



Simultaneous Analysis: The Effect of Electricity Consumption on Human Development Index in ASEAN 5

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Abstract

A high per capita electricity consumption in developed countries is also correlated with high numbers on the human development index. Several studies show the relationship between the level of electricity consumption on economic growth and vice versa. This study aims to explore the relationship between electricity consumption, Human Development Index (HDI), and inflation to Gross Domestic Product (GDP) per Capita in ASEAN 5 countries. Using the simultaneous equation for the period 2012 to 2010 with the indirect least squares (ILS) analysis technique, it is found that electrical energy consumption has a positive effect on GDP per capita but HDI (Human Development Index) does not significantly affect GDP per Capita in ASEAN 5 countries. Meanwhile, the obtained inflation variable does not affect GDP per Capita. Then, we develop the second model and third model to test the impact on GDP per capita, electricity per capita, and HDI. The second model HDI as the dependent variable is influenced by the level of electricity consumption per capita and GDP per capita. This result proves that HDI is not influenced significantly by GDP per capita but is influenced by electricity consumption per capita. The third model shows empirical evidence that GDP per capita and HDI affect the level of electricity consumption. The policy implication is that electricity consumption will increase along with the increase in economic growth. The government must be able to increase supply to fulfill the rising electricity demand.

Key words : Electricity Consumption, HDI, Inflation, Economic Growth.

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INTRODUCTION

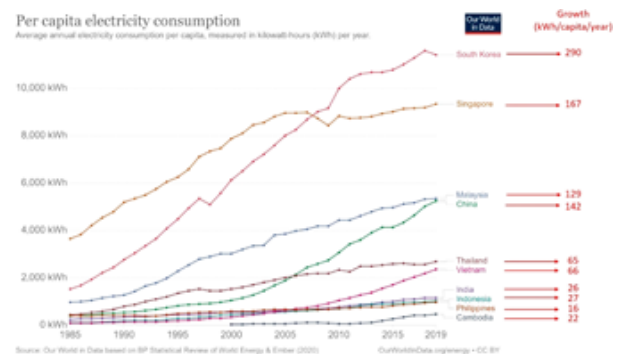
The consumption of electrical energy is closely related to a country's economic development (Bouzait & Pablo-Romero, 2016; Ouedraogo, 2013a). Increased electricity consumption will hasten the country's economic growth (Asmy et al., 2019). Electricity is a critical component in achieving economic growth and supporting labor, both directly and indirectly, as a capital in factors of production (Costantini, Sarwar, Chen, & Waheed, 2017). This statement is consistent with economists, engineers, governments, and energy institutions' recognition of the importance of electricity consumption for economic growth (EIA, 2018).

The demand for electrical energy has increased over the last two decades, particularly the demand for oil and gas. This is supported by the advancement of industrialization, increasing urbanization, and rising living standards, primarily in several countries experiencing rapid economic growth (Lin, Zhao, & Marinova, 2009; Niu et al., 2013; Mcneil, Karali, & Letschert, 2019). These countries include the United States, India, China, and Malaysia (Asmy et al., 2019; Niu et al., 2016; Ouedraogo, 2013a). This condition lends credence to the assertion that there is a strong connection between electricity consumption and economic growth.

A higher level of energy consumption indicates that there are many investors and workers involved in production activities, so industrial activities will also increase (Azad et al., 2014; Niu et al., 2016). Based on GDP data, industrialized countries are more prosperous than agrarian countries (Martínez, 2015; Sanchez-Loor & Zambrano-Monserrate, 2015b). The availability of electricity, which supports the production process and output distribution, also contributes to the rise of

industrialized countries. It is supported by research conducted by (Jamil & Ahmad, 2010) in Pakistan that shows adequate electricity supply is required for industrialization.

To measure the average electrical energy consumption used by each resident, either directly or indirectly, over one year in a country, the indicator of per capita electricity consumption in the number of Kilowatt hours or kWh is used (Statistics Indonesia, 2021). The following is a comparison of per capita electricity consumption in Asian countries:



Source: ourworldindata.org

Figure 1. The Rate of Per Capita Electricity Consumption in Various Countries

Figure 1 compares the per capita electricity consumption of several Asian countries. In 1985, several countries had the same low level of per capita electricity consumption; by 2000, some of them had grown significantly, but some remained at a slow rate, including Indonesia. Based on the figure above, the countries with the highest average growth in annual per capita electricity consumption are South Korea (290 kWh), Malaysia (142 kWh), China (129 kWh), and the countries with the lowest electricity consumption growth are Indonesia (27 kWh), India (26 kWh), Philippines (22 kWh) and Cambodia (16 kWh).

