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Dynamic Model for the Consumption of Electrical Energy in Indonesia

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ABSTRACT

This study aims to find the existence of a long-term relationship between subsidized energy, population, inflation, economic growth, and consumption of electrical energy in Indonesia for the period of 1987–2018. In order to analyse the existence of long run relationship, this research was conducted using the Autoregressive Distributed Lag (ARDL) model. This research focused on the energy subsidy, considering that Indonesia is one of the four countries that still apply subsidized energy. The findings suggest that that there is a long-term cointegration between electricity consumption with regressor variables. The result of Estimation Result of ARDL also confirms the existence of long-term relationships on variables in the model.

Keywords: Energy Consumption, Electricity, Economic Growth, Indonesia
JEL Classifications: Q01, L94, C38

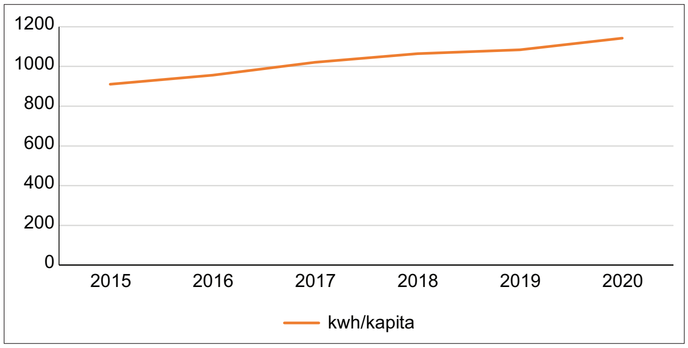
1. INTRODUCTION

The demands for energy keep increasing each year in line with the growth of population (Bilgili et al., 2012; Mutschler et al., 2021; Fu et al., 2015). Limited supply of energy becomes the challenge that should be encountered with solution. Currently, the type of energy with the highest utilization is electricity power. Since the electricity from renewable source and green sources is the type of cleaner energy with minimum effect of pollution if compared with others (Dincer and Acar, 2015). It could be obtained by transforming other forms of energy to become electricity, sourced from, such as sun, wind, potential energy of gravitation from water, and geothermal. Even though that electricity energy is considered as clean energy, yet the sources might not. In Indonesia, the sources of electricity energy are still dominated by coal and oil. It is confirmed that the weaknesses of fossil fuel as source of energy are pollution and contamination as well as fossil fuel limitation (Alhamid et al., 2016).

The high dependency on energy, particularly electricity could be seen from the indicators of people's dependency towards electricity, which is in this case could be seen from increase of electricity consumption each year. In the period of 6 years, the people's consumption on energy, especially electricity implies a rise. The Ministry of Energy and Mineral Resources Republic of Indonesia recorded that as shown in Figure 1 during 2015–2020, the average growth of electricity consumption per capita is 4.66 kwh/capita (ESDM, 2020). From the perspective of electricity distribution in Indonesia, Central Bureau of Statistics (BPS) reported that in 2020, 95% of Indonesian territories have been covered by electricity, although for several areas only 85% of the territories are accommodated by electricity, which is East Nusa Tenggara, 92% of Maluku areas, 94% areas of Central Kalimantan, Southeast Sulawesi and Papua (BPS, 2019).

Nevertheless, if being compared with developed countries, the consumption of electricity per capita in Indonesia is considered low. In the ASEAN level, Indonesia is positioned in the fifth rank side-by-side with Vietnam. If being compared with developed countries, the consumption of electricity per capita in Indonesia only reaches 23.9% out of the electricity consumption of developed countries (World Bank, 2020). On the other hand, the realization

Figure 1: National Consumption for Electricity



Source: The Ministry of Energy and Mineral Resources, January 9, 2020

of electricity consumption is far from national target, in which the government puts target as much as 8.36% by the end of 2020, whereas in real the growth of electricity consumption in 2019 only reaches 4.66%.

With its nature characteristics as limited energy, definitely leads to certain problem. Noticeable impact can be recognized from inefficiency of energy management, which could be seen from the realization of energy consumption that is far from target, energy independence and security that have not been accomplished (Bakar et al., 2015). The prime indicator showcases the inequity of energy's availability and the difficulties in accessing the affordable energy in long-term period as well as the tendency to utilize energy resources, both electricity and other energies for earning foreign exchange instead of driving the economy (Galvin, 2019). This research is intended to analyse the short term and long-term relationship that existed in subsidized energy, population, inflation and economic growth towards the consumption of electrical energy, which is still rarely performed. The information about relationship among variables is crucial to define strategies and policies in economy and energy, for public purposes.

