The Factors Affecting the Household Energy Consumption, Energy Elasticity,and Energy Intensity in Indonesia

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Abstract

The purpose of the study is to explore and analyze the factors influencing the consumption, elasticity , and intensity of household energy sector in Indonesia. The estimated variables in this research based on energy and economic indicators in the period of 2000 - 2013. To get the better result, the estimation used a model of a logarithm natural in forms of doublelog and linearlog. The estimation of household energy consumption used doublelog model and the estimation of intensity of final energy per capita used linearlog model .

The results based on the simple regression analysis show that variables individually : gross domestic product , the number of population, the number of households , and the final energy consumption per capita has positive and significant effect (α = 1 %) on the energy consumption of households. The number of population and the number of household are the most dominant variables affect the energy consumption of households. It means the more the number of population and households the higher energy consumption of households. Then individually, variables of gross domestic product , the number of population, the number of households, the final energy consumption per capita has positive and significant effect (α = 1 %) on the intensity of final energy per capita .

The intensity of final energy per capita in the period of 2000 - 2013 continues to rise, which implies that the price or the cost of energy conversion to gross domestic product to be higher and inefficient . During the period of 2000-2013 the value of elasticity of household energy consumption is less than one (e < 1). It means that household sector has been making use of energy with more efficient .Then during the period of 2000 - 2013 the value of intensity of households energy tends to decrease, it shows that the use of energy households to be more efficient .

Keywords : final energy, household sector, elasticity, intensity, gross domestic product.

I. INTRODUCTION

Economic activities really need energy. Energy has been universally recognized as one of the most important inputs to drive economic growth and human development. The increase of economic growth characterized by the rise of production output will cause the increase of energy needs. The rapid growth of population and technological progress have encouraged the increase of energy consumption. Sahu and Narayan (2011) stated that economic growth is often accompanied by industrialization, electrification, and rapid growth of infrastructure. Economic growth tends to be directly correlated with increased energy consumption.

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Demand or energy consumption is influenced by the macroeconomic and microeconomic variables. Macroeconomic variables such as Gross Domestic Product (GDP) and GDP per capita can influence energy consumption. They reflect economic activities and income of the population. Whereas in microeconomic variables, the most important variable can affect the energy consumption is energy price. Theoritically, energy price also reflect the level of availability or scarcity in the market. Both macroeconomic and microeconomic variables can affect energy consumption in totally backward. The higher GDP means the higher energy demand, while the higher energy prices will cause the lower energy demand (IEO, 2010).

In general, the activity of the energy consumption is grouped into five sectors, namely: household sector, commercial sector, industrial sector, transportation sector, and other sectors (mining, construction, and agriculture). But the topic of the discussion is limited to the household sector only. The selection for household sector based on the consideration that the household sector has a higher sensitivity to energy policy compared with other sectors (Nababan, 2008).

Demand or energy consumption of household sector will continue to increase in coming years, along with increasing economic growth, economic activities, population growth, and price and availability of electronic goods (appliances) to be more affordable by the community. Later, household energy consumption is influenced by various factors, such as economic factors, electrical equipments, household characteristics and demographic characteristics as well as other factors. The indices used to measure the energy needs for economic development are energy elasticity and energy intensity. Therefore, this research aimed to analyze the factors that can influence the huosehold energy consumption, energy elasticity and energy intensity of the household sector in Indonesia.

II. LITERATURE REVIEW

The growth of household sector energy consumption relates to population growth, increasing purchasing power, increasing access to energy, and energy consumption per capita (IEO, 2014). According to Nuryanti and Herdinie (2007) the factors to be considered in analyzing the energy consumption of household sector are the economic factors, the availability of infrastructure, mindset factors, and lifestyle factors. Technically, Battles & Hojjati (2005) and Guertin et al (2003) have reviewed that various characteristics of household such as physical characteristics of house, household expenditure, income level, household demographic, type of energy consumed, and equipment and supplies used in the home have affected household energy consumption. Even in predicting energy needs of household sector, Santosa and Yudiartono (2005) suggested several factors that must be taken into account, namely: (1) final energy consumption for lighting, cooking and non-cooking, (2) numbers of population, (3) population growth rate, (4) share of the population of towns and of villages, (6) number of households.

In determining energy consumption Setiawan et al (2010) used a model end-use approach, also known as a model engineering approach. In this model, they have considered the use of technology in the process of energy flows, and also became a variable of calculation. Explicitly, this approach have made changes in technology and service level. Energy demand of each activity is the product of two factors, namely the level of activity (energy services) and

energy intensity (energy use per unit of energy services). Therefore, the model can be formulated as follows:

$$Energy\ Consumption\ = \sum_{i=1}^{i=n} Qi.\ Ii$$

where: Q*i* = quantity of energy services *i*; I*i* = intensity of energy use for an energy services *i*. The amount of energy activities Q*i* depends on several factors, including the number of population, the proportion of final energy use, the energy consumption pattern, and the classification of customer.

