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Article

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Building an Energy Consumption Model and Sustainable Economic Growth in Emerging Countries

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ABSTRACT

The research objective is to develop a model of consumption energy, using a model of simultaneous equations with two-stage least square method and some of the assumptions that economic progress will have an impact on increasing energy consumption. The study found several macroeconomic factors such as energy prices, gross domestic product, and exchange rates affecting the level of consumption energy. Whereas the increase in world oil prices and the reduction in the fuel subsidy budget by the government will have an impact on decreasing energy consumption in Indonesia. Forecasting analysis showed that overall energy consumption by all sectors tends to increase, except for biomass consumption by industry and total biomass consumption. In addition, it was also found that there was a small tendency for energy supply to offset the increase in energy consumption in the country.

Keywords: Energy, Consumption, Supply
JEL Classifications: E6, Q430, Q470, Q480

1. INTRODUCTION

Indonesia has become a net importer of petroleum, not only due to an increase in population, industrialization and limited investment, but also due to the government's failure to overcome the depletion of oil reserves through a policy of cheap energy prices by providing large subsidies. As a comparison, the gas retail price in 2018 is US $1.0 in Kenya, but only $0.35 in Indonesia.

The nature of the policy of cheap energy prices is growing more deeply in the oil market (energy), consumers are accustomed to receiving subsidized oil prices. The root of the problem here is: First, article 33 of the 1945 constitution states that all natural resources are controlled by the State and used by the government as much as possible for the benefit of the community as a whole.

The first interpretation of this law is that the energy market is controlled by the government, with the power of government intervention in the oil market. The low performance of the state-owned company PERTAMINA and guaranteed prices by the government reflect the failure of state intervention. Second, based the reason for the law is that the biggest market failure is found in the economic sector based on natural resource energy production. As a result, natural resource pricing policies are determined through government intervention, not controlled by market mechanisms. As a consequence, in general the energy market is an imperfect competition market (Alan, 2011; Kilian, 2012).

Based on Sugiyono (2004) the government controls by imposing fixed prices, on the contrary through the perfect competition market mechanism that is most expected by economists. Tambunan (2006) further stated that the policy of cheap energy prices to improve the welfare of the poor can only be implemented if the state has a surplus of income. Monopoly status in PERTAMINA, combined with cheap oil prices, has wider implications than public recognition. Creating consumption fossil energy is faster, so it will provide five impacts such as dependence on fossil energy, waste of fuel use on the community, inefficiency, failure in petroleum diversification, failure to attract investment in the downstream domestic oil industry.

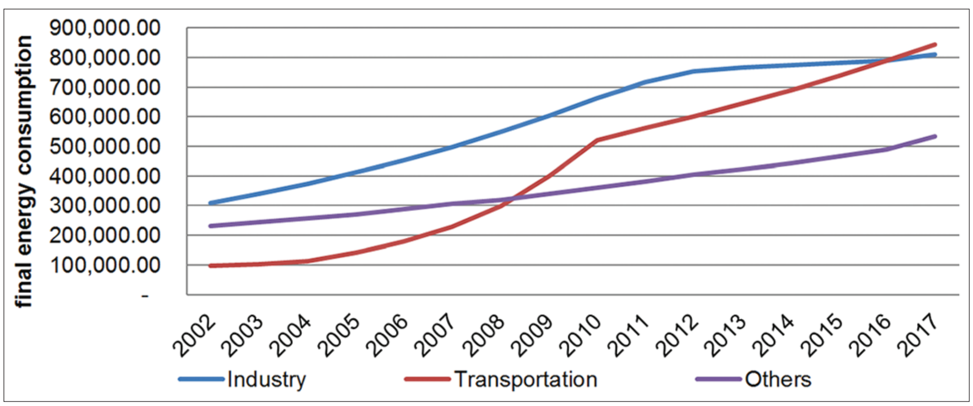
Figure 1, showed that the trend of final energy consumption is increasing. In the period 2002-2017 the economic sector with final energy consumption ranging from the highest to the lowest, respectively were the industrial sector, the transportation sector, other sectors and the agricultural sector. By looking at the rising gross domestic product (GDP) trend as in Figure 2 and comparing it to the trend of final energy consumption which is also increasing as Figure 1, it will strengthen the hypothesis that along with the development of the economy, the need for energy also increases.

So based on the above hypothesis, it is very important for Indonesia to pay attention to the problem of energy availability that is good for household consumption needs as well as for economic activities in the agriculture, mining, construction, transportation, processing industries and economic sectors others. In other words, a condition is always needed maintain a balance between economic growth and energy availability as one of the prerequisites for realizing more advanced economic development.

Looking at the latest developments in the energy sector in Indonesia, various problems are found in terms of consumption, and price. From the aspect of consumption and price, the main problem found is the relatively wasteful use of energy, shown by the level of elasticity of energy use compared to economic growth. The fact that there are poor people who have low purchasing power to meet their consumption is responded by the government by implementing a policy of cheap energy prices. Not only people who are not able to benefit from the implementation of this cheap energy pricing policy, the upper class people and the business world also enjoy it. In other words, the policies implemented by the government so far are one of the triggers of wasteful use of energy in Indonesia. Other negative impacts from the implementation of this cheap energy price policy also encouraged the rampant smuggling of fuel especially abroad. Although currently the government has raised fuel prices but is still lower than world oil prices, therefore the practices of smuggling abroad still occur.

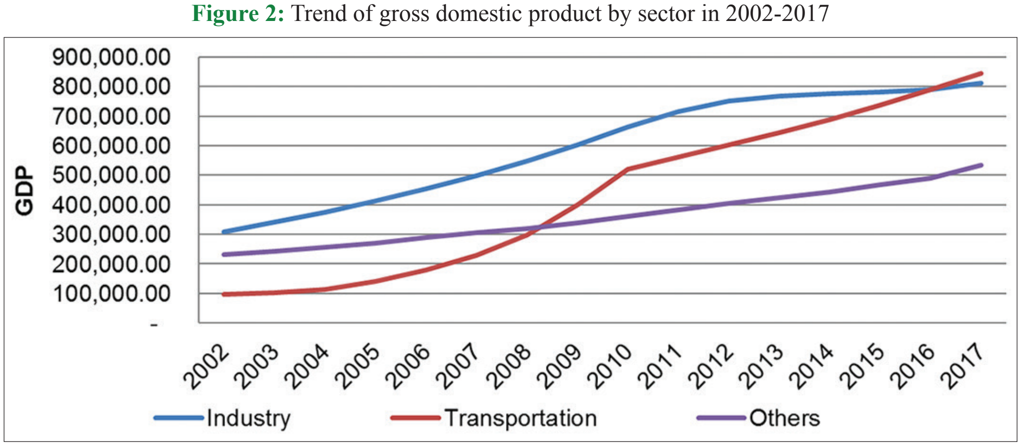
In terms of energy prices, energy prices in Indonesia are relatively cheap and have not yet reached their economic prices. Low energy prices in Indonesia due to energy prices are still subsidized by the government. According to Tambunan (2006), and Akhmad and Amir (2018) stated that the low price of fuel has a negative impact: (1) The high dependence on petroleum energy sources is indicated by the dominance of petroleum in a combination of domestic energy supply (energy mix). These low price signals are a disincentive to diversification and conservation (energy saving) businesses, (2) Fuel subsidies in the state budget threaten

Figure 1: Trend of consumption energy by sector in 2002-2017



Source: Central bureau of statistics of the republic of Indonesia (2018); ministry of energy and human resources of the republic of Indonesia (2017); and author (2018)

Figure 2: Trend of gross domestic product by sector in 2002-2017



Source: Central bureau of statistics of the republic of Indonesia (2018); and author (2018) the government's fiscal sustainability, (3) the non-optimal use of other energy sources, both fossil fuels such as natural gas and coal, whose reserves are far greater than oil and new and renewable energy, (4) the rampant fuel smuggling abroad so that the demand level is higher than the need real on transportation, industry and household sectors; (5) the number of fuel mixing activities which are detrimental to the state and general consumers; and (6) the price signal distorts the feasibility of investment in the downstream oil and gas sector.

Furthermore Hermawati et al. (2016); Singagerda et al. (2018) stated that there were two main problems faced in the aspect of energy supply, namely the limited technology of exploration of energy sources and investment. Due to limitations in the mastery of exploration technology, most of the oil exploration activities at Indonesia were carried out by a foreign oil company contractor with a production sharing contract (KPS) system with an 85% distribution scheme for the central government and 15% for contractors. This condition indicates that not entirely the results of oil exploration can be used for domestic needs, some of which are exported by contractors to obtain better income because of world oil prices that are higher than domestic prices.