2. LITERATURE REVIEW

The growth of consumption in Indonesia that does not meet the government target is alleged due to exceeded electricity supplies, due to the assumption of previous growth of electricity consumption, which is 6.5% (ESDM, 2018). By referring to the data of electricity customers in 2019, it is revealed that the biggest customers are originated from domestic sector. Industrial sector that was expected to absorb bigger electricity energy only contributes the growth as much as 1.13%, the lowest among other sectors, which are social with 5.72%, domestic with 5.61 and public spaces for 4.11%.

According to Kim (2015), the consumption of electrical energy is a key variable that highly relates to economic development. It plays important role in economic development as well as becomes one of the crucial factors to support people's welfare (Best and Burke, 2018). Therefore, its fluctuation in consumption will affect economic growth. Typically, once the economy entering the expansion method, the energy consumption increases, whereas when the economy moves to the contraction period, the consumption decreases. It also explained by the Environmental Kuznets curve, that economic growth increases aligned with energy consumption, yet in certain point, energy consumption will decline in line with the environment awareness (Destek and Sinha, 2020; Murshed, 2021; Deli et al., 2020; Ahmed et al., 2015). Later, the community will develop more efficient technology for its energy utilization. This condition will be met when a country is categorized as developed country (Kong and Khan, 2019).

The correlation between electrical energy with economic growth could be understood with reciprocal relationship. Whether economic growth promotes the electrical energy, vice versa. This close relationship between consumption of electricity power and economic growth is made as basic of the research (Zhang et al., 2017; Iyke, 2015; Bhattacharya et al., 2016; Tang et al., 2016; Solarin and Ozturk, 2016; Heidari et al., 2015). If the correlation between those two are not accurately analysed, then the related policies become improper, inefficiency in managing the electricity power will be repeated without proper solution, in terms of policies.

Several previous researchers analysed relationship between the consumption of electricity energy with economic growth, conducted by (Chen et al., 2007; Yoo and Lee, 2010), (Jamil and Ahmad, 2010; Saidi et al., 2017). Another examination was carried out by Shahbaz et al. (2017) by applying data collected from 157 countries from 1960 to 2014. It reveals that in short-term, from the impact of the growth and feedback, the policies in electricity should be performed to achieve sustainable economic growth for long term economic sustainability. Chen et al. (2007) and Saidi et al. (2017) stated that in long term relationship, high power supply could assure higher economic growth. Later, Yoo and Lee (2010) discovered that the relationship between electricity consumption with economic growth is statistically significant, with the inverse U-Curve. It shows that the higher the economics scale is, the higher the electrics consumption will be. It is stated that more advanced the economy in a country, then dominant industrial sector is shifted from heavy industry to light manufacturing and services that leads to the decrease of power consumption.

The relationship between electricity consumption with economy was revealed by Bese and Friday (2021), and Umurzakov et al. (2020) that studied the determination of variables that influence national demands for electricity. Ameyaw et al. (2017) studied the causality relationship between economic growth with energy consumption by using Granger causality test to determine causality direction between electricity consumption and economic growth. The empirical findings suggest the existence of one-way causality of GDP to electricity consumption. Therefore, it can be said that Ghana is categorized as a country that is not so dependent to energy. From previous researches, several variables are strongly predicted of having correlation with electrical energy, which are population and energy subsidy. The growth of people is linearly proportional with the growth of national electricity consumption. This happens naturally, since more people, indeed, leads to bigger necessities that should be accommodated. The necessities on electricity power shows increasing trend year by year as the economy and population grow (Esseghir and Khouni, 2014; Alam, 2013).