In general, an increase in energy demand or consumption has a close relationship with the development of economic activity (Otzurk, 2010 ; Stern, 2004). It can be viewed in connection with, energy substitutions and changes in technology. Dynamic economic growth characterized with an increase in production and the existence of other economic activities will lead to an increased energy demand that can not be avoided. However, the increase in energy consumption by various sectors should be viewed in terms of usage efficiency. Indicators which are often used to see the level of energy efficiency are the energy elasticity and energy intensity. According to Suslov (2008) the demand or energy consumption was influenced by the degree of elasticity and the intensity of energy use. Energy elasticity is the growth of energy needs required to achieve an certain economic growth rate (or GDP). Mathematically, energy elasticity is the ratio of the growth rate of energy consumption to economic growth (or GDP growth) in a country (Setiawan et al, 2010). Mathematically, it can be written:

$$Energy\ elasticity = \frac{Energy\ Consumption\ Growth\ (\%)}{GDP\ Growth\ (\%)}$$

The lower index of energy elasticity, the more efficient utilization of energy in a country. If the index of energy elasticity is less than 1.00, it shows that energy has been used optimally (Abduh, 2009 ; Pambudi & Gustara, 2009).

Energy intensity is the energy required to increase the Gross Domestic Product (GDP). Energy intensity is the ratio of energy consumption to Gross Domestic Product (GDP). The lower the index of energy intensity, the more efficient the utilization of energy (Yefrichan, 2012). Metcalf (2008) stated that energy intensity *(et)* can be written as a function of energy efficiency and component of economic activity. In particular, it can be formulated :

$$e_t = \frac{E_t}{Y_t} = \sum_i \left(\frac{E_{it}}{Y_{it}}\right)\left(\frac{Y_{it}}{Y_t}\right) \sum e_{it} s_{it}$$

where E_t is the aggregate energy consumption in year *t*, E_{it} is energy consumption in the sector *i* in year *t*, Y_t is GDP in year *t*, and Y_{it} is a measure of economic activity in the sector *i* in year *t*. The above formula is simply stating that the aggregate energy intensity is a function of the specific energy efficiency sector (E_{it}) and sectoral activities (s_{it}). In practice, Jamshidi (2007) states that the high energy intensity indicates the high price or cost of conversion to GDP, whereas the low energy intensity indicates the low price or cost of conversion to GDP.

Based on the above theoritical review and the availability of energy data, in this researh, model of household energy consumption is influenced by the GDP, total population, number of households, and final energy per capita. The model of energy intensity per capita is influenced

by the GDP, total population, and number of households. Then the elasticity and intensity of household energy consumption are determined by using the above formulas.

III. DATA AND MODEL SPECIFICATION

The data used in this study are time-series data of economic and energy indicators for the period of 2000 – 2013 which include: energy consumption final energy use household sector, Gross Domestic Product, total population, number of households, final energy consumption per capita, elasticity and intensity of household energy. Data are obtained from the Handbook of Energy & Economic Statistics of Indonesia (2014) published by Head of Center for Data and Information Technology on Energy and Mineral Resources, Ministry of Energy and Mineral Resources Republic of Indonesia.

Descriptive analysis is used to describe the matters related to data and economic indicators of household energy consumption. To estimate the factors affecting the energy consumption of the household sector, the model specified in two forms, namely: (1) The function model of Household Energy Consumption (KERT), (2) The function model of Final Energy Intensity Per Capita (INTKAPITA). Both models are analyzed with multiple linear regression. Multiple linear regression mathematical form is formulated as follows:

(1) $KERT = \beta_0 + \beta_1 PDB + \beta_2 JUPEND + \beta_3 JUMRT + \beta_4 FINALKAP + u,$

where : *GDP* is gross domestic product, *JUPEND* is the number of population, *JUMRT* is the number of households, *FINALKAP* is the final energy consumption per capita, β_0 is a constant value and individually $\beta_1, \beta_2, \beta_3, \beta_4$, is the regression coefficient of each independent variable, u is error term. The expected sign of each coefficient is $\beta_1 > 0, \beta_2 > 0, \beta_3 > 0, \beta_4 > 0$.

