final energy in the previous four years has a negative and significant effect on energy demand.

Long-Term Test Results of ARDL Model

Table 6
Estimation Results of Long-Term Coefficient of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPE	-0.038693	0.010865	-3.561377	0.0236
LKE	-0.017162	0.005305	-3.235184	0.0318
LEF	0.019594	0.005033	3.893375	0.0176
C	14.39764	0.262927	54.75900	0.0000

Source: Data processed from Eviews output (2024)

Based on table 6 above, the long-term test of the ARDL model can be formulated as follows:

$$\Delta PRE_t = 14.39764 - 0.038693\Delta LPE - 0.017162\Delta LKE + 0.019594\Delta LEF$$

The constant value of 14.39764 means that if energy supply, energy demand, and final energy are constant (fixed) in the long term, then energy demand in Indonesia will also be constant at 14.39764 and this result is significant with a probability of 0.0000 <0.05.

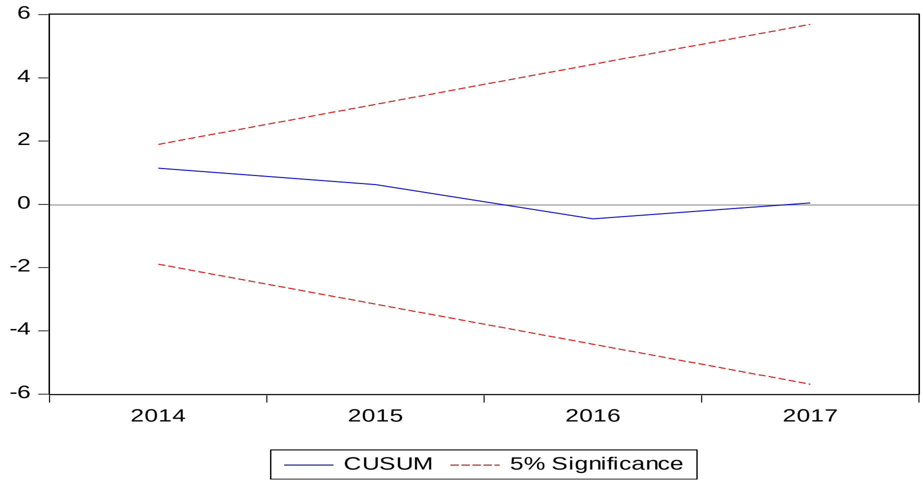
The coefficient of energy supply has a value of -0.038693, which means that if energy supply increases by 1% then energy demand will decrease by 0.0386 Million Boe in the following year. This variable is significant at the 5% level. This means that the energy supply variable has a negative and significant effect on energy demand in Indonesia with a probability of 0.0236 <0.05.

The coefficient of energy requirements has a value of -0.017162, which means that if energy requirements increases by 1%, energy demand will decrease by 0.0171 Million Boe in the following year. This variable is significant at the 5% level. This means that the energy requirements variable has a negative and significant effect on energy demand in Indonesia with a probability of 0.0176 <0.05.

The Final Energy coefficient has a value of 0.019594, which means that if final energy increases by 1%, it will increase energy demand by 0.0195 million BOE in the following year. This variable is significant at the 5% level. This means that final energy has a positive and significant effect on energy demand in Indonesia with a probability of 0.0176 <0.05.

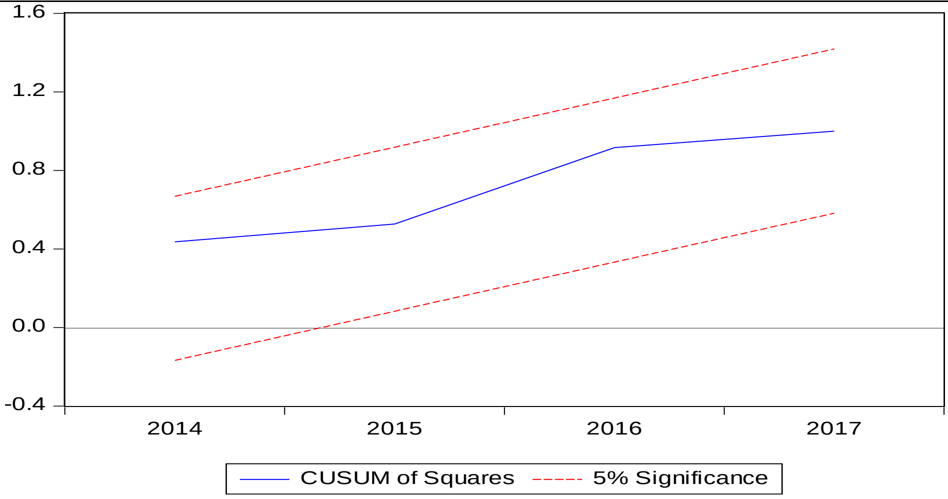
ARDL Model Stability Test (CUSUM)

Model stability testing can be divided into two, namely the CUSUM (Cumulative Sum of Recursive Resedual) and CUSUM Q (Cumulative Sum Of Square Of Recursive Resedual) tests. The CUSUM test is as follows:



Source: Processed data, eviews10 output results (2024)

Image 8 Uji Cusum Test



Source: Processed data, eviews10 output results (2024)

Image 9 Uji Cusum Q

Based on Image 8 and 9, the results of the CUSUM model stability show that the model is in a stable situation and is suitable for use as a reference in determining the long-term relationship between variables. The model stability test results are shown through the CUSUM line (blue) which is still on the 5% significant line (red). The CUSUM Q test results show the same result. This means that the ARDL is declared stable/passes the CUSUM test and all variables are verified.