Energy subsidy is defined as certain value that is discounted by government to companies or domestics towards certain goods/commodity, hence they afford to purchase the goods with cheaper price and obtain more goods, if being compared with the purchasing condition before being subsidized. For electrical energy, the government has already accommodated public with the subsidy, in the form of price reduction for basic rate of electricity (Murjani, 2020). The electricity subsidy only addressed to certain customers, which is the group of social customers (S1 and S2), domestics (R1), business (B1) and industry (I1) with installed capacity of 450 VA for monthly consumption up to 60 kwh. Subsidy is provided in the form of determination of electricity basic tariff (TDL) that set under the production cost only for above mentioned groups, to represents the justice and equity. This subsidy is directly channelled by PT. PLN. The reduction of subsidy will provide impacts to domestics, which are the major supports for entire economic growth. If the subsidy for energy is cut, it will affect people's purchasing power, since they should allocate the budget to settle high electricity bill and reduce the purchases. On the other hand, big subsidy will burden the APBN (state budget). Hence, the energy subsidy could affect the power consumption but not the other way around. Another flexible variable towards energy consumption is inflation. When the inflation hits the high level, the economic uncertainty will also increase. It leads to the incentive reduction for investment and consumption. When the inflation is up, the people's purchasing power goes down. electricity power in consumer goods treats as normal goods, hence the theory of low-high consumption that highly related to income also applies for power consumption (Choi et al., 2018). The energy subsidy for community, is not the policy that applied by all countries. Averagely, only developed countries provide their people with this type of subsidy.

3. RESEARCH METHODS

3.1. Data

This research is considered as quantitative research with secondary data derived from BPS (Central Bureau of Statistics). The variables employed in this research comprise (1) electricity consumption (EC). Hence, electricity consumption is defined as expenses to buy or use electricity power or energy to fulfil one's necessities. This variable uses proxy of national electrical consumption in Indonesia during 1987–2018. This variable is measured with the Kwh unit, (2) Population (Pop), it is defined as number of residents in a geographic area. The variable of population uses the proxy of Indonesian population in the period of 1987–2018, and measured by using inhabitant as the unit of measurement, (3) Economic Growth (EGrowth), defined as the process of output improvement for long-term (Boediono, 1998). In this research proxy for economic growth is economic growth rate in the basis of constant cost 2020 for the period of 1987-2018. Economic growth rate is employed to measure the economic development as the indication of national development. The variable uses unit of percentage (%), (4) Energy Subsidy (Energysubs), defined as cost reduction that is accommodated for customers and producers to purchase and to produce the source of energy. In this research, the energy subsidy is measured by utilizing data of electricity subsidy in Indonesia in the period of 1987–2017. This variable applies the unit of billion, (5) inflation (Inflation), defined as the raise of price on common goods, perpetually due to the increase of production cost or the raise of demands yet the goods are stagnant in numbers. The data are derived from BPS (Central Bureau of Statistics) with percentage unit.

3.2. Model

This research adopts the study conducted by Tang and Tan (2013) and Alam (2013) that employed the variable of electricity consumption as objective variable. Generally, the model that will be estimated is illustrated, as follows:

$$EC=f(EGrowth,Energysubs,Pop,Inflation) \quad (1)$$

In which:
EC: Electricity consumption (Kwh)
EGrowth: Economic growth (%)
Energysubs: Energy Subsidy (Billion)
Inflation: Inflation (%)
Pop: Population (Million)

To test the long-term relationship among variables of energy subsidy, population, inflation, the economic growth towards the consumption of electricity consumption, Autoregressive Distributed Lag (ARDL) is employed. ARDL is a regression model that includes the value of variable that explains present and past value of independent variable, as the addition to the model that comprises lag value of depended variable to be one of the explanatory variables (Gujarati, 2014). The specialty of the model of Autoregressive Distributed Lag is to turn the static theory to become dynamic. Static regression model is the model that ignores the influence of time, through Autoregressive Distributed Lag model, the time variable is put as consideration and the lag is notified (determined) (Gujarati,2014). Besides, the ARDL model is used to handle model with variables that have different stationarity level. From the function of equation (1), the regression-based equation and ARDL model equation for this research, written as follows:

$$\begin{aligned} EC_t &= \beta_0 + \beta_1 EGrowth_t + \beta_2 Energysubs_t \\ &+ \beta_3 Inflation_t + \beta_4 Pop_t + \varepsilon_t \end{aligned} \quad (2)$$

