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An Analysis on Determinants of Energy Intensity in ASEAN Countries

Fajar Fitriyanto[1], Deden Dinar Iskandar [1]
[1]Economics Development, Diponegoro University, Indonesia
E-mail: fajaryanto74@gmail.com

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Abstract

ASEAN is a region with a high level of economic growth. However, ASEAN region is also faced with several important issues in the energy sector such as high energy consumption growth, fossil energy dependency, and fluctuations in energy prices. Energy efficiency is viewed as the proper way to enhance energy security. The concept of energy intensity (ratio of energy consumption per GDP) is used to describe the level of energy efficiency. The objective of the research is to analyze factors that influence energy intensity in ASEAN region. This study uses secondary data in the nine Southeast Asian countries in 2001-2014. This study employs an analysis with Arellano Bond Generalized Method of Moments (GMM) panel data to analyze factors that affect energy intensity. The results of the study find that the variable of GDP per capita and energy prices have a significantly negative effect on energy intensity. The variable of energy consumption per capita has significantly positive effect on energy intensity. The variables of trade openness and foreign direct investment have no significant effect on energy intensity

Keywords: *Energy Efficiency, Energy Intensity, ASEAN*
JEL Classification: C10, Q40**,** Q43

INTRODUCTION

The Association of Southeast Asian Nation (ASEAN) is a region located south of Asian continent consisting of 10 countries. Initiated by Indonesia, Malaysia, Philippine, Singapore, and Thailand, ASEAN is established on August 8, 1967. ASEAN region is totally 4,435,618 km^2 in size and inhabited by more than 615 million people or 8.5% of worldwide population. One purpose of the formation of this association of Southeast Asian countries is to accelerate ASEAN countries economic growth. Economic growth is a good indicator or criterion of a country or regions economic performance.

ASEAN has recorded a strong economic growth for the last decade. The economy of ASEAN countries has increased almost twofold since 2000 up to 6.1 trillion US Dollars in 2013. Besides, the average economic growth rate in ASEAN is above 4% from 2000 to 2013 which is far higher than the OECD countries (1.6%) (Asean Center for Energy, 2015).

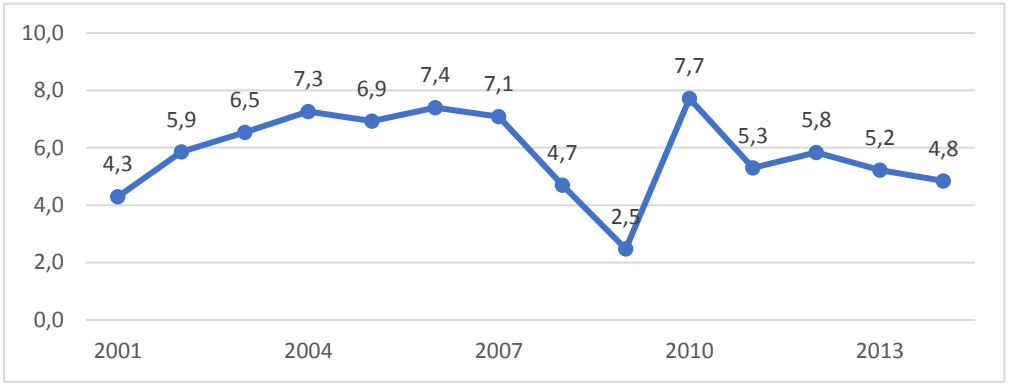

Figure 1. ASEAN's Economic Growth 2001-2014 (in percent)
Source: World Development Indicator

Energy is an important factor of production and economic growth. According to Stern (2004), various economic activities need energy from their production, distribution to consumption. Therefore, energy is important in long-term course which may affect economic growth. According to the International Energy Agency (2015), an increase has taken place in energy consumption in ASEAN between 2000-2013 with an annual average rate of 3.5%. the energy consumption in ASEAN region is up to 619 Mtoe in 2013, increasing to a great extent from 2000 which is only up to 233 Mtoe.

