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Does electricity consumption influence economic growth in Indonesia?

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Abstract

The purpose of this study was to analyze the influence of electricity consumption, investment, and school enrollment on economic growth of Indonesia from 1984-2018. Electricity is used by society in every activity including production and consumption. This study used ARDL-ECM method. Based on the estimation results, all variables were stationary at the first difference. Based on the empirical findings, the appropriate ARDL model was ARDL (1, 2, 1, 1). In the long run, investment had a positive influence on economic growth and school enrollment had a negative influence on economic growth. Meanwhile, in the long run, electricity consumption is insignificant to the economic performance of Indonesia during the study period. However, in the short run, there was only investment had a significant and positive impact on economic growth in Indonesia. School enrollment and electricity consumption had no significant influence on economic growth. Speed of adjustment (ECT (-1)) had a significant influence on GDP. With the Qusum and QusumQ tests, the model showed feasible stability. Therefore, more vigorous electricity policies should be implemented for supporting economic growth.

Keywords: electricity consumption, investment, ARDL-ECM, GDP
JEL Classification: Q400, Q430, E100

Abstrak

Tujuan utama dari penelitian ini adalah menganalisis pengaruh konsumsi listrik, investasi, dan school enrollment terhadap pertumbuhan ekonomi Indonesia periode 1984-2018. Listrik dipergunakan oleh masyarakat dalam setiap aktivitas baik produksi dan konsumsi. Metode penelitian yang digunakan adalah ARDL-ECM. Berdasarkan hasil estimasi terbukti bahwa semua variabel penelitian stasioner pada the first difference. Temuan empiris menunjukkan bahwa model ARDL yang tepat adalah ARDL (1, 2, 1, 1). Dalam jangka panjang, pertumbuhan ekonomi Indonesia terbukti secara positif dipengaruhi oleh investasi, sedangkan konsumsi listrik terbukti tidak signifikan. Dalam jangka pendek, terbukti hanya investasi berpengaruh positif terhadap pertumbuhan ekonomi, school enrolment dan konsumsi listrik terbukti tidak signifikan memengaruhi pertumbuhan ekonomi. Speed of adjustment (ECT (-1)) berpengaruh signifikan terhadap GDP. Dengan uji Qusum dan QusumQ terbukti bahwa model memiliki stabilitas yang layak. Dengan demikian, dibutuhkan kesadaran pengelolaan energi listrik secara bijaksana dan pentingnya sinergi antar-stakeholder (pemangku kepentingan) untuk penguatan institusi dalam pengelolaan energi listrik untuk kelestarian energi di Indonesia.

Kata kunci: *konsumsi listrik, investasi, ARDL-ECM, GDP*
JEL Classification: Q400, Q430, E100

INTRODUCTION

Electricity is the main infrastructure to facilitate community activities to be more efficient so that they can increase economic growth (Adom, 2011; Ibrahiem, 2015; Sarkodie & Adams, 2020a). Modern human life is facilitated by advances in technology and infrastructure. Ateba et al., (2019) stated that high electricity demand occurs in industrialization because it is used as the main energy in production, electricity is used by all sectors of industry. Furthermore, Shengfeng et al. (2013) stated that electricity consumption is not only as a production factor in economic development, but also as an indicator of successful development and socio-economic progress. The use of energy efficiently, cheaply, and in an environmentally friendly manner can encourage

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development in cities to villages, encourage equitable distribution of development results, and encourage electricity consumption from the household level, as well as encourage production (He, 2020; Coester, Hofkes, & Papyrakis, 2020). Ibrahiem (2015); Sarkodie & Adams (2020b) stated that the availability of electricity as a resource has a broad impact on production, trade, schools, hospitals, and creates improvements in public services. Industrialization requires a power supply. Based on research findings in various countries, there is a positive impact of electrical energy in driving the economy. According to Neo-Classical economists, energy can be a stimulus to the economic growth, especially in the manufacturing and industrial sectors (Saudi et al., 2019). According to Mahfoudh and Amar (2015); and Adams et al. (2020), the development of electrical energy can stimulate the African economy. On the other hand, a shortage of electricity supply causes an economic slowdown. Thus, obstruction of electricity supply can cause losses to the industrial sector. Community activities become more effective with electrical energy, especially in developing countries like Indonesia.