ARDL equation for Eq.2, stated as follows:

$$\begin{aligned} \Delta EC_t &= \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta EC_{t-1} + \sum_{i=1}^{n} \alpha_{2i} \Delta EGrowth_{t-1} \\ &+ \sum_{i=1}^{n} \alpha_{3i} \Delta Energysubs_{t-1} + \sum_{i=1}^{n} \alpha_{4i} \Delta Population_{t-1} \\ &+ \sum_{i=1}^{n} \alpha_{5i} \Delta Inflation_{t-1} + e_t \end{aligned}$$

In which:
Δ: first difference
α: intercept
t: Time period
EC: electricity consumption
EGrowth: Economic Growth

Energysub: Energy Subsidy
Population: Natural Algorithm for Population
Inflation: Level of inflation
Mi (i=1,2,3,4): Numbers of lag of each variable
βi (i=1,2,3,4): Coefficient of short-term correlation
ϕi (i=1,2,3,4): Coefficient of long-term correlation
εt: white noise

The initial stage of the research is done by using the data time series to analyze the balance relationship or by conducting the data fixation test in advance to conduct the so-called cointegration test. The test to identify the characteristics of fixed data is the unit root, Dickey-Fuller unit root test, and then identify, and then use the integration test to make the data static. Once the variables in the model have the same degree of integration, there is a balance or cointegration relationship in the model. Therefore, it can be assumed that the variables have a long-term balance relationship. By considering the above description, the model estimation will adopt the ARDL method, where the boundary integral in the ARDL is calculated using the boundary test cointegration model. If the existence of cointegration relationship is proven real, then short-term model with ECM also obtained. The model equation of ARDL ECM is formulated as follows:

$$\Delta EC_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta EC_{t-1} + \sum_{i=1}^{n} \alpha_{2i} \Delta EGrowth_{t-1} + \sum_{i=1}^{n} \alpha_{3i} \Delta Energysubs_{t-1} + \sum_{i=1}^{n} \alpha_{5i} \Delta POP_{t-1} + \sum_{i=1}^{n} \alpha_{4i} \Delta Inflation_{t-1} + \vartheta ECT_{t-1} + \mu_t$$

While, for obtaining long-term relationship, the model equation is formulated as follows:

$$EC_t = \beta_0 + \beta_1 EGrowth_t + \beta_2 Energysubs_t + \beta_3 Inflation_t + \beta_4 Pop_t + \varepsilon_t \quad (2)$$

in which, ECT_{t-1} is specific term for error correction that represents the speed of adjustment towards long-term equilibrium, in which the coefficient value should negative and significant int the level of 5%. In this step, the diagnostic and stability test should be applied to ensure that the model has no issue with serial correlation, functional form, normality and heteroscedasticity.

4. RESULT AND DISCUSSION

4.1. Analysis Result

Unit root test is used to examine whether certain coefficient of predictive autoregressive model has value of 1 or not. For the existence of unit root, Dickey-Fuller (DF) test is employed. Later the value of DF will be compared with the critical value developed by Mac-Kinnon.

4.2. Stationary Test

Before estimating the time series, data stationary test is conducted for prior data. The method used in this study is the unit root test. Stationary time series data show a constant pattern over time. Estimation of nonstationary data will lead to the emergence of inconsistencies and spurious regression. So that the actual classical inference methods cannot be applied (Gujarati, 2014). The unit root test used in this study is the Augmented Dickey Fuller test (ADF). If the value of the ADF t statistic is greater than the MacKinnon critical value, then the variable does not have a unit root,

Conversely, if the value of the ADF t-statistic is smaller than the MacKinnon Critical value, then the variable has a unit root so it is not stationary at a particular significance level. Unit Root test is done one by one for all variables in the analysis, both for dependent and independent variables. Unit root test results are obtained on the level, and it can be seen in Table 1. Table 1 shows that variable of electricity and Energysub are not stationary.

From Table 2, it can be concluded that the data used in this study are integrated at the second difference (variable energy consumption/EC and Energysubs) and considered in the stationary level are variable of EG, POPULATION, INFLATION. If in one model, it is found several stationary levels for each variable, then, ARDL model is suggested.