Along with the increasingly scarce availability of fossil energy, because it is a non-renewable energy, today various countries in the world, including Indonesia, are again promoting the use of biomass energy as one of renewable energy (Abdmouleh et al., 2015). Biomass is all organic matter, derived from wood, plants, animal waste, and other organic sources, which can be used as an energy source. This is in line with the expression of Pandey et al. (2012), which states that biomass is all organic materials derived from plants and animals, industrial products and wastes cultivating agriculture, plantations, forestry, livestock and fisheries, which can be processed into bioenergy.

In general, energy is seen as an input factor in the world of processing industry, agriculture and other economic sectors. In aggregate, energy is always linked to activities population economy in pursuit of economic growth. Demand for energy in the future will still be affected by an increase in population, an increase in the number of economies (income per capita) and increase life mobility. It often occurs in developing countries, when energy efficiency is achieved, the efficiency results are still consumed by population growth (Momete, 2007).

Along with the pace of the domestic economy, energy consumption by various sectors tends to increase; this triggers an increase in energy prices. The development of the domestic economy, the dynamics of the world economy also tended to drive up domestic energy prices. Although a number of countries, including Indonesia, experienced an economic contraction due to the 2018 United States and China trade wars which impacted IDR depreciation on foreign currencies, especially the dollar by an average of 70%, Indonesia's fundamentals are still relatively stable (Zweig, 2018). In order to encourage the growth of the real sector, including in the energy sector, the Government of Indonesia imposes a tax incentive policy in order to increase investor interest in investing in Indonesia, especially in the energy sector.

Based on the description above, the problems to be raised in this study are the impact of economic policies and other external factors on energy consumption and supply in Indonesia as well as effective energy consumption and supply policies for the Indonesian economy. So from the problem, the main objective of this research is to build a model of energy consumption according to energy users and supply based on the type of energy in the Indonesian economy by using an energy balance approach to analyze the impact of economic policies and other external factors regarding energy consumption and supply in Indonesia and in the end it can formulate the implications of effective energy supply policies and efficient energy consumption in the Indonesian economy.

2. LITERATURE REVIEW

The role of energy in economic growth is clearly explained in an article written by Herring and Sorrell (2009); Stern and Kander (2012), Bhattacharya et al. (2016). In principle they explained about the important role of energy in driving a country's energy growth. The article written by Stern and Kander (2012) explained the relationship between energy and economic growth and explained the role of energy in economic production. When business and financial scientists pay significant attention to the impact of oil prices and other energy prices on economic activity, the growth theory of neoclassical economics does not pay close attention to the role of energy or natural energy sources in influencing economic growth. Resource and ecological economists criticize the theory, especially with regard to thermodynamic implications for economic production and economic prospects in the long run.

When alternative models explain that the growth process does not work in neoclassical economics, the results of empirical studies show the role of energy in the growth process (Stern and Kander, 2012). The main findings show that the energy use per unit of economic output decreases, but there is a large shift in energy from the direct use of fossil fuels like coal to the use of higher quality fuels, especially electricity (Armaroli and Balzani, 2007). When this shift occurs in the composition of the final energy use placed in the use of the energy balance and the level of economic activity found a double problem. When this and other trends are placed in the balance sheet, the prospect of reducing energy use in economic activity is limited (Stern and Cleveland, 2004).

Sugiyono (1999) built the Indonesian energy model with using two paradigms, namely the top-down model paradigm and the bottom-up model. The top-down model presents an analysis of macroeconomic behavior based on price and elasticity. The bottom-up model considers various technology options for energy supply and energy user sectors in terms of cost, fuel and emission characteristics. However, for the purposes of projecting demand and energy providers, using a combined top-down and bottom-up paradigm. Thus the purpose of this research is to make projections of energy demand and supply at Indonesia. This demand and energy supply projection is carried out for two economic conditions in Indonesia, namely before and after the economic crisis.

In addition, Sugiyono (2004) also wrote an article about changing the energy policy paradigm towards sustainable development.

This article was written with the background of energy resources used in Indonesia is the fossil energy (oil, natural gas, and coal) that is not a renewable energy and renewable (hydroelectric and geothermal) where the rate of discovery of energy reserves lower than the level energy consumption. If no new reserves are found, Indonesia becomes an oil importing country. Various policies have been implemented so far with an emphasis on intensification, diversification and conservation. In his research found the fact that the dependence on oil for the transportation sector was unavoidable. Thus, energy policy is currently not responsive to the vulnerability of oil supply and it can be said that Indonesia has now become an oil importing country.

Khan (2008) conducted a study using a regional and global approach to solve the problem of energy security and ecological imbalance, with the specific aim of China's energy security problems by building a model policy that relies on the creation of innovation systems capable of reducing energy dependence. China's economic growth depends on energy has become a major concern of policy makers in the country related to the economy and national security. China wanted to really try to create system innovations for their own needs on a large scale as part of a science-based economy in the future. Only with a reorientation strategy by building a POLIS model in order to meet their own needs.

Tubbs (2008) built a simulation model for energy supply and demand in Canada. Research by Tubbs (2008) was motivated by his desire to use multiple regression models and inter-regional trade models when evaluating climate policy in Canada. The integrated energy supply and demand model between Canada and the United States is very important for analyzing Canadian climate policy because the Canadian economy is very integrated with the United States economy. The conclusion of the Tubb's is that an appropriate energy economy model is needed in estimating the effectiveness and economic impact of public policies related to climate change. The main finding from Tubbs (2008) study states that future output in accordance with the energy sector will decrease when prices are set on emissions in Canada.

Meanwhile, Nondo et al. (2010) presented the relationship between energy consumption and energy growth for a number of countries in Africa. The background of this research by Nondo et al. (2010) was the fact that Sub-Saharan Africa is basically blessed with a number of natural energy resources such as wind, coal, oil, wood and sunlight, but this large amount of resources has not been exploited for decades. As a result, many African countries experience serious energy deficits due to poor investment in energy infrastructure. This study uses panel data to analyze the long-term relationship between energy consumption and GDP in 19 African countries based on annual data for the period 1980-2005. Short-term estimation results suggested that energy consumption and GDP move together in the long run, whereas in long-term estimation showed that short-term and long-term causal relationships are not in the same direction, moving from energy consumption to GDP. This implied that reducing energy consumption can cause a decline in economic growth.

Whereas Krichene (2005) developed a simultaneous equation model that links oil prices, changes in the nominal effective exchange rate of the US dollar, and interest rates, which then identifies monetary policy shocks to an increase in demand for crude oil. The findings of Krichene (2005) stated that the supply and demand of crude oil and natural gas for prices are very inelastic in the short term, meaning that there is a very high change/evaporation in the crude oil and natural gas market.

3. METHODOLOGY

This research is an explanatory research, using an econometric method (Koutsoyiannis, 1977; Intriligator et al., 1996). The variables to be used in this study include those related to world oil prices, exchange rates, interest rates, population, no of household, taxes, wages, and trends. The model built in this study is an econometric model in the form of simultaneous equations consisting of 2 equation blocks (energy consumption block, and economic output block), while the model estimation method uses two stage least squares because each structural equation over identified.

While the main data used is balance sheet data Indonesian energy sourced from the Republic of Indonesia's mineral resources ministry of energy. In addition to estimating the estimation coefficient and elasticity based on historical data, estimation of forecasting data is also conducted. Forecasting is carried out until 2025 with the consideration that the year is in accordance with the national energy policy design that is valid in 2025. From historical data and forecasting data then calculating the elasticity of energy use to determine the level of energy use efficiency based on historical data and the level of energy consumption efficiency future. In addition, simulations are also carried out on external shocks such as an increase in world oil prices, the exchange rate of the Rupiah is well-maintained, and the reduction in interest rates and fuel subsidies is the most predictable factor in energy consumption in relation to the dynamics of economic development in Indonesia.

3.1. Energy Consumption Block

Energy consumption block include sector energy consumption industry, household sector, transportation sector, agriculture sector and energy demand by other sectors. The industrial sector is the largest sector consuming energy and various types of energy (Bazilian and Onyeji, 2012; Resosudarmo et al., 2012). In contrast, the agricultural sector is the sector that consumes the least energy.