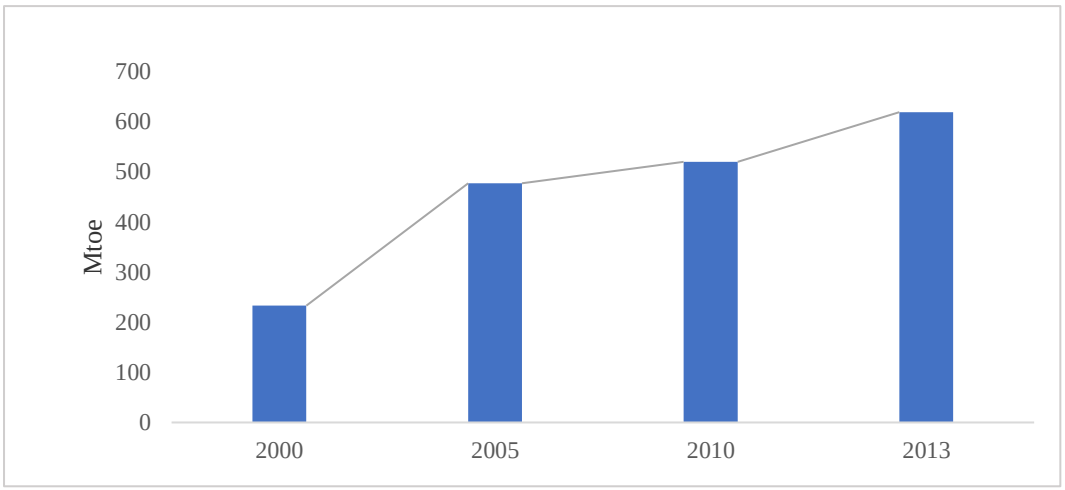

Figure 2. Energy Consumption in ASEAN Region
Source: ASEAN Energy Outlook (2015)

Figure 3 presents the existing mixed energies in ASEAN region consisting of oil, coal, natural gas, and renewable energy. In 2013, fossil energy contributes about 90% of energy supply in ASEAN, and the remaining 10% is supplied by renewable energy. Considering these data phenomena, we may conclude that there is a high dependency of fossil energy in ASEAN region. The non-renewability of fossil energy will cause a shock in the national need for energy. An intensive use of fossil energy has caused an increase of pollutant concentration in the global atmosphere and constitutes a threat of severe environmental damage to the ozone layer, which results in global warming (Todaro & Smith, 2006).

ASEAN will be a region to export fossil-based fuel, considering the fact that its coal and natural gas production exceeds its consumption. However, at the same time, the ASEAN region also imports oil. The ASEAN regions oil consumption is up to 254.6 MTOE in 2013, exceeding its production of about 134.6 MTOE. The growth rate of natural gas consumption shows that its consumptive pattern still exceeds its production, similar to oil with an average growth rate of gas consumption up to 6.1% in 1990-2013. This value is higher than the production growth rate of 4% within the same period (ASEAN Center for Energy 2015). This condition may, if it does not change, affect the ASAEN regions trade which is initially net exporter to importer of natural gas.