4.3. ARDL Estimation

Next step is performing ARDL estimation. It consists of 3 stages. Firstly, is the determination of lag length in equation model. The lag length determination applies Selection Model method based

Table 1: Augmented Dickey fuller resultant level

Variable	ADF-t stat	MacKinnon critical values			Description
		1%	5%	10%	
EC	4.480674	−3.66166	−2.96041	−2.61916	Non-Stationary
EGrowth	−3.904386	−3.66166	−2.96041	−2.61916	Stationary
POPULATION	−4.526128	−3.69987	−2.97626	−2.62742	Stationary
ENERGYSUBS	−1.867197	−3.66166	−2.96041	−2.61916	Non-Stationary
INFLATION	−5.561413	−3.66166	−2.96041	−2.61916	Stationary

Source: Primary Data, processed, 2020

Table 2: Augmented Dickey fuller result at 1st difference

Variable	ADF-t stat	MacKinnon critical values			Description
		1%	5%	10%	
D(EC)	−3.748996	−3.67017	−2.96397	−2.62101	Stationary
D(ENERGYSUBS)	−5.145361	−3.69987	−2.97626	−2.62742	Stationary

Source: Data Primer Processed, 2020

on Akaike Information Criterion (AIC). From AIC Table 3, it is resulted the lowest value of AIC, located in the ARDL lag (1, 3, 3, 1, 3). Then the estimation is illustrated as shown in Table 3.

4.4. Cointegration Test

Cointegration test is used to identify whether the residual data are in the level of stationary or integrated at the degree of zero or I(0). If the residual data turn to be unintegrated at the degree of zero or I(0), instead they integrate at the degree of d or I(d), it could be concluded that the variable has no cointegration characteristics. Cointegration test in this research is carried out by using Bounds testing approach as shown in Table 4.

From the calculation, if the value of F-Statistics is lower than critical value of Lower Bound, then the hypotheses with 0 result is not rejected and could be concluded that no long-term relationship existed (not being cointegrated) between electricity consumption with the regressor. On the contrary, if the value of F-Statistics is bigger than the critical value of Upper Bound, then the zero hypotheses is rejected. It can be said that there is long-term relationship (being cointegrated) between electricity consumption with the regressors. Hence, from the result of cointegration test as presented in Table 5, it can be assumed that there is a long-term cointegration between electricity consumption with regressor variables.

4.5. Short Term and Long-term Analysis

From Table 5, it can be concluded the movement pattern of variable for short-term. First, the coefficient value of economic growth D(EGrowth) is negative and insignificant in the early of short-term, then in the next period, D(EGrowth (−1)), D(EGrowth (−2)) valued positive and significant. It means that for short term, economic growth establishes insignificant influence towards electricity consumption. Then in the next period, the increasing growth of economics pushes the electricity consumption. In other words, it can be said that the impact of economic growth towards electricity consumption takes longer time to be recognized. Population has the same pattern as economic growth. At the early short-term period, population has no influence towards electricity consumption, yet in the next period, for lag 1 and lag 2, the population positively and significantly influences

Table 3: Estimation Result of ARDL for Model of electricity consumption

Variable	Coefficient	Std. error	t-statistic	Prob.*
ELECTRIC (−1)	0.110429	0.22111	0.499429	0.6258
ECGROWTH	−4.11518	3.682783	−1.11741	0.2840
ECGROWTH (−1)	−4.00411	3.675	−1.08955	0.2957
ECGROWTH (−2)	−0.37764	1.624375	−0.23248	0.8198
ECGROWTH (−3)	−2.2797	0.891005	−2.55857	0.0238
POPULATION	−1.31E-05	2.84E-05	−0.46054	0.6527
POPULATION (−1)	−0.00058	0.000204	−2.85099	0.0136
POPULATION (−2)	0.001485	0.0004	3.710191	0.0026
POPULATION (−3)	−0.00088	0.000215	−4.10528	0.0012
INFLATION	−1.16228	1.009641	−1.15118	0.2704
INFLATION(−1)	−1.24737	1.054929	−1.18242	0.2582
ENERGYSUBS	−3.26E-05	7.70E-05	−0.42277	0.6794
ENERGYSUBS(−1)	−6.15E-05	8.58E-05	−0.71647	0.4864
ENERGYSUBS(−2)	−0.00013	6.17E-05	−2.06698	0.0593
ENERGYSUBS(−3)	−0.00013	9.42E-05	−1.35112	0.1997
C	−2322.96	570.0762	−4.07482	0.0013
R-squared	0.999105	Durbin-Watson stat		2.246162
F-statistic	967.8328			
Prob(F-statistic)	0			