The distribution of electricity in Indonesia for both the household and industrial sectors continues to increase as shown in Table 1.

Electricity as a basic social need and its relationship with economic activity is a special discussion for researchers. Based on a study by Hdom & Fuinhas (2020), the use of power plants had a positive and negative influence on the Brazilian economic conditions. He (2020) explored the causal relationship between electricity consumption and economic performance using ARDL and Johansen Test which showed a long-run balance between electricity consumption and economic performance in Guangdong, China. Saudi et al. (2019) with the ARDL method in Indonesia found that renewable and non-renewable power plants were able to significantly boost the economy. In Africa, Sarkodie & Adams (2020b) found that income inequality causes differences in electricity consumption due to the difficulty of accessing electricity for low-income communities. Ibrahiem (2015) analyzed the relationship between renewable electricity consumption, investment, and economic growth with ARDL model which found that electricity consumption and investment had a positive influence on economic growth in the long run in Egypt.

In Indonesia, electricity demand continues to increase along with the growth of national development. Based on BPS data (2020), there was an increase in electricity distribution from

Table 1. GDP and Energy Indicator

	Unit	2013	2014	2015	2016	2017	2018	2019
GDP at 2010 ConstantPrice	Trillion Rupiah	8,156	8,565	8,983	9,435	9,913	10,425	10,949
GDP Nominal	Trillion Rupiah	9,546	10,570	11,526	12,407	13,590	14,838	15,834
GDP Nominal per Capita	Thousand Rupiah	32,464	41,916	45,120	47,957	51,891	55,990	59,065
Population	Thousand	248,818	252,165	255,462	258,705	261,891	265,015	268,075
Number of Households	Thousand	63,938	64,767	65,582	66,385	67,173	67,945	68,701
Primary Energy Supply	Thousand BOE	1,221,019	1,241,900	1,209,659	1,366,007	1,335,037	1,464,680	1,559,295
Primary Energy Supply per Capita	BOE / capita	4.91	4.92	4.74	5.28	5.10	5.53	5.82
Final Energy Consumption	Thousand BOE	747,855	761,386	759,624	738,080	771,509	871,345	945,867
Final Energy Consumption per Capita	BOE / capita	3.01	3.02	2.97	2.85	2.95	3.29	3.53

Source : Ministry of Energy and Mineral Resources, 2019

2012-2018. McNeil, Karali, & Letschert (2019) explained that the demand for electricity in Indonesia would continue to increase along with the increase in industrialization. The use of electricity as an important instrument in public activities indicates the progress of electricity network development and effort to equalize electricity distribution in Indonesia. Improving electricity services lead to community socio-economic development (Siyaranamual, Amalia, Yusuf, & Alisjahbana, 2020). From year to year, there are additional power plants and electricity supplies to all over Indonesia so it can overcome gaps between regions and create public welfare. McNeil, Karali, & Letschert (2019) explained that from 2010 to 2015 the electrification rate in Indonesia experienced a significant increase. However, the electrification rate varies widely between provinces, where the western part of Indonesia has a higher electrification rate than the eastern part. However, electricity consumption in Indonesia is still relatively low compared to other countries. Based on the Ministry of Energy and Mineral Resources (2019) electricity consumption in Indonesia was lower than Malaysia, India, and Thailand. Therefore, it is necessary to carry out a study investigating to what extent electricity boosts Indonesia's economic performance. The objectives of this research are to estimate and analyze the role of electricity consumption on economic performance of Indonesia from 1984-2018. The main contribution of this study to econometric modeling in long-run and short-run analysis and policy implications for improving the management of electricity resources in Indonesia.