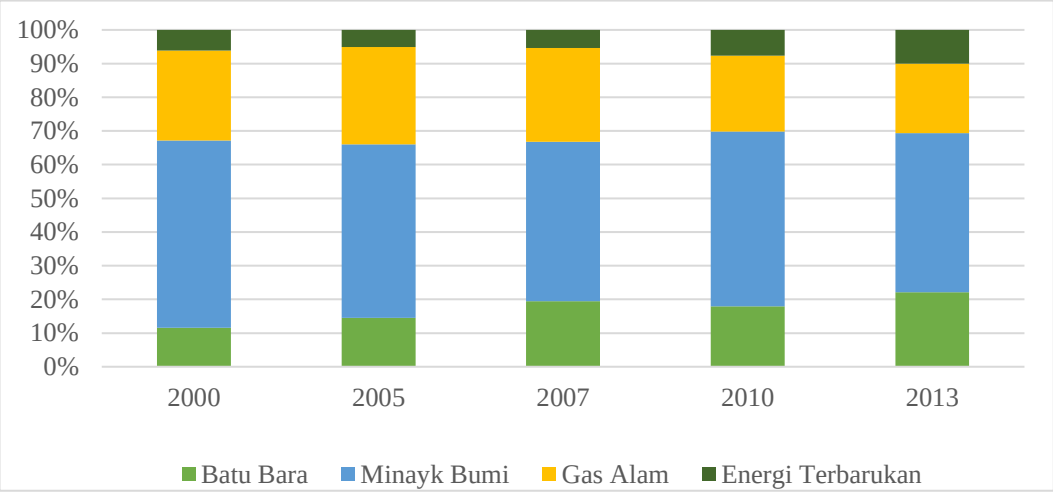

Figure 3. Mixed Energies in ASEAN region
Source: ASEAN Energy Outlook (2015)

In addition, oil price in the last decade fluctuates. According to the Energy Information Administration (2018), oil price is strongly correlated to economic growth. Therefore, post 1998 economic crisis, oil price tends to change in line with economic growth. As previously stated, ASEAN is oil importer, thus its member countries are at the risk of getting affected by fluctuating oil price. Some of its member countries are vulnerable to disturbance of energy supply since their need for energy depends on oil import (Yong, 2012).

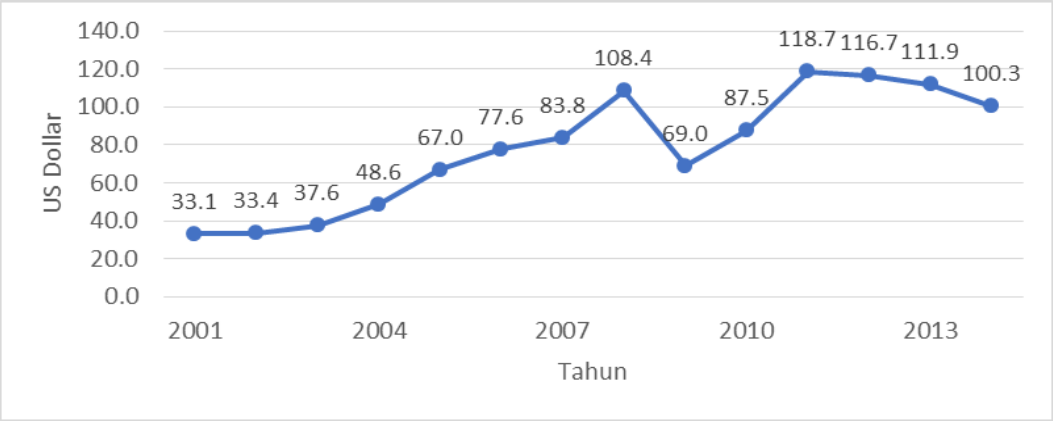

Figure 4. World Oil Price (US Dollars/Barrel)
Source: BP Statistical Review 2017 World Energy

From the explanation above, we may conclude that ASEAN is currently facing a high growth of fossil energy consumption and dependence on fossil energy. In addition, ASEAN is also facing an energy price fluctuation phenomenon. One thing to do to solve problems in energy sector is to efficiently use or utilize energy. According to the International Energy Agency (in Keay 2011), energy efficiency is deemed to be the best way of cost efficient to improve energy security and to solve climate change. An improvement in energy efficiency may reduce the need for investment in energy infrastructure, cut fuel cost, enhance competitiveness and improve consumers' prosperity. Environmental benefits may also be achieved by reducing greenhouse gas emission and local air pollution.

ASEAN member countries have established a cooperation to realize energy efficiency. This energy cooperation is expressed in the policy of ASEAN Plan of Action on Energy Cooperation (APAEC) with a target to reduce energy intensity for 20% in 2020 (Direktorat Jenderal Kerja Sama ASEAN, 2017). According to Batthacharayya (2011), energy intensity measures the need for energy per unit of economic variables (for example GDP, added value, etc.). Energy intensity may be formed from the highest aggregate level (economic macro scale) to the lowest aggregate level in physical unit (energy consumption unit per production volume unit). This indicator may be applied to national, regional, or sectorial level of economic activities, either for primary energy consumption or final or secondary energy consumption. A simple energy intensity equation may be presented as follows:

$$EI = E/Q \quad (1)$$

EI means energy intensity, E means energy and Q means type of output. The concept of energy intensity may be used to describe energy efficiency level. Energy intensity refers to energy used or needed per unit of output. Energy intensity is a general indicator used to assess trend in energy efficiency and has been many used by previous researchers (Adom, 2015; Metcalf, 2008; Rafiq, Salim, & Nielsen, 2016; Sahu & Narayanan, 2011). Energy intensity is inversely proportional to energy efficiency, in which the less the energy is needed to produce one unit of output (good and service), the more efficient the energy is used. Decreasing energy intensity from time to time may become an indicator of improvement in energy efficiency. This research aims at analyzing the influence of the GDP per capita,

energy consumption per capita, energy price, FDI and trade openness variables on the energy intensity variable as the indicator of energy efficiency.

An aggregate economic growth is frequently interpreted as an increase of national production. According to Krugman (2010), an economic growth may be marked with an increase of goods and services production in the society and peoples prosperity improvement. The relation of GDP per capita and energy intensity may be viewed using Kuznets inverted U curve approach (Chima & Hills, 2007). In the initial phase of economic growth when GDP per capita is still low, the energy needed is also still relatively low. However, in the subsequent phase, industrialization and other various economic activities which intensively use energy take place. Economic activities which need intensive energy lead to an increase of ratio of energy consumption per GDP or energy intensity. When the economy keeps growing and all facilities and infrastructure are available, the next phase is a shift of output composition to any forms of service instead of industries which intensively use energy. Various technology innovations and substitution of energy to more efficient one also develop in this phase. This condition results in lower usage of energy per GDP. This phase is reflected by curves descending slope (Indra, 2009). The empirical research conducted by Deichmann et al. (2018) studies the relation of GDP per capita and energy intensity variables in 137 countries. The research finds a negative relation between GDP per capita and energy intensity.

The energy consumption per capita variable positively influences energy intensity (World Bank 2013). An efficient country will have low energy intensity. High efficiency is generally related to high technology and high life standard, which lead to low energy consumption per capita. However, the phenomena of a country with high energy intensity and low energy consumption per capita may take place. The country may have low and inefficient GDP (Ramachandra, Loerincik, & Shruthi, 2014). Energy consumption is closely related to growth in industrial and transportation sectors and growth in urban area. A country's energy consumption does not only depend on GDP, but also on climate and human way of life. In an area, regardless of industrial, agricultural and service sectors which participate in GDP and consume energy, the country's people use energy for cooking, heating and various tasks in their daily life (Ramachandra et al., 2014).

The energy price variable is also considered to influence energy intensity (Adom, 2015). A change in energy price influences people's consumption pattern. According to Thaler (in Kartiasih 2012), higher energy price will cause higher energy efficiency, and therefore energy intensity will be lower since countries with higher energy tend to consume less energy. Higher energy price forces people to find alternative transportation method, such as walking, biking, public transport or other methods. These alternative transportations are more energy efficient since they may reduce the total energy consumed. Energy price is also considered an appropriate instrument of energy policy to improve energy efficiency. The research conducted by Filipovi, Verbi, & Radovanovi (2015) shows that there is negative relation between energy price and energy intensity in OECD countries.

Foreign Direct Investment (FDI) may be interpreted as an amount of long-term investment in a company in other country. FDI is one characteristic of global economic system. Before investor invests its capital in a country, there are certainly many things to consider. One of the considerations is the energy sector. Energy usage is an important factor in investment consideration. This becomes important

since in long-term course, investors will not have to worry that their business will lack of energy (Djulius, 2017). Foreign direct investment may fill the gap between saving inventory, foreign exchange reserves, government revenue and managerial expertise needed in the process to achieve targeted development and growth. Foreign direct investment also brings production techniques or technologies, taste and life style and various business practices. However, there is assumption that some multinational companies worsen the development, on the reason that multinational companies even worsen distribution of income and the products and technologies they bring are inappropriate to what the country needs (Todaro & Smith, 2006)

The foreign direct investment variable negatively influences energy intensity. This result confirms the assumption that FDI enters by carrying modern technology which potentially improve energy efficiency (Mielnik and Goldemberg 2002). FDI may be in the form of direct capital, indirect technology and managerial skill or effect participation through a spillover effect of knowledge on fund receiving country. According to Adom (2015), the potential energy efficiency of FDI inflow may be viewed from three perspectives: scale effect (through improving gross domestic product), composition effect (changing sectorial composition), and technical effect (adoption of energy efficient technology).