3.1.1. Industrial sector energy consumption

Energy consumption in the industrial sector is the sum of fuel consumption, electricity consumption, coal consumption, gas consumption and consumption of biomass in the industrial sector. The equation of the total energy consumption of the industrial sector can be formulated:

$$IDTOt=IDOLt+IDELt+IDCOt+IDGt+IDBIOt \quad (1)$$

Where:

IDTOt=Total energy consumption in the industrial sector (thousand BOE)

IDOLt=Industrial sector fuel consumption (Thousand BOE)
IDELt=Industrial sector electricity consumption (Thousand BOE)
IDCOt=Industrial sector coal consumption (Thousand BOE)
IDGt=Industrial sector natural gas consumption (Thousand BOE)
IDBIOt=Consumption of industrial sector biomass (Thousand BOE).

3.1.2. Energy consumption of the household sector

In addition to the industrial sector that needs energy, the household sector also needs energy (Resosudarmo et al., 2012). Energy is used by the household sector for lighting, cooling/heating, cooking, and others. Household sector energy consumption is the sum of fuel consumption, electricity consumption, gas consumption and consumption of the household sector biomass. The total equation for household energy consumption can be formulated:

$$RETOt=REOLt+REELt+REGt+REBIOt \quad (2)$$

Where:
RETOt=Total household energy consumption (Thousand BOE)
REOLt=Household sector fuel consumption (Thousand BOE)
REELt=Household sector electricity consumption (Thousand BOE)
REGt=Household sector gas consumption (Thousand BOE)
REBIOt=Household sector consumption of biomass (Thousand BOE).

3.1.3. Energy consumption in the transportation sector

Besides industry and households, the transportation sector also needs energy (Resosudarmo et al., 2012). The biggest energy consumed by the transportation sector is BBM (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2018). In addition, electricity and gas are also used by this sector. However, the consumption of electricity and gas used by the transportation sector is very small, resulting in a variable consumption of electricity and gas in the transportation sector as an exogenous variable.

While the total energy consumption in the transportation sector is the sum of fuel consumption in the transportation sector, electricity consumption and gas consumption in the transportation sector. The fuel consumption equation and the total energy consumption of the transportation sector can be formulated:

$$TROLT=TRRTOt+TROTTOt \quad (3)$$

$$TRTOt=TROLt+TRELt+TRGt \quad (4)$$

Where:
TROLt=Total fuel consumption in the transport sector (Thousand BOE)
TRTOt=Total energy consumption in the transport sector (Thousand BOE)
TRELt=Total electricity consumption in the transport sector (Thousand BOE)
TRGt=Total gas consumption in the transport sector (Thousand BOE).

3.1.4. Energy consumption of other sectors

Sectors that have not been mentioned in the previous section are included in other sectors, such as the commercial sector, service sector, trade and others (Resosudarmo et al., 2012). Other sectors also consume energy. Energy consumed by other sectors is fuel, electricity, gas and biomass energy.

The total energy consumption of other sectors is the sum of fuel, electricity, gas and biomass consumption by the sector. The total equation for energy consumption in other sectors can be formulated:

$$OCTOt=OCOLt+OCELt+OCGt+OCBIOt \quad (6)$$

Where:
OCTOt=Consumption of all types of energy by other sectors (Thousands of BOE).

3.1.5. Total energy consumption

Final consumption of all types of energy is total addition energy consumption in the industrial sector, total energy consumption in the household sector, total energy consumption in the transportation sector, total energy consumption in other sectors and consumption not for energy (Resosudarmo et al., 2012).

The total final consumption equation for all types of energy can be formulated:

$$FCTOt=IDTOt+RETOt+TRTOt+AGRTOt+OCTOt + NEUt \quad (7)$$

Where:
FCTOt=Total energy consumption of all sectors (Thousands of BOE)
NEUt=Non-energy consumption (Thousand BOE).

3.1.6. Block of economic output

This research begins with a general hypothesis which states that a country's economic progress will affect energy consumption. And energy consumption affects GDP, through GDP sector. Thus this study formulated GDP which affects consumption and energy supply both directly and indirectly and vice versa (Dartanto, 2013; Abdmouleh et al., 2015). So that the block of economic output equations consists of GDP equations in the form of sector identity and GDP equations in the form of structural equations.

3.2. Total GDP

Total GDP is the sum of all GDP sector, i.e. sum of GDP in the industrial, transportation, agriculture and other sectors.

The total GDP equation can be formulated:

$$GDPt=INDPt+TRPt+OCPt \quad (8)$$

Where:
GDPt=Constant GDP price (Rupiah Trillion)
INDPt=GDP in the industrial sector (Rupiah Trillion)
TRPt=GDP in the transportation sector (Rupiah Trillion)
OCPt=GDP in other sectors (Rupiah Trillion).

3.3. Industrial Sector GDP

GDP in the industrial sector is affected by the total energy consumption of the industrial sector, total government expenditure and the variable difference. Industrial sector GDP equation can be formulated:

INDPt =ai0+ai1IDTOt+ai2GEXPt+ah3INDPt-1+U35 (9)

Where:
INDPt=GDP in the industrial sector (Rupiah Trillion)
GEXPt=Total government expenditure (Rupiah Trillion)
INDPt-1=Industrial sector GDP Lag (Rupiah Trillion)

Expected expected parameter parameters: ai1, ai2>0 and 0<ai3<1.

3.4. Transportation Sector GDP

Transportation sector GDP is affected by the total energy consumption of the transportation sector, total government expenditure and variable measures (Resosudarmo et al., 2012; Dartanto, 2013). The transportation sector GDP equation can be formulated:

TRPt=aj0+aj1TRTOt+aj2GEXPt+aj3TRPt-1+U36 (10)

Where:
TRPt=GDP in the transportation sector (Rupiah Trillion)
TRPt-1=Transportation sector GDP lag (Rupiah Trillion)

Expected expected parameter parameters: aj1, aj2> and 0<aj3<0.

3.5. Other Sector GDP

GDP in other sectors is influenced by the total energy consumption of other sectors, total government expenditure and variable measures (Dartanto, 2013; Akhmad and Amir, 2018). The equation of GDP in the agricultural sector can be formulated:

OCPt=al0+al1OCTO+al2GEXP+al3OCPt-1+U38 (11)

Where:
OCPt=GDP in other sectors (Rupiah Trillion)
OCPt-1=GDP in other sectors (Rupiah Trillion)

Expected expected parameter parameters: al1, al2, al3>0

3.6. Government Expenditures

In addition to total and output sector equations, the equation of government expenditure needs to be formulated. Government expenditure equations are formed in identity equations that can be formulated:

GEXPt=GEXPNSt+GEXPSOLt+GEXPSNOLt (12)

Where:
GEXPt=Total government expenditure (Rupiah Trillion)
GEXPNSt=Non-subsidized government expenditure (IDR Trillion)
GEXPSOLt=Government expenditure for fuel subsidies (Rupiah Trillion)
GEXPSNOLt=Government expenditure on non-fuel subsidies (Rupiah Trillion),

3.7. Fuel Subsidy Expenditures

Fuel subsidy spending is government expenditure (Dartanto, 2013). Fuel subsidy expenditures are influenced by government revenues, the rupiah exchange rate against the US dollar in the previous year, the final consumption of BBM and the variable variations. The fuel subsidy expenditure equation can be formulated:

GEXPSOLt=am0+am1REVGOVt+am2EXCHt-1+am3FCOLt +am4GEXPSOLt-1+U39 (13)

Where:
GEXPSOLt=Government expenditure for fuel subsidies (Rupiah Trillion)
REVGOVt=Government revenue ((Rupiah Trillion)
EXCHt-1=Lag of rupiah exchange rate against US Dollar (Rp/USD)
GEXPSOLt-1=Lag of government spending on fuel subsidies

Expected parameter parameters: am1, am3>0; am2<0 and 0<am4<1.

3.8. Government Revenue

Government revenue is one of the factors that determine the existence of government spending on fuel subsidies (Resosudarmo et al., 2012). Therefore the equation of government revenue needs to be formulated. The equation of government revenue can be formulated:

REVGOVt =an0+an1DPDBt+an2TAXt+U40 (14)

Where:
REVGOVt=Government revenue (Rupiah Trillion)
DPDBt=GDP Increase (Rupiah Trillion)
TAX=Tax (Rupiah Trillion)

Expected parameter parameters: and 1, and 2>0.

The research also used policy simulation, where: (1) Increasing world oil prices by 10%, (2) The exchange rate of the rupiah against the US dollar rose by 5%, and (3) the reduction in fuel subsidy spending by 10%.