Source: Primary Data, Processed, 2020

Table 4: Cointegration test with bounds testing approach

F-bounds test		Null hypothesis: No levels relationship		
Test statistic	Value	Signif.	I(0)	I(1)
F-statistic	6.785296	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Primary Data, Processed, 2020

Table 5: The Estimation Result of ARDL for Short Term Model

Variable	Coefficient	Std. error	t-statistic	Prob.
D(EGROWTH)	−4.11518	2.105216	−1.95475	0.0725
D(EGROWTH (−1))	2.657334	0.839232	3.166388	0.0074
D(EGROWTH (−2))	2.279695	0.60031	3.797527	0.0022
D(POPULATION)	−1.31E-05	1.22E-05	−1.0713	0.3035
D(POPULATION (−1))	−0.0006	0.000135	−4.47269	0.0006
D(POPULATION(−2))	0.000882	0.000157	5.606496	0.0001
D(INFLATION)	−1.16228	0.529501	−2.19505	0.0469
D(ENERGYSUB)	−3.26E-05	4.54E-05	−0.71661	0.4863
D(ENERGYSUB (−1))	0.000255	5.61E-05	4.538576	0.0006
D(ENERGYSUB (−2))	0.000127	4.90E-05	2.599101	0.022
CointEq (−1)*	−0.88957	0.118483	−7.50801	0.000
R-squared	0.846976			
Adjusted R-squared	0.761963			

Source: Primary Data, Processed, 2020

Table 6: The estimation result of ARDL for long-term model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EGROWTH	−12.11440	4.191500	−2.890229	0.0126
POPULATION	1.05E-05	6.51E-07	16.16045	0.0000
INFLATION	−2.708777	1.836638	−1.474857	0.1641
ENERGYSUB	−0.000392	0.000200	−1.964715	0.0712
C	−2611.321	300.5835	−8.687505	0.0000
EC = electricity − (−12.1144*EGROWTH + 0.0000 *POPULATION −2.7088 *INFLATION −0.0004*ENERGYSUB −2611.3206)				

Source: Primary Data, Processed, 2020

Table 7: Diagnostic test

Normality test: Jarque-bera		Conclusion
Jarque Bera	0.240747	Residual Normal
Probability	0.886589	
Breusch-Godfrey Serial Correlation LM Test		
F-statistic	0.292566	No autocorrelation
Obs*R-squared	1.464705	
Prob. F(2,11)	0.752	
Prob. Chi-Square(2)	0.4808	
Heteroskedasticity Test: Harvey		
F-statistic	2.566633	No heteroskedasticity
Obs*R-squared	21.67954	
Scaled explained SS	28.97747	
Prob. F(15,13)	0.0477	
Prob. Chi-Square(15)	0.1165	
Prob. Chi-Square(15)	0.0162	

Source: Primary Data, Processed, 2020

the electricity consumption. The value of ECT in variable CointEq(−1)* is negative and significant. Therefore, this result confirms the existence of long-term relationships on variables in the model Table 6.

To ensure that the research results obtained are the results of an unbiased model, the following diagnostic tests are carried out as shown in Table 7:

From diagnostic test, entire assumptions related to model are accomplished. Then, it could be concluded that model has delivered robust and unbiased estimators.

4. CONCLUSION

The findings suggest that that there is a long-term cointegration between electricity consumption with regressor variables. The result of Estimation Result of ARDL also confirms the existence of long-term relationships on variables in the model. The results also concluded that the data used in this study are integrated at the second difference of energy consumption and energy subsidy variables and considered in the stationary level are variable of economic growth, population and inflation.

The results highlight that the Indonesian consumption on electricity power is considered low if being compared with neighbouring countries, but it does not mean that the resources could be employed carelessly. The energy source is limited, it is non-renewable resources. It should be well-noticed that the increasing of energy consumption means that we are closer to energy crisis. In the short run, growth and feedback effects suggest that more vigorous electricity policies should be implemented to attain sustainable economic growth for the long-term.

Practically, the results would imply that policies related to energy subsidies must be studied carefully. In the short term, the growth and feedback effects suggest that stronger electricity policies must be implemented to achieve long-term sustainable economic growth. Energy is non-renewable, meaning that energy, especially electricity consumption increases, the closer the energy crisis will be. Therefore, it is necessary to implement policies related to energy consumption in order to achieve energy sustainability in Indonesia for example energy saving policies.

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