LITERATURE REVIEW

According to the neoclassical theory, energy is one of the supporting forces of economic growth (Heidari et al., 2013). Sarkodie & Adams (2020a) described the importance of electrical energy in production activities to reduce transaction costs, encourage increased output, promote income distribution, and encourage the use of electricity for the poor. Ateba et al. (2019) explained that advanced economic development is characterized by adequate consumption of energy, technology and infrastructure. Some studies described the importance of electricity as a vital component in development. However, at the same time it is also a challenge in use of friendly energy for environmental sustainability. Several issues on the relationship between electricity consumption and economic growth showed the important implications in environmental sustainability issues. To increase the efficiency of electricity consumption, especially from fossil fuels, it is necessary to implement a low energy policy in order to reduce environmental degradation (He, 2020).

The theory of economic growth by Solow (1956) can systematically explain the role of technology in output formation as follows:

$$Y(t) = K(t)^{\propto}(A(t)L(t))^{1-\propto} \quad \text{.....(1)}$$

Y denotes real output, *K* denotes the stock of physical capital, *L* denotes labor, and *A* denotes technology proxy for efficiency in production. Mahfoudh & Ben Amar (2015) explain that *A (t)* reflects the advancement of technology which is in this case electricity consumption which can be used as a key factor in capital formation. Mankiw et al. (1992) elaborate that *L* and *A* can grow exogenously at the levels of *n* and *g*, if:

$$L(t) = L(0)e^{nt} \quad \text{.....(2)}$$

$$A(t) = A(0)e^{gt} \quad \text{.....(3)}$$

The performance of *A* and *L* will achieve effectiveness at:

$$k(t) = sy(t) - (n + g + \delta)k(t)$$
$$= sk(t)^{\propto} - (n + g + \delta)k(t) \quad \text{.....(4)}$$

$\delta\delta$ is depreciation, *s* is investment, *k* is capital per labor where $k = K/AL$, so that they will result in $y = Y/AL$ which is effective output per labor. Economic conditions still allow for the occurrence of long-term balance, therefore the above equation becomes:

$$k^* = [s/(n + g + \delta)]^{\frac{1}{1-\alpha}} \quad \text{.....(5)}$$

By substituting the equation (5) with production function, long-term balance per capita will be obtained with the assumptions from Solow (1956) about the importance of affixing savings and population factors. The formula of production function in the long term (6) is shown in the (see appendix 1).

Empirically, Fei & Rasiah (2014) found that in Canada, Norway, Ecuador, and South

Africa, electricity is a key variable in economic growth. Adom (2011) confirmed the causality between electricity consumption and economic output in Ghana during 1971-2008 by applying the Toda method and Yomamoto Granger Causality test. Using the Johansen Cointegration test and the Granger Causality test, Pandey & Rastogi (2019) examined the interrelationship of electricity consumption and economic growth to environmental degradation in India and found the short-run causality of electricity consumption, economic growth, and CO_2 emissions. Yan et al. (2018) proved that China's fast-paced economy relies heavily on electricity supply. In addition, Shengfeng et al. (2013) tested the short and long run causal relationship between electricity consumption and real GDP with the VECM method which found the long run relationship between real GDP and electricity consumption, as well as the direct causal relationship between electricity consumption and economic growth both in the short and long run in China.

RESEARCH METHOD

The utilization of electric energy in supporting economic performance is an interesting issue. The purpose of this study was to estimate the role of electricity consumption on economic performance of Indonesia from 1984-2018. The dependent variable was GDP while the independent variables were electricity consumption, investment ratio, and school enrollment. The independent variables reflected the importance of human capital supporting resources in economic development. Production requires inputs in the form of capital (K), labor (L), and productive energy (S) (Pokrovski (2003).

This study used ARDL-ECM method (Autoregressive Distributed - Lag Error Correction Model) developed by Pesaran & Shin (1995). This study used the modified model by Ibrahiem (2015). The model modification aimed to examine the long and short-run relationship between electricity consumption, investment, and school enrollment on economic growth in Indonesia. This model can change the static theory to be dynamic through an autoregressive model and a lag distribution model where time is also taken into account so that the lag period will be known (Gujarati, 2003). Based on Pesaran et al. (2001), the formula is as follows:

$$\Delta GDP_t = \alpha + \beta_1 GDP_{t-1} + \beta_2 INV_{t-1} + \beta_3 SCH_{t-1} + \beta_4 ELC_{t-1} + \sum_{i=1}^{n} b_i \Delta GDP_{t-1} + \sum_{i=1}^{n} c_i \Delta INV_{t-1} + \sum_{i=1}^{n} d_i \Delta SCH_{t-1} + \sum_{i=1}^{n} e_i \Delta ELC_{t-1} + \varepsilon_t \quad (7)$$