Electricity consumption in several ASEAN countries, including Indonesia, is low due to energy sources that are still heavily reliant on fossil (Ouedraogo, 2013a, 2013b; Deutch, 2017). The provision of electrical energy to remote parts of the country, particularly in Southeast

Asian countries with large islands, is a challenge in and of itself. The cases in the United States also show that investment in energy procurement in areas far from the city center is related to investment, allocation costs, and customer interconnection (Zvoleff et al., 2009; Makhholm, 2022; Kanagawa & Nakata, 2008).

The effect of electricity consumption on economic growth has been extensively researched, (Soytas, Sari, & Ewing, 2007; Pardo Martínez, 2015; Bouznit & Pablo-Romero, 2016; Pata, 2018). Most emphasized the importance of electricity consumption, be it for domestic or industrial activities. In the short term, energy use is positively correlated to changes in economic output as measured by Gross Domestic Product (GDP) (Ouedraogo, 2013a; Heidari, Turan Katircioğlu, & Saeidpour, 2015). In the long run, however, there is a possibility that the two variables have a different relationship (Samu, Bekun, & Fahrioglu, 2019; Asmy et al., 2019).

Research by Bah & Azam (2017), investigated the causal relationship between electricity consumption, economic growth, financial development, and CO₂ emissions in South Africa from 1971 to 2012, and their findings indicate that there is no causal relationship between electricity consumption and economic growth. Likewise, the results of the study conducted by Sanchez-Loor & Zambrano-Monserrate (2015a), in Colombia and Ecuador as well as those of Chouaïbi & Abdessalem (2011), in Tunisia, suggest no empirical evidence of a causal relationship between electricity consumption and economic growth.

Different findings from the study Bah & Azam (2017), are presented by Sarwar, Chen, & Waheed (2017), which aims to examine the empirical relationship between economic growth, electricity consumption, oil prices,

gross fixed capital formation, and population. The results of this study confirm a two-way relationship between electricity consumption and GDP. It is also supported by the findings of Odhiambo (2009), in South Africa, and the same conclusion is reached when data from Malaysia are used, indicating that there is a positive relationship between electricity consumption and economic growth (Asmy et al., 2019). Although there is no empirical evidence that there is a causal relationship between the level of electricity consumption and GDP in Malaysia.

Among the studies that investigate and analyze the impact of the Human Development Index (HDI) on economic growth are (Wang et al., 2018). Their research discovered that the relationship between economic growth and HDI is contrary to the hypothesis. There is no evidence that a high HDI promotes economic growth. Even the increase in HDI is influenced by the increase in CO₂ emissions in Pakistan. Meanwhile, research in Sub-Saharan Africa shows empirical evidence that increasing HDI fosters economic growth.

Meanwhile, there is a theoretically negative relationship between inflation and economic growth. If the inflation rate is high, economic growth will be slow due to rising prices. Research by Adaramola & Dada (2020), yields that inflation hurts economic growth in Nigeria. In contrast, Ong and Sek (2013), argue the influence of inflation on economic growth is not significant.

There are still differences in results based on empirical evidence that shows the effect of the level of electricity consumption on economic growth. Several studies that claim that the level of electricity consumption has a positive impact on economic growth are mostly in one direction. Many experts agree that there is no empirical evidence to support the effect of economic growth on the level of electricity consumption (Sanchez-Loor & Zambrano-Monserrate, 2015 a; Bah & Azam, 2017).

Different results from research by Bah & Azam (2017), are shown by Sarwar, Chen, & Waheed (2017), which aims to examine the empirical relationship between economic growth, electricity consumption, oil prices, gross fixed capital formation, and population. The data used were panel data from 210 countries from 1960 to 2014. The methods used were Pedroni Panel Cointegration, Modified OLS, and Panel Vector Error Correction Test. This study found a two-way relationship between electricity consumption and GDP, oil prices and GDP, fixed capital formation, population, and GDP. The findings also revealed a negative relationship between energy consumption and economic growth in countries that use nonrenewable energy.