An economic openness in trade may be viewed from two components of international trade: export and import. Trade openness is an important component of economic growth and an improvement of international trade improves economic activities. It is quite unlikely that a country does not make trading interaction with other countries. Therefore, trade openness is one characteristic of open economy. According to P. Todaro and C. Smith (2006), trade must be understood in a wider perspective than merely a movement of resources and commodities between countries. Opening economy and community to commercial relations and world trade will not only invite goods and services transfer to come, but will also invite other good influences. The good influences include transfer of production technology, consumption pattern, health system, education and social and other matters brought from developed countries.

According to Rafiq, Salim, and Nielsen (2016), there is a negative and significant relation between energy intensity and trade openness. In addition, greater trade openness may serve to be a channel for transfer of cleaner and more energy-efficient technology from a developed country to a developing country and minimize the negative effects of greenhouse gas emission. Meanwhile, according to Cole (2006), the impact of trade openness on energy intensity depends on whether the country imports or exports energy-intensive products. Therefore, the final impact of openness on trade depends on the relative weight of energy consuming export and energy-efficient import.

A previous research which supports this study is that of Metcalf (2008). He studies factors which influence energy intensity in the United States within the period of 1970-2003. This research is divided into two phases: first, to analyze any change in energy intensity at state level (covering 46 states) by employing the decomposition methodology of Fisher's Ideal Index; and second, to employ an econometric method to identify change supporting factors in efficiency and index of economic activities. The decomposition analysis shows that most of energy intensity reduction is caused more by an improvement of energy efficiency.

Meanwhile, the shift from energy-intensive activities to less energy-intensive economic activities gives lower contribution to the change of energy intensity during the research period. Energy price and income per capita has a negative relation with energy intensity, while population has a positive relation with energy intensity.

Meanwhile, Mahmood and Ahmad (2018) studies the relation of energy intensity and economic growth in the selected 19 countries. This study results in a negative and significant relation between economic growth and energy intensity in the research area, a negative influence of population growth on energy intensity and a negative influence of tax and energy price variables on energy intensity.

Filipovi, Verbi, and Radovanovi (2015) study the determinants of energy intensity in the 28 member countries of the Europe Union (UE-28) in the period of 1990-2012. The variables used are GDP per capita, energy price, energy consumption per capita, gross inland consumption growth and energy tax. The research finds that energy price, energy tax and GDP per capita negatively influence energy intensity, while energy consumption per capita and gross inland consumption growth positively influence energy intensity. Energy price has the highest influence on energy intensity, and, therefore, energy price is deemed the most effective variable in energy conservation policy.

Deichmann et al. (2018) conduct a study to examine the relation between energy intensity and economic growth in 137 countries with the research period of 1990– 2014, of which results confirm a negative correlation between GDP per capita and energy intensity. Rafiq, Salim and Nielsen (2016) analyze the impacts or urbanization and trade openness on emission and energy intensity in twenty urbanized developing countries. The empirical results show that population density and prosperity increases emission and energy intensity, while renewable energy seems to be inactive in these developing countries, but non-renewable energy increases CO2 emission and energy intensity. Besides, openness significantly reduces pollutant emission and energy intensity, while urbanization significantly increases energy intensity, but insignificantly increases emission. The reason of this may, partly, be the trend of current increase of adoption of cleaner technology in developing countries.

Rezkia (2011) conducts a study of factors which influence energy consumption in Southeast Asian region in the period of 1990– 2004. Employing data from 5 countries, which are Indonesia, Malaysia, Myanmar, Thailand and Philippine, some conclusions may be made from this study. The estimation results show that GDP per capita, population, and industrials added value to GDP significantly, positively influence a change in energy consumption. Meanwhile, crude oil price and economic crisis evidently do not influence a change in energy consumption.