$\beta_1, \beta_2, \beta_3$ and β_4 coefficients showed long-run relationship. GDP was transformed into a natural logarithm as a proxy for economic growth. *INV* showed investment in Indonesia, SCH showed school enrollment as a variable for education level and ELC for electricity consumption. The H_0 hypothesis showed no cointegration relationship between electricity consumption, investment, and school enrollment on economic growth, while H_1 showed cointegration relationship between variables in the study. In the next stage, the short run coefficients were tested using error correction model (ECM):

$$\Delta GDP_t = \alpha + \sum_{i=1}^{n} \gamma_{1i} \Delta GDP_{t-1} + \sum_{i=1}^{n} \gamma_{2i} \Delta INV_{t-1} + \sum_{i=1}^{n} \gamma_{3i} \Delta SCH_{t-1} + \sum_{i=1}^{n} \gamma_{4i} \Delta ELC_{t-1} + \gamma ECT_{t-1} + \varepsilon_t \quad (8)$$

Table 2. Description of Variables

Data/Variable	Definition of Operational Variable	Data Source
GDP (constant USD 2000)	The economic gross value of all population, plus taxes, and minus subsidies. GDP is transformed into a natural logarithm.	The World Bank
Investment ratio (% of GDP)	Gross capital formation, which consists of spending on adding assets and increasing inventories in the economy.	The World Bank
School enrollment, primary (% gross)	Ratio of total population with basic education,	The World Bank
Electricity consumption (kWh per capita)	Total electricity and heat generation production, excluding transmission, distribution and transformers.	The World Bank

Source : The World Bank, 2020

RESULT AND DISCUSSION

In the first stage, the data stationary was tested. The stationarity test was carried out to confirm that all variables were not in I (2). Based on Augmented Dickey-Fuller test and Phillips-Perron test, GDP was stationary at 1st differences, electricity consumption was stationary at 1st differences, investment was stationary at 1st differences, and school enrollment was stationary at first difference. The detailed results of Augmented Dickey-Fuller test and Phillips-Perron test can be seen in the table 3.

After carrying out unit root test, estimation of optimal lag for ARDL was carried out. Based on the estimation results, the best estimation was ARDL (1, 2, 1, 1). The ARDL method can be used for short-term and long-term analysis with relevant estimators. Based on ARDL estimation, lagged 1 of GDP had no significant influence on economic growth during the study period. Investment had a significant and positive influence on GDP, but its lagged 1 of investment had negative influence on GDP and lagged 2 of investment had positive influence on GDP. Surprisingly, school enrollment had no influence on economic performance, lagged 1 of school enrollment had negative influence on GDP. The electric power consumption and its lagged 1 had no significant effect on GDP. The ARDL estimation results can be seen in table 4.

To ensure the coefficient stability, ARDL Bound Test was carried out. If F-statistic is greater than I(1), there is cointegration between variables. So, ECM (*error correction model*) can be used in long-run analysis. Based on Bound test, F statistic value (8.8994) was higher than I(1) bound, then the model had cointegration. The results of Bound test can be seen in table 5.

Table 3. Results of Unit Root Tests

Variables	Augmented Dickey-Fuller		Phillips-Perron	
	Level	1st Difference	Level	1st Difference
lnGDP	-0.1317	-4.4256	-0.0192	-10.6722
	(0.9630)	(0.0001) ***	(0.9498)	(0.0000) ***
INV	-1.1531	-4.6608	-1.4212	-4.6608
	(0.6829)	(0.0007) ***	(0.5604)	(0.0007) ***
SCH	-1.9764	-6.4307	-2.0742	-6.3938
	(0.2953)	(0.0000) ***	(0.2557)	(0.0000) ***
ELC	5.5789	-3.4200	6.1588	-3.4060
	(1.0000)	(0.0173) **	(1.0000)	(0.0179) **

Source: Secondary data (processed)

Note: ***, ** and * are significant levels of 1%, 5% and 10%, respectively.