4. DISCUSSION

4.1. Energy Consumption

4.1.1. Industrial sector

The industrial sector is a sector in the Indonesian economy that consumes the most complete types of energy (Resosudarmo et al., 2012). To be able to carry out production activities, the industrial sector consumes fuel, electricity, coal, gas and biomass energy types. Of the five exogenous variables included in the fuel consumption equation in the industrial sector, only the difference in fuel consumption in the industrial sector is significant. The parameter value of the alleged change in the amount of fuel consumption in the industrial sector is 0.8050. This implies that if the industrial sector's fuel consumption in the previous year increased by 1000 BOE, the fuel consumption in the industrial sector for the current year would increase by 805 BOE. Meanwhile, variable fuel price differentials, gas price growth, electricity prices and industrial sector GDP growth have no effect statistically significant on the fuel consumption of the industrial sector.

In addition to BBM, the industrial sector also consumes electricity, coal, gas and biomass energy both partially and simultaneously depending on the type and needs of the industry. In other words, various types of energy used can be complementary or substitution. The results of parameter estimation and elasticity in the industrial sector electricity consumption equation (IDEL) revealed that as a whole the alleged parameter sign of exogenous variables as expected, but only the variable electricity consumption in the industrial sector is significantly different from zero in the electricity consumption of the industrial sector. This implied that if electricity consumption in the industrial sector last year tended to increase, the sector's electricity consumption industry will increase. Meanwhile, the variable price of electricity, fuel, gas, coal and GDP in the industrial sector has no statistically significant effect on the fuel consumption of the industrial sector.

The results of the study showed that the variable price of coal has a negative effect, while the variable price of electricity, GDP of the industrial sector, and the trend has a positive effect on coal consumption in the industrial sector. Electricity prices that have a positive effect on coal consumption in the industrial sector indicate that coal and electricity energy in the industrial sector are mutually substituted (Sugiyono, 2004).

In line with this, the results also showed that trend variables have a positive effect on coal consumption in the industrial sector at a significant level of 10%, indicating that coal consumption in other sectors has an increasing tendency. The elasticity value of coal consumption in the industrial sector against coal prices, electricity prices and trends greater than one (in absolute value) in the short term. This indicates that coal consumption in the industrial sector is responsive to changes in coal prices, electricity prices and trends (Bazilian and Onyeji, 2012). The elasticity value of industrial sector coal consumption to industrial sector GDP is 0.870 in the short term. This implies that if the industrial sector GDP increased 1% last year, the coal consumption in the industrial sector will increase by 0.870% in the short term. Thus it can be stated that coal consumption in the industrial sector is not responsive to changes in GDP in the industrial sector. Whereas in the results of the equation of gas consumption in the industrial sector it is known that the gas consumption variable the industrial sector has a positive influence on gas consumption in the industrial sector and is significantly different from the number at the real level of 10%. The parameter value of industrial sector gas consumption in the previous year was 0.6932, meaning that if the industrial sector's gas consumption increased the previous year, consumption industrial gas in the current year will increase.

The results showed that the consumption of biomass in the industrial sector was influenced by the variable price of fuel and the variable rate of consumption of biomass in the industrial sector at a significant level of 15% and 1% respectively. The elasticity of consumption of industrial sector biomass to fuel prices is −0.297 in the short term and −6.787 in the long run. This value indicates that the consumption of biomass in the industrial sector is not responsive to changes in fuel prices in the short term, but is responsive in the long run.

The total consumption of the five main types of energy by the industrial sector, namely fuel consumption, electricity, coal, gas, and biomass in this study are formulated in the identity equation. Mathematically the identity equation is written as follows:

$$IDTO=IDOL+IDEL+IDCO+IDG+IDBIO$$

This equation shows that if there is a disruption or a change in policy related to fuel consumption, consumption of electricity, coal, gas, and consumption of biomass by the industrial sector will affect the total energy consumption by the industrial sector (Dartanto, 2013; Akhmad, 2018). Furthermore, changes to the total energy consumption by this industrial sector will affect other endogenous variables both directly and indirectly.

4.1.2. Household sector

Meanwhile, for the Energy Consumption by the Household Sector, the results of parameter estimation and elasticity in the household fuel consumption equation (REOL) showed that the overall parameter estimates of exogenous variables are as expected. Variation in consumption of biomass in the household sector, the number of households and the lag of fuel consumption in the household sector is significantly different from zero at the real level of 10%. Meanwhile, variable fuel prices, gas price increases and electricity prices did not have a statistically significant effect on household consumption of fuel.

The household sector also consumes electricity, gas and biomass energy both partially and simultaneously depending on the needs of each household. In other words, according to Bazilian and Onyeji (2012) various types of energy used can be complementary or substitute. The results of the study found that household consumption of biomass in the household sector negatively affected household fuel consumption. If the consumption of biomass increases, the consumption of fuel will decrease. This shows that between fuel and biomass energy in the household sector can replace each other.

The elasticity value of fuel consumption in the household sector against the consumption of biomass in the household sector and the number of elastic households in the short and long term (Armaroli and Balzani, 2007). It showed that if there is a change in the consumption of biomass in the household sector and the number of households will provide a large influence on household fuel consumption. The result of parameter estimation and elasticity in the household electricity consumption equation (REEL) showed that all exogenous variables are included in the equation has a sign as expected and is significantly different from zero at least at a real level of 20%. The electricity price variable coefficient has a negative effect, while the variable GDP increase in total and the household electricity consumption lag has a positive effect on household electricity consumption.

The results of the study found that the elasticity value of household electricity consumption to electricity prices last year was 0.275 in the short term and 5.279 in the long run. This value means if last year's electricity price increased by 10%, the household sector electricity consumption fell by 2.75% in the short term and 52.79% in the long run. This indicated that electricity consumption in the household sector is not responsive to changes in electricity prices in the short term, but is responsive in the long run. Meanwhile, the elasticity value of household electricity consumption to GDP growth is <1 in the short and long term. This indicated that electricity consumption in the household sector is not responsive to changes in GDP growth both in the short and long term (Hermawati et al., 2016).

For parameter estimation results and elasticity equations of gas consumption in the household sector (REG) can be disclosed that the overall mark estimated parameters exogenous variables as expected. Variable gas prices are negative and variable electricity prices and lagged positive household gas consumption real with zero at the real level of 20% and 10%.

Furthermore, the results of parameter estimation and elasticity equation biomass consumption in the household sector (REBIO) indicated that biomass consumption of the household sector is affected by the coefficient of number of households and consumption of biomass in the household sector on the real level of 1%. The elasticity of consumption of biomass in the household sector to the variable of the number of households is inelastic in the short and long term. This indicates that the change in the number of households have little impact on the consumption of biomass in the household sector in the short and long term.

The total consumption of the four main types of energy by the household sector, namely fuel consumption, electricity, gas, and biomass in this study are formulated in the identity equation. Mathematically the identity equation is written as follows:

RETO=REOL+REEL+REG+REBIO

This equation showed that if there is a disruption or a change in policy related to fuel consumption, electricity consumption, gas consumption, and consumption of biomass by the household sector will affect the total energy consumption by the household sector. Furthermore, changes in consumption of the four main types of energy by the household sector will affect other endogenous variables, both directly and indirectly.

4.1.3. Transportation sector

The results of parameter estimation and elasticity on fuel consumption of ground transportation equation (TRRTO) showed variable lag the price of gas and fuel consumption of ground transportation positive effect on fuel consumption and land transportation were significantly different at the level of 10%. The price of gas has positive effected on road transport fuel consumption indicate that energy fuel and gas in the industrial sector are substitutes. It means that the elasticity of road transport fuel consumption of the gas price inelastic in the short term and long term, and also indicated that changes in gas prices have little impact on changes in road transport fuel consumption in the short and long term.

For parameter estimation results and elasticity to the equation other transport sector fuel consumption (TROTTO) can be revealed that the transport sector GDP variable positive effect on fuel consumption and different other transport was statistically significant at 15% real level. This indicates that the increase in the transportation sector's GDP will increase fuel consumption other transport. The elasticity of other transport fuel consumption to GDP transport sector is inelastic in the short term and long term.

For fuel consumption (TROL) and total sector energy consumption transportation (TRTO) is formulated in the identity equation. The total consumption of transportation fuels (TROL) is the sum of land transportation fuel consumption (TRRTO) with the consumption of other land transportation fuels (TROTTO). The total energy consumption of the transportation sector is the sum of the total fuel consumption, electricity consumption and gas consumption in the transportation sector. Mathematically this identity equation is written as follows:

TROLL=TRRTO+TROTTO

TRTO=TROLLEY+TREL+TRG

The equation identified that if there is a disruption or a change in policy related to fuel consumption by land transportation and other transportation will affect the total fuel consumption by the transportation sector. Furthermore, changes in fuel consumption by the transportation sector will affect other endogenous variables both directly and indirectly.