Effect of Energy Supply on Energy Demand

Based on the above research using the ARDL model shows that the energy supply variable in the short term has a negative and insignificant effect on energy demand in Indonesia. This can be seen from the coefficient value of -0.009904 with a probability value of 0.3130> 0.05 which indicates that if energy supply increases it will reduce energy demand. This is in line with research conducted by Zhang et al (2019) in “Energy Supply and Demand Dynamics”, panel data analysis from developing countries shows that an increase in energy supply is not always followed by an increase in energy demand in the short term, which indicates a lag effect in energy consumption adjustment.

However, in the long run, the energy supply variable has a negative and significant effect on energy demand in Indonesia. This can be seen from the coefficient value of -0.038693 with a probability value of 0.0236. This means that when energy supply increases excessively but is not matched by adequate distribution infrastructure, it can actually reduce energy demand. This is in line with research (Ahmad & Zhang, 2020) which shows that excess energy supply in the long run encourages changes in consumption behavior and the adoption of energy-saving technologies, resulting in a decrease in energy demand.

Effect of Energy Requirements on Energy Demand

Based on the above research using the ARDL model shows that the energy requirements variable in the short term has a negative and significant effect on energy demand in Indonesia. This can be seen from the coefficient value of -0.008046 with a probability value of 0.0017. This means that if there is an increase in energy requirements, energy demand will decrease. This is in line with the research of Bernstein and Griffin (2019), a decrease in energy requirements can cause a negative impact on energy demand in the short term due to an imbalance between supply and demand.

In the long term, the energy requirements variable has a negative and significant effect on energy demand in Indonesia. This can be seen from the coefficient value of -0.017162 with a probability value of 0.0318. This means that when energy requirements increases, energy demand decreases, and this is statistically significant or real. This is in line with Stern's (2018) research in the Energy Economics Journal, increasing energy efficiency and adopting energy-saving technologies can reduce overall energy demand, even though basic energy needs remain.

Effect of Final Energy on Energy Demand

Based on the above research using the ARDL model, it shows that the final energy variable in the short term has a positive and insignificant effect on energy demand in Indonesia. This can be seen from the coefficient value of 0.002690 with a probability value of 0.4691. This means that any increase in final energy use will be followed by an increase in energy demand, but the effect is not strong enough. This is in line with the research of Asafu-Adjaye (2016), on four developing countries in Asia found that final energy has a positive but insignificant effect on energy demand, which indicates that an increase in final energy consumption is not always directly proportional to the increase in overall energy demand.

However, in the long run, the final energy variable has a positive and significant effect on energy demand in Indonesia. This can be seen from the coefficient value of 0.019594 with a probability value of 0.0176. This means that when the final energy consumption (energy that is ready to be used by consumers) increases, this directly leads to an increase in overall energy demand. This is in line with Aminuddin's (2014) study which found that every 1% increase in final energy consumption led to a 0.85% increase in energy demand over a 5-year period. This is reinforced by a study by Rahman (2018) which confirmed similar findings using panel data from various developing countries, where final energy has a positive and significant coefficient at the 1% level in influencing long-term energy demand.

CONCLUSION

Based on the results of the analysis that has been carried out using the analysis method, namely the Autoregressive Distributed Lag (ARDL) model in this study, the following conclusions can be drawn:

1. In the long term, the energy supply variable has a negative and significant effect on energy demand. This can be seen from the coefficient value of -0.038693 with a probability value of 0.0236 <0.05. While in the short term the energy supply variable has a negative and insignificant effect on energy demand. This can be seen from the coefficient value of -0.009904 with a probability value of 0.3130 < 0.05.
2. In the long term energy requirements variable has a negative and significant effect on energy demand. This can be seen from the coefficient value of -0.017162 with a probability of 0..0318 > 0.05. While in the short term the energy requirements variable has a negative and significant effect on energy demand. This can be seen from the coefficient value of -0.008046 with a probability of 0.0017 <0.05.
3. In the long run, the final energy variable has a positive and significant effect on energy demand. This can be seen from the coefficient value of 0.019594 with a probability of 0.0176 <0.05. While in the short term, the final energy variable has a positive and insignificant effect on energy demand. This can be seen from the coefficient value of 0.002690 with a probability value of 0.4691 > 0.05.
4. The relationship between energy supply, energy requirements, and final energy together has a positive and significant effect on energy demand in Indonesia. This means that if energy supply, energy requirements, and final energy increase, energy demand will also increase.

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