Indra (2009) conducts a study related to the relation of energy intensity and GDP per capita in ten Asia-Pacific countries with different economic performance. The research results show that developed countries with high GDP per capita tend to have their energy intensity decreased in line with an increase of their GDP per capita. Meanwhile, an increase of GDP per capita in developing countries is not able yet to decrease energy intensity. This research also observes the influence of energy price on energy consumption per capita. The results state that an increase of energy price causes a decrease of energy consumption per capita in a little portion.

METHOD

This research employs dependent variable and independent variable. The dependent variable used is energy intensity variable, while the independent variable includes gross domestic product per capita (GDP per capita), energy consumption per capita, energy price, foreign direct investment and trade openness. An operational definition is required to prevent difference in definition and to provide an express limitation to each of the research variables. The operational definition of each variable is explained below:

1. Energy Intensity
   Energy intensity level is the ratio of energy supply to gross domestic product as measured at purchasing power parity. Energy intensity is an indication of how much energy is used to generate one unit of economic output. The Energy Intensity unit used is Mega Joule (MJ) / US Dollar of constant GDP 2011.
2. Gross Domestic Product per Capita
   Gross Domestic Product per capita is calculated by dividing Gross Domestic Product with 2010 constant price of that year with total population. The data uses US Dollar unit.
3. Energy Consumption per Capita
   Energy consumption per capita is the consumption of primary energy before transformation to other fuel of final usage used in any activities in that country. This value has included imported energy, minus export. Energy consumption per capita refers to total energy consumption divided by total population. The unit of energy consumption per capita is kilogram of oil equivalent (Kgoe).
4. Energy Price
   Energy price as referred to in this research is energy price proxied with the real price of world crude oil. This oil price is measured in US Dollar per barrel.
5. Foreign Direct Investment (FDI)
   FDI is total foreign investment including capital equity, reinvested profit and long-term and short-term capital as stated in balance of payment. Foreign direct investment is measured in US Dollar unit.
6. Trade Openness
   Trade openness is the aggregate value of import and export of goods and services stated as gross domestic product (GDP) percentage.

Secondary data are employed in this research, consisting of a combination of time series data and data per observation (cross section) or commonly known as panel data. The object of this research includes nine countries in Southeast Asia in the period from 2001 to 2014 (14 years). The data are obtained from the World Bank and BP Statistical Review World Energy. This research employs the panel data of Arrelano Bond Generalized Method of Moments (GMM) to analyze any factors which influence energy intensity. This analysis technique is employed with an expectation to generate better results in analyzing any factors which influence energy intensity in Southeast Asian region.

Table 1. Sources of Data

Variable	Source of Data
Energy Intensity	World Bank
GDP per capita	World Bank
Energy Consumption per Capita	World Bank
Energy Price	Bp Statistical Review World Energy
Trade Openness	World Bank
Foreign Direct Investment	World

Source: World Bank and Bp Statistical Review World Energy

RESULT AND DISCUSSION

Energy Intensity Development in ASEAN Region

In response to limited fossil fuel reserve and volatile energy price issues, ASEAN member countries have conclude a policy to diversify and efficiently use sources of energy. This policy is expressed in the ASEAN Plan of Action for Energy Cooperation (APAEC). APAEC is a series of policy guiding documents to support the implementation of multilateral energy cooperation to promote regional integration and the purpose of connectivity in ASEAN (Zamora, 2015).

APAEC focuses on seven programs, one of which is the Energy Efficiency and Conservation (EE&C). EE & C is ASEAN's collective effort in energy efficiency toward target of energy intensity reduction. The purpose of the EE & C program is to reduce energy intensity in ASEAN by 20% in 2020 and 30% in 2025 (Direktorat Jenderal Kerja Sama ASEAN, 2017). From 2010-2015, ASEAN has applied policies and programs to improve energy efficiency. This policy has resulted in energy intensity reduction of 8.5% (Zamora, 2015).