The availability of energy, particularly oil greatly affects the amount of land transport, both non-passenger land transports (privately owned motor vehicles and non-passenger motor vehicle, etc.) as well as passenger land transport (public transportation, minibuses and buses). Therefore it is important to look at the effect of the availability of fuel either directly or indirectly on the amount of land transport as the main means of transportation in community mobilization (Sugiyono, 1999; Momete, 2007; Herring and Sorrell, 2009). Whereas for the results of parameter estimation and elasticity in the equation of the number of non-passenger land transportation, it was found that the GDP variable in the land transportation sector and the lag in the number of non-passenger land transportation had a positive effect on the number of non-passenger land transportation, each at a real level below 10%. The elasticity of the number of non- passenger land transport sector to GDP for 0227–2596 for the short term and long term. The elasticity value means that when the transport sector's GDP increased by 10% the number of non-passenger road transport will increase by 2:27% in the short term and will increase by 25.96% in the long term. Therefore it can be stated that the number of non-passenger land transport are not responsive to changes in the transport sector GDP in the short term, but responsive to the long-term.

Meanwhile, the result of parameter estimation and elasticity in the equation of the number of passenger land transportation is known that the GDP variable in the transportation sector and the lag in the number of passenger land transportation have a positive effect on the amount of passenger land transportation at a real level below 10%. The elasticity value of the number of passenger land transportation to the transport sector GDP is 0.2929 for the short term and 1.6867 for the long term. The value of elasticity means that if the transportation sector's GDP increases by 10%, the number of passenger land transportation will increase by 2929% in the short term and will increase by 16,867% in the long run. Therefore it can be stated that the number of passenger land transportation is not responsive to changes in the GDP of the transportation sector for the short term (Nondo et al., 2010), but responsive to long-term.

The amount of land transportation is formulated in the form of identity equality. The amount of land transportation is the sum of the number of non-passenger land transportation (VEHICOM) and passenger land transportation (VEHIPAS). Mathematically this identity equation is written as follows:

VEHI=VEHICOM+VEHIPAS

This equation figure out that in the event of a disturbance or a change in policy relating to the number of non-passenger land transportation and the number of passenger land transportation will affect the amount of land transportation. Furthermore, changes to the amount of land transportation will affect other endogenous variables both directly and indirectly.

4.1.4. Other sectors

The results of parameter estimation and elasticity of other sector fuel consumption (OCOL) revealed that the overall parameter estimates of exogenous variables were as expected. Coal price variables and lags of other fuel consumption sectors have a significant positive effect on fuel consumption in other sectors and are significantly different at the real level of 20% and 1%.

The estimation found that the elasticity value of other sectors of fuel consumption on coal prices amounted to 2691 in the short term and 8183 in the long run. The value of elasticity means that if coal prices increase by 10%, the amount of fuel consumption in other sectors will increase by 26.91% in the short term and will increase by 81.83% in the long run. This indicates that fuel consumption in other sectors is responsive to changes in coal prices in the short and long term. Whereas for the results of parameter estimation and elasticity of other sector gas consumption (OCG) revealed that as a whole the estimated parameter parameters of exogenous variables are as expected. The variable gas price index negatively affects other sectors' gas consumption at a real level of 20% and other sector GDP variables have a positive effect on gas consumption in other sectors at a significant level of 10%.

The estimation results fond that the elasticity value of other sector gas consumption to the gas price index is −1812 in the short term and −2396 long-term. The value of elasticity means that if gas prices increase by 10% then the amount of gas consumption in other sectors will decrease by 18.12% in the short term and will decrease by 23.96% in the long run. This indicates that gas consumption by other sectors is responsive to changes in short-term and long-term gas prices. Whereas the results of parameter estimation and other sector electricity consumption elasticity (OCEL) explained that overall the parameter estimates of exogenous variables are as expected. Of the seven exogenous variables included in the electricity sector equation for the other sectors, only the electricity consumption lag variable in other sectors had a significant effect on electricity consumption in other sectors, which was significantly different from 0 at 1% real level.

Furthermore, the results of estimation of parameters and elasticity of consumption of biomass in other sectors. The estimation results show that the other sector GDP growth variables and other sector biomass consumption lags have a positive effect on consumption of other sector biomass at 1% level. The results also showed that the elasticity of the other sectors of biomass consumption to GDP growth in other sectors by 0017 and 0061 in the short term over the long term. Value has a meaning if GDP in other sectors increases by 10%, consumption of biomass will increase by 0.17% in the short term and 0.61% in the long run.

In the equation for total energy consumption in other sectors (OCTO) which is expressed as an identity equation, which is the sum of fuel consumption, gas consumption, electricity consumption, and consumption of biomass in other sectors. Mathematically this identity equation is written as follows:

OCTO=OCOL+OCG+OCEL+OCBIO

This equation showed that if there is a disruption or a change in policy related to fuel consumption, electricity consumption, gas consumption, and consumption of biomass in other sectors will affect the total energy consumption of other sectors (Dartanto, 2012; Bhattacharya et al., 2016). Furthermore, changes to the total energy consumption by other sectors will affect other endogenous variables both directly and indirectly.

4.1.5. Total consumption

As mentioned earlier, the analysis in this study was conducted by dividing the energy consumption by sector and type of energy refers to the availability of data and the purpose of the research is expected. According to the sector, energy consumption is divided into five sectors, namely energy consumption by the industrial sector, the household sector, the transportation sector, and other sectors. Meanwhile, the types of energy analyzed include BBM, electricity, coal, gas and biomass. The equation of total energy consumption of all sectors (FCTO), total BBM consumption (FCOL), total electricity consumption (FCEL), total coal consumption (FCCO), total gas consumption (FCG), and total consumption of biomass (FC_BIO) formulated in the identity equation. Mathematically, the equation written as follows:

FCTO=IDTO+RETO+TRTO+AGRTO+OCTO+NEU

FCOL=IDOL+TROTO+REOL+AGR_OL+OCOL+NEU

FCEL=IDEL+REEL+TREL+OCEL

FCCO =IDCO

FCG= IDG+REG+TRG+OCG

FCBIO=IDBIO+REBIO+OCBIO

Based on Indonesia's energy data published by the Ministry of Energy and Mineral Resources (MEMR), all sectors consume fuel, namely the industrial sector, the transportation sector, the household sector, the agricultural sector, and other sectors, and non-oil consumption sectors (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2018). For sectors that consume electricity and gas, include the industrial sector, the household sector, the transportation sector, and other sectors, while the data on electricity and gas consumption by the agricultural sector is not yet available.

Furthermore, for sectors that consume coal, Indonesia's energy balance is only recorded in the industrial sector. In other words, total coal consumption equals total coal consumption by the industrial sector. To obtain the relationship between the simultaneous equations, the equation for total biomass consumption is formulated as the sum of consumption biomass industry, biomass consumption household sector, and other sectors of biomass consumption.

4.2. Output in Economy Indonesia

As explained in the formulation of the problem and the framework of research that this study departs from the general hypothesis that economic progress (economic output) affect the consumption and supply of energy, and vice versa. Therefore, in this study defined the factors that affect the GDP are all factors influencing consumption and energy supply, on the contrary the factors that influence energy consumption and supply also affect GDP (Stern and Kander, 2012). In this study GDP consists of industrial sector GDP (INDP), transportation sector GDP (TRP), and other sector GDP (OCP).

The results of parameter estimation and GDP elasticity of the industrial sector found that the GDP lag variable in the industrial sector had a positive effect on GDP in the industrial sector and was significantly different from zero to the real level of 1%. This indicates that if the GDP in the industrial sector in the previous year tends to increase, it will cause GDP in the industrial sector to increase.

While the results of parameter estimation and GDP elasticity of the transportation sector (TRP) stated that the transportation sector's total energy consumption variable in the previous year, total government expenditure and the GDP lag of the transportation sector has a positive effect on GDP in the transportation sector and significantly different from zero to the real level of 10%. This indicated that if the transportation sector's total energy consumption in the previous year, total government expenditure and industrial sector GDP in the previous year tended to increase, transportation sector GDP increased (Stern and Kander, 2012; Singagerda et al., 2018).

The GDP elasticity value of the transportation sector to the total energy consumption of the transportation sector last year was 0.426 in the short term and 1,255 in the long run. The value of elasticity means that if the total consumption of the transportation sector in the previous year increased by 1%, the transportation sector GDP will increase 0.426% for the short term and 1.255% in the long run. Thus it can be stated that the transportation sector GDP is not responsive to changes in the total energy consumption of the transportation sector in the previous year in the short term, but responsive in the long run. In contrast, the transportation sector GDP is not responsive to changes in total government spending in the short, and long-term.