Other studies concerning the relationship between human development and economic growth include research by (Niu et al., 2013; Wang et al., 2018), which describes the relationship between renewable energy consumption, economic growth, and Human Development Index (HDI) in Pakistan using data from 1990 to 2014. This research, which used the Two-Stage Least Square (2SLS) method, found that the consumption of renewable energy does not improve the human development process in Pakistan. Interestingly, it also revealed that there is a negative relationship between economic growth and the Human Development Index (HDI), which contradicts research by (Rahman, Raja, & Ryan 2020).

The control variables used in this research are inflation and HDI variables for equation 1. The inflation variable is chosen to represent the level of price development in ASEAN countries. If the inflation rate is kept under control, economic growth is expected to occur, and the impact of the HDI variable and electricity consumption will be more precise.

The purpose of this research is to investigate empirically the relationship between human development and economic growth. This study relied on panel data from 5 countries from 1990 to 2020. Using the simultaneously regression, it would investigate whether there is a significant relationship between the Human Development Index (HDI) and economic growth to electricity consumption.

METHOD

Type of this research data is quantitative. This research includes data from ASEAN 5 countries, namely Indonesia, Malaysia, Thailand, the Philippines, and Singapore during the period 1990 to 2020. The source of data obtained from the World Bank data. The 1990 - 2020 observation period was chosen due to the availability of data in each country. We collected the data that available in www.worldbank.org.

We collected the data from 5 countries of ASEAN among 11 countries. The reason chosen 5 countries because 5 countries as the five original member ASEAN countries. The approach used was the simultaneous equation model. The first step is to identify the structural equations.

The followings are equations used in this research:

$$LGDP_{it} = \alpha_0 + \alpha_1 LEC_{it} + \alpha_2 HDI_{it} + \alpha_3 INF_{it} + e_{it} \quad (1)$$

$$HDI_{it} = \beta_0 + \beta_1 LEC_{it} + \beta_2 LGDP_{it} + e_{it} \quad (2)$$

$$LEC_{it} = \Omega_0 + \Omega_1 HDI_{it} + \Omega_2 LGDP_{it} + e_{it} \quad (3)$$

Model 1 dependent variable is LGDP and model 2 dependent variable is HDI. Where LGDP is the log variable for Gross Domestic Product (GDP) per capita based on constant prices in USD in country i period t. LEC is the log variable of per capita electricity consumption in kWh country i period t, HDI is the HDI variable for country i period t, and inf is the inflation variable for country i period t.

The structural equation identification test uses the K-k formula compared to m-1, where K is the number of all exogenous variables and k is the number of exogenous equations in a given

equation. While m represents the number of endogenous variables.

The results of the identification of the three equations show that the value of K is 1, k in equation (1) is 1, in equation (2) is 0, in equation (3) is 0, while the number of endogenous variables or m is 2, in equation (1) is under-identified, in equation (2) is exactly identified, and in equation (3) is also exactly identified. After identifying the equation model, the data processing method used was determined, which was the Indirect Least Squares (ILS) method. The model was then tested with software reviews 10.

RESULTS AND DISCUSSION

This research used data from countries included in ASEAN 5, which were obtained from World Bank data. The selection of ASEAN 5 as the object of research is based on data from the International Energy Agency (IEA) (2010), that the growth in energy consumption in the ASEAN region reached 4%, which is significantly higher than the growth in global energy consumption, which was only 1.8%. This figure places ASEAN among the Asia Pacific regions with the fastest-growing rates of energy consumption.

Table 1. Descriptive Statistic

Variable	Obs	Mean	Std. Dev.
Gdp	155	15.734.28	20.099.25
Electricity Consumption	155	3.493.22	2.940.5
HDI	155	0.77	0.087
INF	155	2.14	1.64

Source: World Bank (processed)

According to Table 1, ASEAN 5 countries have an average GDP per capita of 15,734.28 USD, which can be classified as high per capita income because it has a nominal value greater than 12,000 USD. Meanwhile, each ASEAN 5 country has average electricity consumption of 3493.22 kWh. The ASEAN 5

countries have an average HDI and inflation of 0.77 and 2.14, respectively.