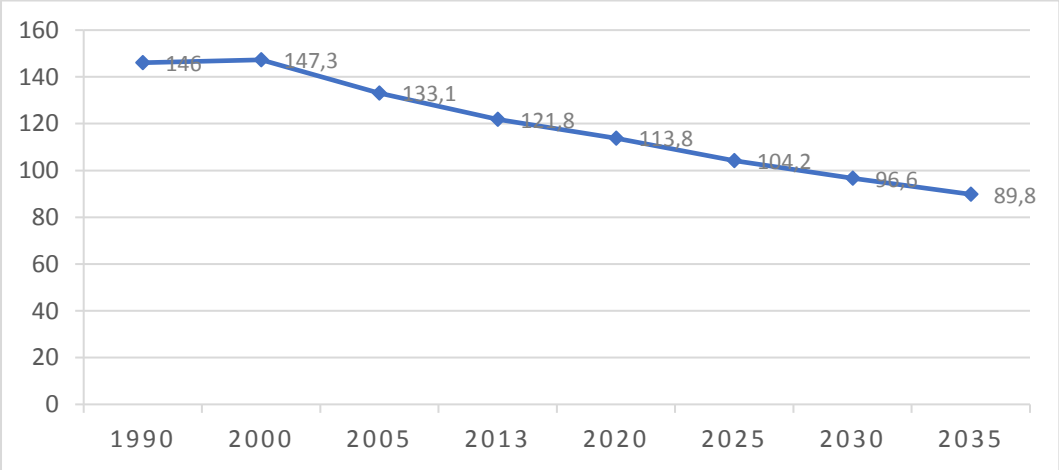

Figure 5. Estimated Trend of Energy Intensity in ASEAN
Source: (International Energy Agency, 2015)

Energy intensity or the ratio of energy consumption to GDP is an indicator of energy efficiency. The less a country's energy intensity value, the country may be considered as having efficient energy consumption. Figure 5 shows that energy intensity in ASEAN has a descending trend in the period of 1990-2013. In 1990, the energy intensity value is 146 tonne of oil equivalent (TOE) /million US Dollars with GDP calculation using constant price. In 2005, the energy intensity value is 133.1 TOE /million in 2013 and decreases again to 121.8 TOE / million. With an

assumption of economic growth rate of 6.1% during the period 2013-2035, it is expected that the energy intensity decreasing trend will continue to 89.8 02 TOE / million US Dollars (International Energy Agency, 2015).

Table 2. ASEAN Countries Energy Intensity in Mega Joule/US Dollar (MJ/US Dollar)

Country	2002	2005	2008	2011	2014
Brunei	3.43	3.39	5.28	5.54	5.25
Cambodia	8.68	5.50	4.29	6.01	5.59
Indonesia	5.20	4.86	4.25	3.94	3.70
Malaysia	5.50	5.77	5.65	5.13	5.13
Myanmar	7.27	5.68	4.13	3.04	3.24
Philippine	4.63	3.95	3.48	3.13	3.03
Singapore	4.13	3.42	3.23	2.83	2.70
Thailand	5.42	5.50	5.33	5.39	5.56
Vietnam	6.03	6.02	5.86	5.97	5.72

Source: *World Bank*

In 2014, Singapore is a country with the lowest energy intensity among the other ASEAN member countries. Singapore's energy intensity value is 2.70 MJ/US Dollar, which means that Singapore is the most efficient country to use energy in ASEAN by using the energy intensity indicator. Vietnam is a country with the highest energy intensity among the member countries with the intensity value of 5.72 MJ/US Dollar. ASEAN member countries energy intensity value generally does not significantly decrease within the last 14 years, while Brunei and Thailand have their energy intensity value increased from previous year.

Panel GMM Panel Data Estimation Result

This research employs an analysis with data panel Arrelano Bond *Generalized Method of Moments* (GMM) to observe the independent variables, which are GDP per capita, energy consumption per capita, energy price, foreign direct investment and trade openness on the dependent variable, which is energy intensity. The result of GMM panel data estimation is as follows:

Table 3. GMM Panel Data Estimation Result

Variable	Coef.	z stat
Energy Intensity t-1	0.80000	(16.86)
Consumption per capita	0.00029	(6.57)
GDP Per capita	-0.06045	(-6.19)
Energy Price	-0.00370	(-3.34)
Foreign Direct Investment	0.00001	(2.73)
Trade Openness	0.l30827	(2.79)