The results of parameter estimation and GDP elasticity of other sectors can be seen that the variables of government expenditure and other sector GDP in the previous year had a positive effect on GDP in other sectors and were significantly different from zero at the real level of 10%. This indicates that if the total government expenditure and other sector GDP in the previous year increases, the GDP of the agricultural sector will increase. The GDP elasticity value of other sectors for government expenditure is 0.279 in the short term and 0.903 in the long run. The value of elasticity means that if government expenditure increases by 1%, the GDP of other sectors will increase 0.279% in the short term and 0.903% in the long run. Thus it can be stated that GDP in other sectors is not responsive to changes in government spending in the short and long term. Against total GDP is formulated in the form of identity equality. Likewise, the total government expenditure (GEXP) is formulated in the form of identity equality. Total GDP is the sum of industrial sector GDP, transportation sector GDP, agricultural sector GDP and other sectors GDP.

Total government expenditure is the sum of non-subsidized government expenditure (GEXPNS), government expenditure on fuel subsidies (GEXPSOL), and government expenditure for non-BBM subsidies (GEXPSNOL). Mathematically the two identity equations are stated as follows:

GDP=INDP+TRP+AGRP+OCP

GEXP=GEXPNS+GEXPSOL+GEXPSNOL

Based on these identity equations it can be stated that if there is a disturbance or a policy change that is related to the exogenous variables in the two identity equations it will affect the total GDP variable and the total government expenditure variable. Furthermore, changes in total GDP and total government expenditure will affect other endogenous variables, both directly and indirectly.

The results of parameter estimation and elasticity of fuel subsidy expenditure indicate that variables are government revenue and the total final consumption of BBM has a positive effect on fuel subsidy expenditure and is significantly different from zero at the real level of 10% and 15%. This indicates that if government revenues and total fuel consumption increase, the fuel subsidy expenditure will increase.

The estimation results also showed that the value of the elasticity of fuel subsidy expenditure on government revenues is 0.683 in the short term and 0.766 in the long run. Meanwhile, the value of elasticity of fuel subsidy expenditures on total fuel consumption is 1,711 in the short term and 1,919 in the long run. From this value the elasticity of the expenditure of inelastic fuel subsidies on government revenues in the short and long term, but elastic to the total final consumption of BBM in the short and long term. Changes to government revenues have little impact on fuel subsidy spending in the short and long term (Tubbs, 2012; Hermawati et al., 2016), whereas the change in the total final consumption of BBM has a major impact on fuel subsidy spending in the short and long term.

The results of parameter estimation and elasticity of government revenue indicated that the variable increase in total GDP and tax has a positive effect on government revenues and is significantly different from zero at the real level of 10% and 1%. This indicates that if the increase in GDP and taxes increases, government revenues will increase. The analysis results shown in the estimation show that the elasticity value of government revenue to GDP increases is 0.027 in the short term. Meanwhile, the value of elasticity of government revenues to taxes is 0.964 in the short term. The value of elasticity means that if the increase in total GDP and taxes increases by 10%, government revenues will increase by 0.27% and 9.64%. This indicates that government revenues are not responsive to changes in GDP growth and taxes.

4.3. Impact of Economic Policies and Changes in External Factors on Energy Consumption in Indonesia

To see the impact of economic policies and external shocks on energy consumption in the Indonesian economy, a simulation analysis was carried out. The results of simulation of impact of alternative economic policy and external factors change on consumption energy in Indonesian economy can be seen in Table 1 as follows:

4.4. Impact of the Increase in World Oil Prices

As presented in Table 1 showed that the increase in oil prices of 10% would have an impact on the increase in fuel prices and electricity prices respectively by 0.1897% and 0.0019%. While the increase in fuel and electricity prices have an impact on decreasing consumption of all types of energy industry sectors except the industrial sector gas consumption. The increase in gas consumption by the industrial sector was 0,0004% due to gas energy being fuel-substituted energy for the industrial sector, so that the increase in world oil prices caused the industrial sector's fuel consumption to decline and industrial gas consumption to increase.

Simulations of the increase in world oil prices also impacted decreasing consumption of fuel and gas in the household, transportation and consumption sectors in other sectors, except electricity consumption and household biomass, consumption of biomass in other sectors and fuel consumption in the agricultural sector. The increase in electricity and gas consumption in the household sector was 0.0285% and 0.0013% respectively. This is caused by the fuel energy used by the household sector can be replaced by electricity and biomass, so that the increase in world oil prices has a positive impact on electricity consumption and household biomass. The same thing happened on consumption of biomass in other sectors. When considered by type of energy, this simulated impact on the decrease in the total consumption of fuel, electricity, coal, gas and biomass, respectively for 0.0326%, 0.0004%, 0.0034%, 0.0014% and 0.0597%.

Directly or indirectly, this simulation has an impact on the Indonesian economy, where GDP in the industrial, agricultural and other sectors decreased by 0.0055%, 0.0133%, 0.0328% respectively, so that total GDP declined. In contrast, the transportation sector has not changed. This occurs because the GDP of the transportation sector is elastic to the total energy consumption of the transportation sector (ELR = 1,255). If total energy consumption decreases by 1%, GDP will decrease by 1.255%. Meanwhile, the increase in world oil prices by 10% had an impact on the total energy consumption of the transportation sector by 0.0098 (smaller than 1%), so that the increase in world oil prices could be eliminated by the energy consumption of the transportation sector.

In addition to GDP sector which has decreased due to the increase in world oil prices by 10%, government revenues also decreased by 0.0046%. This is caused by a decrease in total GDP by 0.0059%. The total government expenditure and government expenditure on fuel subsidies also decreased by 0.0172% and

Table 1: Alternative impacts of economic policy and changes in external factors on energy consumption in the Indonesian economy

Variables	Unit	Baseline	Percentage of changes		
			Simulation 1	Simulation 2	Simulation 3
Total energy consumption in the industrial sector	Thousand BOE	14406746	−0.0064	0.0007	−0.0001
Total energy consumption of the household sector	Thousand BOE	931544	−0.0189	0.0032	−0.0006
Total consumption of the transportation sector	Thousand BOE	1362652	−0.0098	0.0025	−0.0007
Total consumption of other sector	Thousand BOE	143030	−0.0231	0.0035	−0.0007
Total final energy consumption	Thousand BOE	16981321	−0.0074	0.0010	−0.0002
Total GDP	Thousand BOE	28633.30	−0.0059	0.0024	−0.0003
Industrial sector GDP	Thousand BOE	27079.90	−0.0055	0.0011	0.0000
Transportation sector GDP	Thousand BOE	494.30	0.0000	0.0202	0.0000
Other sector GDP	Thousand BOE	305.00	−0.0328	0.0000	0.0000
Total government expenditures	Thousand BOE	974683.00	−0.0172	0.0381	−0.0062
Fuel subsidy expenditures	Thousand BOE	531398.00	−0.0316	0.0698	−10.00
Government revenue	Thousand BOE	869989.00	−0.0046	0.0008	−0.0001

Source: Ministry of energy and resources republic of Indonesia (2018); author (2018). Simulation 1: World oil prices rise 10%. Simulation 2: The appreciation of the rupiah against the US Dollar 5%. Simulation 3: The fuel subsidy spending fell 10%. BOE: Barrel of equivalent, GDP: Gross domestic product

0.0316% respectively. This decline occurred due to a decrease in total consumption final energy and government revenue. From the description above it can be concluded that the increase in world oil prices by 10% has a negative impact on total final consumption, the transformation of electricity and gas energy, and the supply of energy. But the increase in world oil prices has a positive impact on providing energy from the aspect of fuel supply.

4.5. The Impact of Appreciation of the Rupiah Exchange Rate against the US Dollar

The 5% appreciation of the rupiah exchange rate against US Dollar will have an impact on increasing sector of energy consumption in general. In addition, this simulation has an impact on increasing energy transformation and energy supply in Indonesia.

In Table 1 showed that the appreciation of the rupiah exchange rate against the US Dollar has an impact on the increase in coal, gas prices and biomass price index. However, this simulation has an impact on the decline in fuel and electricity prices in a row by 0.0155% and 0.0009%. Although the prices of coal, gas and the biomass price index have increased, while prices Fuel and electricity declined, in total energy prices in Indonesia decreased by 0.008%. The total decline in domestic energy prices has an impact on increasing sector of energy consumption, including total energy consumption in the industrial, household, transportation and other sectors with an increase below 0.004%.