Table 4. ARDL Estimation (1, 2, 1, 1)

Variables	Coefficient	T-Statistic	Std. Error
LOGY (-1)	-0.0157	-0.0965	0.1629
INV	0.1679	3.0572***	0.0549
INV (-1)	-0.2456	-3.0643***	0.0801
INV (-2)	0.1667	3.1096**	0.0536
SCH	0.0541	0.5952	0.0908
SCH (-1)	-0.1772	-2.0564*	0.0862
ELC	-0.0059	-0.8657	0.0069
ELC (-1)	0.0060	0.8366	0.0072
C	50.2047	5.4731***	9.1730
Adj. R-square	0.6381		
F-statistic	7.6132		
Prob(F-statistic)	0.0000		

Source: Secondary data (processed)

Note: the lag optimal of ARDL is ARDL (1, 2, 2, 1)

Note: ***, ** and * are significant levels of 1%, 5% and 10%, respectively.

Table 5. ARDL Bound Test

Test Statistic	Value	k
F-statistic	8.8994	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.37	3.2
5%	2.79	4.67
2.50%	3.15	4.08
1%	3.65	4.66

Source: Secondary data (processed)

In general, the long-run economic growth of Indonesia was influenced by investment and school enrollment. The long-run estimation results showed that electricity consumption had no significant influence on GDP. This showed due to less than optimal use of electricity and not distributed well. Investment had a positive influence on economic performance. Education quality variables, namely school enrollment had a significant and negative influence on economic growth of Indonesia from 1984-2018. The findings of this study are interesting. It is evident that in the long term, electricity consumption can not contribute to the acceleration of national income in accordance with the theoretical framework and previous empirical studies. The largest electricity consumption in Indonesia is dominated by the household sector in 2012-2015 (BPS, 2020). The use of electricity are very broad for the household, health, education, and government sectors. Apart from being a source of energy, electricity is said to support daily activities of Indonesian people both for production and consumption. Development requires equal distribution of electricity. Therefore, electricity equalization policies, such as electricity for villages, is very much needed. Economical and efficient use of electricity also needs to be encouraged and campaigned.

Ali et al. (2020) studied whether the relationship between electricity consumption and economic growth in Nigeria was supported by electricity consumption or showed a causal relationship between electricity consumption and economic growth. Ibrahiem (2015) analyzed the influence of renewable electricity consumption and foreign direct investment on economic growth in Egypt which found that there was a long-run relationship between variables, as well as electricity use and investment had a positive influence on the economic growth of Egypt. In China, He (2020) found that electricity consumption, urbanization, and metropolitan economic performance are cointegrated. Saudi et al. (2019) found that renewable and non-renewable electricity consumption is a key factor in Indonesia's economic growth.

Table 6. Estimated Long-run Coefficient Using ARDL Model

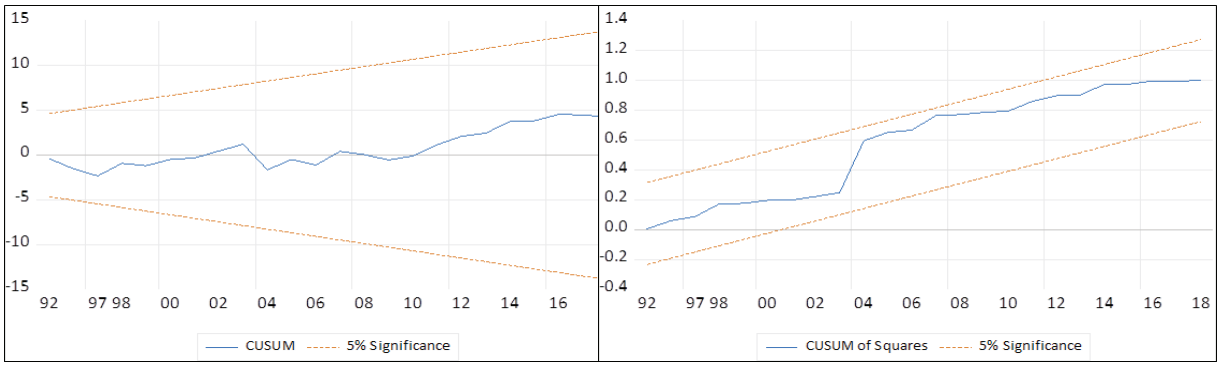
Variables	Coefficient	Std. Error	t-Statistic	P-value
Constant	49.4274	5.4119	9.1331	0.0000***
INV	0.0877	0.0306	2.8624	0.0091***
SCH	-0.1213	0.0486	-2.4975	0.0205**
ELC	7.9700	0.0008	0.0979	0.9229