After the identification shows under-identified and exact results, the data in the equation are processed using ILS. Previously, the classical assumptions of normality, linearity, multicollinearity, and heteroscedasticity were tested. The assumption of normality using the Jarque-Bera probability residual test is greater than 0.05, linearity using the Breusch-Godfrey serial correlation on the Prob F statistic is above 0.05, and multicollinearity testing using the correlation between variables is also above 0.05. Heteroscedasticity is also tested above 0.05 using Breusch Pagan Godfrey. Table 2 shows the results of the simultaneous model regression using the ILS technique.

Table 2. The Effect of Electricity Consumption Rate, HDI, and INF on GDP Predicted

Variables	Coefficient	Prob
Lec_Predicted	0.99	0.00
HDI_Predicted	1.45	0.63
Inf	-0.00	0.76
R-sq	0.96	
Prob > F	0.000	

Source: processed data

Based on Table 2, which shows the estimation results from the simultaneous model. There is a variable that significant effect to GDP per capita. The variable is the log of electricity consumption per capita. The other variables, while showing a direction consistent with the hypothesis, were not significant to GDP per capita in the ASEAN 5 countries.

The variable's coefficient for electricity consumption is 0.99. It demonstrates that a 1% increase in electricity consumption per capita will result in a 0.99% increase in national product per capita (GDP/ capita). The findings of this research support the hypothesis that increased electricity consumption can stimulate economic growth. It corresponds to research by Samu, Bekun & Fahrioglu (2019), that there is a

significant positive relationship between the two variables.

The significant results of the electricity consumption variable on economic growth in ASEAN 5 countries are consistent with a study conducted by Thaker (2019), which states that the role of electricity in encouraging economic growth is very important in Malaysia, which has seen a drastic increase in per capita electricity consumption along with increasing economic growth in recent decades. This increase is driven by increased industrialization, urbanization, and population growth. According to data from Malaysia Power Center (*Pusat Tenaga Malaysia*) (2004), Malaysian electricity consumption rose from 3,464 GWh in 1971 to 94,278 GWh in 2008. The demand for electricity consumption in Malaysia is expected to increase to 274 TWh by 2030.

The HDI variable has a coefficient of 1.45, indicating that HDI has a positive but not statistically significant effect on GDP per capita in the ASEAN 5 countries. Referring to previous research and theory, it is not proven in ASEAN that an increase in HDI will lead to an increase in economic growth. This contrasts with the findings of Rahman, Raja, & Ryan (2020), who discovered a significant positive relationship between the Human Development Index (HDI) and economic growth. These results indicate that HDI has an important role in increasing the momentum of economic growth.

Table 3. The Effect of Electricity Consumption Rate, GDP on HDI

Variables	Coefficient	Prob
Lec_Predicted	0.095	0.00
Lgdp_Predicted	0.001	0.596
R-sq	0.99	
Prob > F	0.000	

Source: processed data

Tables 3 and 4 supplement the estimation results in Table 2 by presenting the effect of electricity consumption on HDI

and the effect of GDP on electricity consumption, respectively.

The findings of this research indicate that electricity consumption affects the increase in HDI. It is in line with research by Saepudin and Acuviarta (2016), which concludes that the increase in HDI in Indonesia is influenced by the increase in electricity consumption. While the results in Table 3 shows that GDP per capita does not affect increasing HDI. This finding supported the result from (Wang et al., 2018). According to Wang et al., (2018), the higher of economic growth in Pakistan supported by shifting from agriculture to non-agriculture sector. Most of people in Pakistan (70% work in agriculture sector) are not receive the higher income to improve the quality of their life.

Economic growth have no correlation with equality of income (Ghosh, 2015). Meanwhile, Owusu & Asumadu-Sarkodie (2016), discovered that income inequality does not significantly increase HDI. Unqualified economic growth will lead to inequality. As a result, economic growth will not improve HDI. Meanwhile, the HDI level and GDP per capita have an impact on per capita electricity consumption (Sarkodie & Adams, 2018).