Based on Tambunan (2006), and Singagerda et al. (2018), the appreciation of the rupiah exchange rate against the US Dollar also had an impact on the Indonesian economy. The GDP of the industrial sector and transportation has increased, except for the GDP of other sectors that have not changed. The increase in l GDP sector in general causes total GDP to also increase. In addition, total government expenditures, fuel subsidy expenditures and government revenues also increased by 0.0381%, 0.0698% and 0.0008% respectively. This happened because the appreciation of the exchange rate affects the increase in GDP. Increased GDP has an impact on increasing government revenues. Increased government revenues have an impact on increasing fuel subsidy spending. Increased spending on fuel subsidies has an impact on increasing total government spending.

4.6. Impact of Decreasing Fuel Subsidy Expenditures

The simulation results of a 10% reduction in the fuel subsidy policy show the impact of changes in energy consumption in the Indonesian economy. The reduction in fuel subsidy spending has a negative impact on total government spending and energy consumption of all sectors of the economy. The negative impact caused by the reduction in fuel subsidy spending by 10% is smaller than the impact caused by the increase in world oil prices by 10%.

The decline in energy consumption in Indonesia has an impact on the decline in total GDP by 0.0003%, but GDP sector (GDP of the industrial, transportation, agriculture and other sectors) has not changed. This happens because the negative impact caused by the decrease in spending on subsidies is eliminated by total government expenditure, so GDP sector does not change. Thus the reduction in fuel subsidies did not have an impact on the decline in GDP sector.

Directly or indirectly, alternative policies to reduce fuel subsidies have an impact on the supply of energy in Indonesia. In Table 1 this simulation has an impact on decreasing the supply of domestic fuel, coal and gas by 0.0013%, 0.0002% and 0.0001% respectively.

4.7. Forecasting Consumption Energy in Indonesian Economy 2018-2025

Forecasting the consumption of energy in the Indonesian economy needs to be done to obtain an overview of future conditions so that it is useful in planning and developing Indonesia's energy economy. Forecasting is carried out from 2009 until 2025. The forecasting limit for 2025 refers to the Indonesian Energy Development Print (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2008) which has been compiled up to 2025. The results of forecasting endogenous variables are presented in Table 2.

From the results of forecasting consumption of energy in the Indonesian economy as presented in Table 2 it can be seen that the development of the total energy consumption of the industrial sector from 2018 to 2025 tends to increase. In 2018 the total energy consumption of the industrial sector reached 14 352 519.28 million BOE and in 2025 reached 16 011.22 million BOE, with an average growth rate of 1:39 per cent. In terms of the types of energy consumed by the industrial sector, the consumption of electricity, coal and gas is likely to increase in a row for 16:39%, 12:21% and 9:57%. In contrast, fuel and biomass consumption tended to decline by 5.70% and 1.07%. This is presumably because fuel prices tend to increase, and the availability of biomass energy is increasingly limited.

Furthermore, from Table 2, it can be seen that the development of total household energy consumption from 2018 to 2025 tends to increase. In 2018 the total energy consumption of the household sector reached 895.93 million BOE and in 2025 it reached 1 029.98 million BOE, with an average growth rate of 2.76%. When viewed from the type of energy consumed by the household, fuel, electricity, gas and biomass sectors, it tends to increase. This happened because of an increase in population which led to an increase in the number of households. The increase in the number of households has led to an increase in energy consumption (Dartanto, 2013). Gas consumption is the largest energy consumption of the household sector compared to other types of energy. This is because gas for households is still subsidized by the government.

Meanwhile, the total energy consumption of the transportation sector has increased with a growth rate of 16.17% consisting of consumption of fuel, electricity and gas. Fuel consumption is the largest energy consumption consumed by the industrial sector. When compared with other sectors, the transportation sector is the sector that consumes the most energy. The trend of increasing energy consumption in the transportation sector is due to the increase in fuel consumption in the transportation sector.

Table 2: Forecasting results of energy consumption without policy alternatives 2018–2025

Variable	Unit	2018	2025	Percentage of growth
Total energy consumption in the industrial sector\	Thousand BOE	14352519.28	16011220.17	1.39
Total energy consumption in the household sector	Thousand BOE	895926.63	1029982.91	2.76
Total energy consumption for transportation sector	Thousand BOE	982519.22	5075891.50	16.17
Total energy consumption for other sector	Thousand BOE	137155.82	389405.77	9.28
Total fuel consumption	Thousand BOE	1459587.51	5178902.84	12.25
Total electricity consumption	Thousand BOE	234353.46	549603.98	7.56
Total coal consumption	Thousand BOE	12795546.81	12380065.29	0.21
Total gas consumption	Thousand BOE	1714448.48	4503938.65	9.98
Total biomass consumption	Thousand BOE	307414.21	229961.18	−1.85
Total final energy consumption	Thousand BOE	16511350.47	22842471.94	3.14
Total GDP	Rupiah Trillion	27767.32	48075.55	5.60
GDP of Industrial sector	Rupiah Trillion	26083.11	41607.63	5.02
GDP of transportation sector	Rupiah Trillion	370.03	3037.64	19.20
GDP of other sectors	Rupiah Trillion	355.79	1136.17	10.09
Total government spending	Rupiah Trillion	1243396.51	2749933.28	6.63
Government spending for fuel subsidize	Rupiah Trillion	458778.61	1494029.99	10.88
Government income	Rupiah Trillion	1268620.82	1370168.92	0.33

Source: Ministry of energy and resources republic of Indonesia (2018); author (2018). BOE: Barrel of equivalent

Other sector fuel consumption also tends to increase, namely 10.79%. Not only fuel consumption in other sectors which tend to increase, the consumption of electricity, gas and biomass in other sectors also tends to increase, respectively by 1.20%, 1.01% and 1.94%, resulting in total energy consumption other sectors increased by 9.28%. With increasing consumption in all sectors, the total final energy consumption tends to increase. In the period 2018-2015, the average growth in total final energy consumption was 3.14%. This positive growth in total final consumption of energy is an accumulation of total final consumption of all types of energy which have a tendency to increase, except for the total consumption of biomass. The average growth in total final consumption of fuel, electricity, coal and gas was respectively 12.25%, 7.56%, 0.21% and 9.98%. In contrast, the total consumption of biomass decreased by 1.85%. This shows that in the Indonesian economy biomass energy has not had a large influence on the national energy market. Even though it's energy biomass is needed as diversification, efficiency and energy conservation. This is due to the limited availability of biomass energy.

Along with the increase in energy consumption will encourage an increase in GDP sector and total GDP. From Table 2 the forecasting results show that the GDP of the industrial, transportation and other sectors tends to increase in a row with growth of 5.02%, 19.20% and 10.09%. Increased GDP sector will increase total GDP. Total GDP tends to increase with growth of 5.60%.

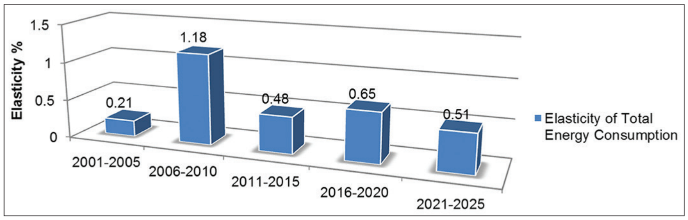
The trend of an increase in the amount of energy consumption and the Indonesian economy is also strongly influenced by a number of socio-economic indicators, including the exchange rate of the Rupiah against the US Dollar, interest rates, wages, taxes, population and number of households. The exchange rate of the Rupiah against the US Dollar tends to weaken, with an average growth rate of 7.63% (Bank of Indonesia, 2017). The weakening of the rupiah exchange rate has led to an increase in imports of crude oil, fuel and gas. On the other hand, bank nominal interest rates tended to decline, with an average growth rate of 7.04% (Bank of Indonesia, 2017). The interest rate cut provides improved investment climate in economic development, including efforts to improve energy supply in Indonesia.

Other economic indicators such as wages and taxes can be seen in the Appendix. From the Appendix, the wages of the mining sector tend to increase with a growth rate of 3.86%. In contrast, other sectors declined with a growth rate of 21.39%. Meanwhile, taxes have a tendency to increase. In the Appendix showed that taxes tend to increase with a growth rate of 3.58%. With increasing taxes, it will increase government revenues. From Table 2 showed that government revenues increase with a growth rate of 0.62%. The population and number of household members tend to increase with an average growth of 1.07% and 1.61%. Taxes and wages in the mining sector tend to increase with an average growth of 3.58% and 3.86%. In contrast, the sector others tend to decline with an average growth of 21.39%.