Source: Secondary data (processed)
Note: ***, ** and * are significant levels of 1%, 5% and 10%, respectively.

Table 7. Estimated Short-run Coefficient Using ARDL-ECM Model

Variables	Coefficient	**Std. Error**	**T-Statistic**	**P-value**
C	0.3210	0.2584	1.2424	0.2261
ECT (-1)	-1.2878	0.3209	-4.0122	0.0005***
D (INV)	0.1439	0.0687	2.0948	0.0469**
D (SCH)	0.0398	0.1118	0.3557	0.7251
D (ELC)	-0.0082	0.0069	-1.1891	0.2460
Adj. R-square	0.3496			
F-statistic	4.7629			
Prob(F-statistic)	0.0057			
Observations	29			

Source: Secondary data (processed)
Note: ***, ** and * denote significant level at 1%, 5% and 10%, respectively.



Source: Secondary data (processed)
Figure 1. Cusum & CusumQ

Based on ARDL-ECM model, ECT (-1) showed a negative and significant speed of adjustment which means the ECM model was valid and had significant influence in long-run and short-run. Adj. R-square of 0.3496 showed the coefficient of determination of the model. Based on the short run estimation results, investment had a significant influence on economic growth. Changes in electricity consumption had no influence on GDP in short-run. This means the right policy on electricity consumption is really needed according to help economic activity. School enrollment had no influence on economic growth in Indonesia. This condition is caused by the inequality of education in Indonesia.

The ECT coefficient was 1.2878 which means the difference between GDP and its equilibrium value will be adjusted within 1 year. This is in line with a study by Saudi et al. (2019) which showed a significant relationship in short run between electricity consumption and economic growth of Indonesia. In Ghana, Adom (2011) found a causal relationship between electricity consumption and economic growth. A robustness test was used to ensure the stability of the selection and use of the model. Based on the Cusum Test, the model was stable from 1992 to 2018. Based on the CusumQ test, the model was stable from 1992 to 2018.

CONCLUSION AND RECOMMENDATION

Nowadays, modern human life is supported by electricity and other technological advances. All human activities cannot be separated from electricity from household to industrial level. Based on the results, surprisingly there was no significant influence of electricity consumption on economic performance of Indonesia in long-run and short-run. This is due to the electricity usage is not optimal and electricity distribution problem. The results also indicated that investment had a positive influence on economic performance of Indonesia in long-run and short-run. However, school enrollment had a negative influence on economic growth of Indonesia in long-run and the school enrollment had no influence on economic growth in short-run. Therefore, the recommended policies are 1) Indonesia should enhance improvments to the competence of electricity production, 2) intensify electricity distribution throughout Indonesia because there are still many areas in Indonesia that do not have electricity, 3) electricity production policy in accordance with demand-supply, and 4) improvement of the education sector and promotion of foreign investment to boost the national economy. The government also needs to prioritize investment in the electric energy source industry as the main public facility in order to create an even distribution of lighting that can be enjoyed by Indonesians at affordable prices. The limitation is electricity usage data.

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APPENDICES

Appendix 1

The formula of production function in the long term.

$$\ln[\frac{Y(t)}{L(t)}] = \ln A(0) + gt + \frac{\propto}{1-\propto}\ln(s) - \frac{\propto}{1-\propto}\ln(n + g + \delta \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . (8)$$