Source: Processed by the author based on STATA 14 output

This research employs a one tailed test with significance level of 5 percent. The result state that GDP per capita variable significantly influences energy intensity with negative coefficient direction. This negative coefficient shows that Kuznets curve hypothesis is consistent, which is the existence of non-linear relation (quadratic) between energy intensity and GDP per capita (Indra, 2009). In ASEAN,

only Singapore and Brunei have high income, while the remaining countries are classified in upper-middle class (Malaysia and Thailand), lower-middle (Indonesia, Myanmar, Philippine and Vietnam), and low-income country (Cambodia).

According to Indra (2009), countries like Indonesia, Filipina, Thailand and other middle or low income countries have not achieved a turning point. In other words, those countries are still in an intensive building phase in energy usage. The reason of this is that they still put an emphasis on infrastructure building such as road, railway, and other various public facilities. This process will result in high energy consumption per GDP value.

Energy consumption per capita variable significantly influences energy intensity with a positive coefficient direction. This means that an increase of energy consumption in ASEAN region will result in an increase of energy intensity. This is in line with the research conducted by Filipovi, Verbi, and Radovanovi (2015) which studies the relation of energy intensity and energy consumption per capita. Countries with high energy intensity and low energy consumption per capita have low income and inefficient energy, since the energy is used for extractive industries which consume much energy, but do not generate high GDP (Ramachandra et al., 2014). Most of ASEAN countries have lower middle income and high energy intensity value with low consumption per capita.

Oil price significantly influences energy intensity with negative coefficient. This means that an increase of oil price will decrease energy intensity in ASEAN region. According to Adom (2015), an increase of oil price will lead to a decrease of energy consumption in some communities with lower middle income. On the other hand, high earning communities will prefer encountering an increase of energy price by investing in goods with more efficient energy usage. This will eventually increase energy efficiency and decrease energy intensity.

Openness variable shows results inconsistent to the hypothesis. According to P. Todaro and C. Smith (2006), the good impacts of trade openness like transfer of efficient technology, economy, social do not always occur and conform to the existing development targets. Meanwhile, according to Cole (2006), the impacts of trade openness on energy intensity depend on whether the country imports or exports intensive energy products. Therefore, the final impacts of openness on trade depend on the relative weight of energy consuming export and energy efficient import.

Foreign direct investment variable shows results inconsistent to the hypothesis. This finding is in line with the research conducted by Hübler and Keller (2010) which investigates the impacts of foreign direct investment on energy intensity in 60 developing countries. The other finding of this research is an increase of energy efficiency in developing countries through FDI does not automatically occur and without a climate or energy policy.

FDI is likely to decrease energy intensity through transfer of technology, but is, on the other hand, likely to promote a shift toward more energy intensive production through a change in production sectorial composition. Besides, we cannot separate transfer of technology from sectorial composition effect (Zeeb, Maqsood, & Munir, 2015). In addition, according to Shah et al. (2015) who study the relation of FDI and energy consumption in ASEAN countries find that FDI will increase energy consumption in ASEAN region. This means that the existing FDI will only increase energy consumption, but not increase energy efficiency.

CONCLUSION

GDP per capita variable and energy price variable negatively influence energy intensity. Energy consumption per capita variable positively, significantly influences energy intensity. Meanwhile, trade openness and foreign direct investment (FDI) variables do not significantly influence a decrease of energy intensity. The stakeholders need to support and disseminate energy conservation policy. FDI policies which contain energy efficiency element need to be made, so that an increase of FDI will not only increase energy consumption but have no impact on energy efficiency. One point of Kyoto Protocol is the concept of clean development mechanism (CDM), explaining that FDI which carries transfer of technology, increase efficiency and reduce greenhouse gas effect must be supported. CDM provides option to developed countries to cooperate with developing countries in investment projects with a purpose to improve energy efficiency and reduce greenhouse gas. In addition, international trading process, both export and import, needs to consider management standard of energy efficiency element, such as standardization for energy efficiency management. This way, trade activities will play a role in reduction of energy intensity in ASEAN region.

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