As explained before, the indicator used to calculate energy efficiency is the energy consumption indicator. Energy use elasticity is defined as the ratio between the growth of final energy consumption and the growth of gross domestic product (GDP). Energy use elasticity is said to be efficient if the energy consumption elasticity value is equal to one. Whereas value usage elasticity greater than one is said to be inefficient (Ministry of Energy and Mineral Resources, 2018; Yusgiantoro, 2000). In this section, a discussion about energy efficiency uses indicators of energy use elasticity. The energy use elasticity displayed is a five-year period of energy use elasticity using historical data from 1990-2017 and forecasting data for 2018-2025 based on the model built.

Figure 3 indicated that in the period 2001-2005 there has been a saving of energy, the opposite happened in the 2006-2010 period where the inefficient use of energy due to the global economic crisis that had occurred in 2008 and its impact felt in in 2009. The value of the elasticity of energy consumption in 2006-2010 is 1.18, whereas it meant an increase in GDP of 1% would increase total energy consumption by 1:18%. The inefficient use of energy during this period led to an average GDP increase was smaller than the

Figure 3: The development of the average elasticity of total energy consumption



Source: Ministry of Energy and Resources Republic of Indonesia (2018); author (2018)

increase of energy consumption, so that the average elasticity of energy during this period is greater than one (inefficiency).

In the next period the value of energy consumption elasticity for the period of 2011-2015, 2016-2020 and 2021-2025 is smaller than one, which is equal to 048, 0.65 and 0.51. The elasticity value means an increase in GDP of 1% will increase total energy consumption in a row by 048%, 0.65% and 0.51%. This indicates that the total energy consumption for the period 2011-2015, 2016-2020 and 2021-2025 is efficient. In addition, there is also a reduction program energy subsidies are gradually being implemented by the government and the development of various types of equipment and technologies that are energy efficient machine encourages the use of more energy efficient.

Looking at the fact data, the results of the analysis that has been carried out and the results of other empirical studies, there are two aspects that need to be considered in order to realize Indonesia's energy security in the future. The first aspect is the relatively inefficient use of energy. Although the average energy consumption value in the future is smaller than one (efficient), but the elasticity value is close to one. As time goes on, energy consumption tends to increase because the population increases and energy needs in the implementation of development increase. Therefore various efforts through the application of appropriate strategies to realize energy savings by various sectors of users need to be formulated.

Another aspect is the supply of energy, especially fossil energy reserves, as un-renewable resources, the availability of which is increasingly limited shown by energy prices, especially oil which tends to increase (Armaroli and Balzani, 2007; Badan Pengkajian dan Penerapan Teknologi [BPPT], 2017; Abdmouleh et al., 2015). In the future the availability of fossil energy will run out, so that the utilization of energy sourced from renewable resources is a choice that must be made. As an agricultural country with a tropical climate, Indonesia is rich in renewable resources, such as energy use of water, wind, biomass, biodiesel, biogas and other sustainable energy sources (Sugiyono, 2004). By implementing the right and aligned strategy from these two aspects, it is believed that Indonesia will be able to realize energy security, namely by implementing a sustainable energy strategy.

The energy saving strategy aims to reduce energy use. Thus Tubbs (2008) stated that with energy savings as if Indonesia has found new energy sources. If Indonesia can save fuel consumption by around 10%, it means finding a new oil field that can produce around 150,000 barrels per day, which in fact requires a large amount of money in produce it. Energy savings seen from energy user sources include savings on the demand side and on the supply side. Energy savings can also be seen in terms of the application of technology including the replacement of technology with more efficient and environmentally friendly technologies, the addition of technology (retrofitting) to production units so that it works more efficiently (BPPT, 2017).

From the user side, energy saving opportunities can be carried out through the use, operation and maintenance of tools and machines efficiently by each user. According to BPPT (2017) the savings opportunities made are different for each sector of energy users. The biggest opportunity for savings is in the commercial and household sectors, and the smallest is in other sectors. It happened because of the sector households (and also the commercial sector) as direct consumers of energy that can reduce energy use directly. In the industrial and transportation sectors related to the use of tools and machinery, the savings opportunities are relatively limited.

As previously explained, energy savings can also be done from the demand side, also can be done from the supply side (Tubbs, 2008). From the provider side, energy savings can be done in at least three ways. First, data collection and compilation of accurate information systems by type of energy and users by a unit or task force. The data and information can be used to monitor and provide information, guidance and consultation to the industry about the possibility of implementing more efficient technologies for certain types of industries. Second, building and implementing efficient energy transformation and distribution technologies so as to reduce leakage. Savings through the application of transformation technology for example more use of water inputs for electricity generation. Meanwhile, savings through the implementation of an efficient distribution system according to BPPT (2017) for example by developing a wider natural gas network both from its natural gas source and the area supplied to reach industrial areas in Sumatra, Java and Kalimantan. And third, implementing the right energy utilization strategy, through applying the right energy utilization strategy by looking at availability fossil energy and the potential for alternative energy development can be formulated other efforts in energy saving from the supply side.

As time goes on, energy consumption tends to increase because the population increases and energy needs in the implementation of development increase. Meanwhile, fossil energy reserves, as un-renewable resources, are increasingly limited availability shown by energy prices, especially oil prices which tend to increase (Bhattacharya et al., 2016). Given the depletion of fossil energy reserves, especially oil, various efforts need to be made by the Indonesian government in the run short, medium and long term (Resosudarmo et al., 2012; BPPT; 2017). In the short term, various efforts needs to be done in connection with efforts to increase the productivity of energy use, among others, by converting kerosene to gas for households, and reducing fuel subsidies. In addition, a stable rupiah exchange rate policy needs to be taken to counteract the negative impact of rising world oil prices that can energy supply decreases.

In the long term, efforts to shift energy use sourced from un-renewable resources to energy use are of a nature renewable resources, such as energy use of water, wind, biofuels (biomass, biodiesel, biogas and others), and other sustainable energy sources. According to Armaroli and Balzani (2017), a number of types of alternative energy have been developed, but their utilization is not optimal because the production costs are still high so the price is more expensive than the price of fossil energy.

5. CONCLUSION

Based on the results of the study it can be concluded that the sector's energy consumption is one of the dominant factors affecting energy consumption and supply in Indonesia where energy consumption and supply in the industrial sector is influenced by coal prices, electricity prices, fuel prices, industrial sector GDP, sector trends and energy consumption the previous year industry. Energy consumption in the industrial sector is responsive to changes in coal prices, electricity prices and trends in the short term and responsive to changes in fuel prices in the long run.

Meanwhile, household energy consumption is affected by electricity prices, gas prices, household sector biomass consumption, GDP, population, number of households and household sector energy consumption the previous year. The household sector's energy consumption is responsive to changes in gas prices and GDP in the long term, and is responsive to changes in electricity prices, household sector biomass consumption, population and number of households in the short and long term.

The energy consumption of the transportation sector is influenced by gas prices and the GDP of the transportation sector and the energy consumption of the transportation sector in the previous year. Energy consumption in the transportation sector is responsive to changes in the GDP of the transportation sector in the long run. While other sectors 'energy consumption is influenced by gas prices, coal prices, GDP of other sectors and other sectors' energy consumption the previous year. Other sectors' energy consumption is responsive to gas and coal prices in the short and long term.

The GDP of the industrial sector was influenced by the GDP of the industrial sector the previous year. The GDP of the transportation sector is influenced by the total energy consumption of the transportation sector, total government expenditure and sector GDP transportation the previous year. The GDP of the transportation sector is responsive to changes in the total energy consumption of the transportation sector in the long run. The GDP of other sectors is affected by total government expenditure. The GDP of other sectors is affected by total government spending. GDP in other sectors is not responsive to changes in total government spending in the short and long term.

The effective policy that encourages consumption of energy is the policy of appreciation of the rupiah exchange rate against the US Dollar. The appreciation of the rupiah exchange rate against the US Dollar was able to reduce the negative impact caused by the increase in world oil prices. In the future, overall energy consumption of all sectors tends to increase, except for the total consumption of biomass. Increased consumption the biggest energy is total fuel consumption. In line with that, the supply of fossil energy tends to increase. As time goes on, energy consumption tends to increase because the population increases and energy needs in the implementation of development increase. Meanwhile, fossil energy reserves, as un-renewable resources, are increasingly limited availability shown by energy prices, especially oil prices which tend to increase.

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