Based on the three equations in Tables 4 concluded that the level electricity consumption is influenced by GDP but not HDI.

Table 4. The Effect of GDP, HDI, on Electricity Consumption

Variables	Coefficient	Prob
Lgdp_Predicted	0.07	0.00
HDI_Predicted	9.54	0.00
R-sq	0.99	

Source: processed data

The impact of the electricity consumption variable on economic growth in ASEAN 5 countries is consistent with a study conducted by (Thaker et al., 2019). They states that the role of electricity in encouraging economic growth is very significant in Malaysia, which has seen a drastic increase in electricity consumption per

capita in line with increasing economic growth over the last few decades. This increase is driven by increased industrialization, urbanization, and population growth. According to data from Malaysia Power Center (*Pusat Tenaga Malaysia*) (2004), Malaysian electricity consumption rose from 3,464 GWh in 1971 to 94,278 GWh in 2008. The demand for electricity consumption in Malaysia is expected to increase to 274 TWh by 2030.

Based on these findings, electricity consumption affects the increase in HDI. This finding contradicts the conclusion made by Wang et al., (2018), that an increase in electricity consumption per capita does not affect HDI. The positive effect of GDP per capita on HDI is insignificant and opposes research by (Ouedraogo, 2013b; Sarwar, Chen, & Waheed, 2017).

According to Table 4, both GDP per capita and HDI variables have a positive and significant effect on per capita electricity consumption. An increase in GDP per capita will increase the demand for electricity consumption, both in households and in the industry (Ouedraogo, 2013a; Sarwar, Chen, & Waheed, 2017). The HDI variable also has a positive effect on the rise in electricity consumption. It is well known that increased access to education, health, and income has increased per capita electricity consumption. This finding is consistent with the findings of the study by Sanchez-Loor & Zambrano-Monserrate (2015b), even though no direct relationship was discovered in this study.

ASEAN 5, part of the ASEAN+6 group, is the world's fastest-growing and most dynamic energy consumption center. The significant influence of electricity consumption is consistent with the various programs being implemented by the group's countries to achieve Energy Security to ensure the security and availability of energy in the

region through renewable energy. According to Sarwar, Chen, & Waheed, (2017), Wang et al., (2018), nonrenewable energy will harm GDP.

CONCLUSION

The influence of per capita electricity consumption encourages the ASEAN region's economic growth to accelerate. With a high level of electricity consumption, the opportunities for the development of economic sectors that use electricity input will higher.

The increase in HDI has no direct impact on the increase in GDP per capita. The rise in HDI is more concerned with improving human life quality and is not directly related to GDP per capita. These results may differ when using the dynamic panel approach. The inflation variable although influential but not significant on economic growth. These findings indicate that inflation in ASEAN countries remained relatively stable during the study period.

The estimation also shows that higher electricity consumption will encourage an increase in HDI. However, it turns out that the increase in GDP per capita does not significantly affect HDI. This means that the issue of increasing HDI is not solely dominated by the problem of increasing income. There are still two major issues in ASEAN countries, namely education and health problems (Wang et al., 2018)

Increased GDP per capita and HDI will result in increased per capita electricity consumption. This finding should concern ASEAN countries, particularly because the supply of electrical energy must be increased and is expected to be environmentally friendly (Yustisia & Sugiyanto, 2014; Nasution, Ambarita & Siregar, 2018; (Ben-Jebli, Ben-Youssef, & Ozturk, 2015).

The government can implement several policies to realize renewable and

environmentally friendly energy so that increased consumption of electrical energy can have a positive impact on economic growth. The government must be able to find alternatives to provide renewable energy because the existing energy is still not environmentally friendly and still relies heavily on fossil energy sources as a primary energy, namely coal, gas, and oil.

Several energy sources that can be used as alternatives are water, geothermal, and nuclear. The three energy sources have a high density, or the amount of energy produced by one kilogram of fuel material, with nuclear energy having the highest density level when compared to water, geothermal, and other energy sources. The higher the density of the energy source, the less land is needed to generate electricity, and the less fuel is required (Sarkodie & Adams, 2018). As a result, the use of high-density energy sources will be more environmentally friendly because there will be no need to sacrifice land functions as a habitat for flora and fauna (Chapel, 2022).

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