(2) $INTKAPITA = \beta 0 + \beta 1\ GDP + \beta 2\ JUPEND + \beta 3\ JUMRT + u$

where: β_0 is a constant value, and individually $\beta_1, \beta_2, \beta_3$ is the regression coefficient of each independent variable, *u* is the error term. The expected sign of each coefficient is $\beta_1 > 0, \beta_2 > 0, \beta_3 > 0$. To get a better estimation results (Ghozali, 2005), the models are estimated with doublelog for *KERT* model and with linearlog for *INTKAPITA* model. It is based on the difference in units and scale of independent variables. Then the energy elasticity of household sector is obtained by the formula :

$$e_t = \frac{\%\Delta KERT_t}{\%\Delta GDP_t}$$

where e_t is the value of the energy elasticity of the household sector in year *t*, $KERT_t$ is the growth of household sector energy consumption (%) in year *t*, GDP_t is GDP growth (%) in year *t.* Whereas, the energy intensity of household sector is formulated as :

$$i_t = \frac{KERT_t}{GDP_t}$$

where i_t is the value of the energy intensity of the household sector in year *t*, $KERT_t$ is the energy consumption of the household sector in year *t*, GDP_t is gross domestic product in year *t*.

IV. RESULTS AND DISCUSSIONS

4. 1. Indicators of Economic and Energy.

The activity of energy consumption is related to the economy and population. The higher economic activities will lead to the higher energy consumption. Likewise with the population, the greater number of the population means the greater the activity of energy consumption. In general, the economy is reflected by the Gross Domestic Product (GDP) and GDP per capita which indicates the amount of activity or economic growth. The activity energy consumption is also influenced by other variables such as the number of households, final energy consumption per capita, and supply of final energy per capita. These variables are the energy indicators. Figure 1, Figure 2, and Figure 3 present the rate of economic growth of economic indicators and indicators of energy.

The Handbook of Energy & Economic Statistics of Indonesia (2014) published that in 2013 the amount of GDP reached Rp 8,078 trillion, with an average growth rate of 14.78% per year since 2000. In 2013 GDP per capita reached Rp 34,43 million (nominal price) with an average growth rate of 13.43% per year since 2000 (Figure 1). In 2013 the population of Indonesia reached 242 million or increase of an average of 1.24% per year since 2000. While the number units of household reached 64.04 million in 2013 with an average increase of 1.64% per year since 2000 (Figure 2). In 2013 the supply of primary energy amounted to 1,328 million BOE with an average growth of 4.61 per year since 2000. While the final energy consumption grew at an average of 4.49% per year, and the final energy consumption per capita grew at an average of 3,20% per year since 2000 (Figure 3). The data indicated that the need of national energy consumption can still be met by the availability of energy.

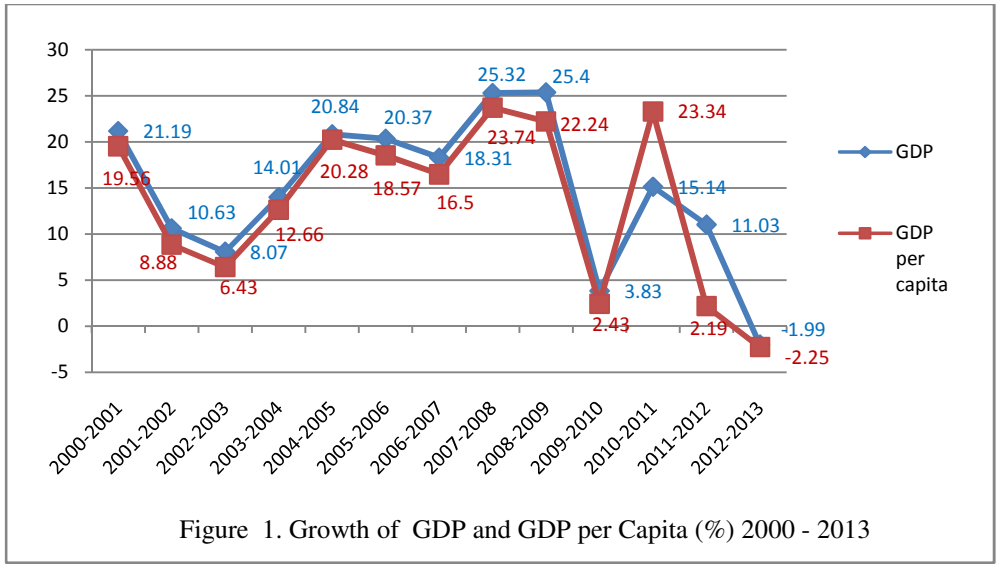

Figure 1. Growth of GDP and GDP per Capita (%) 2000 - 2013

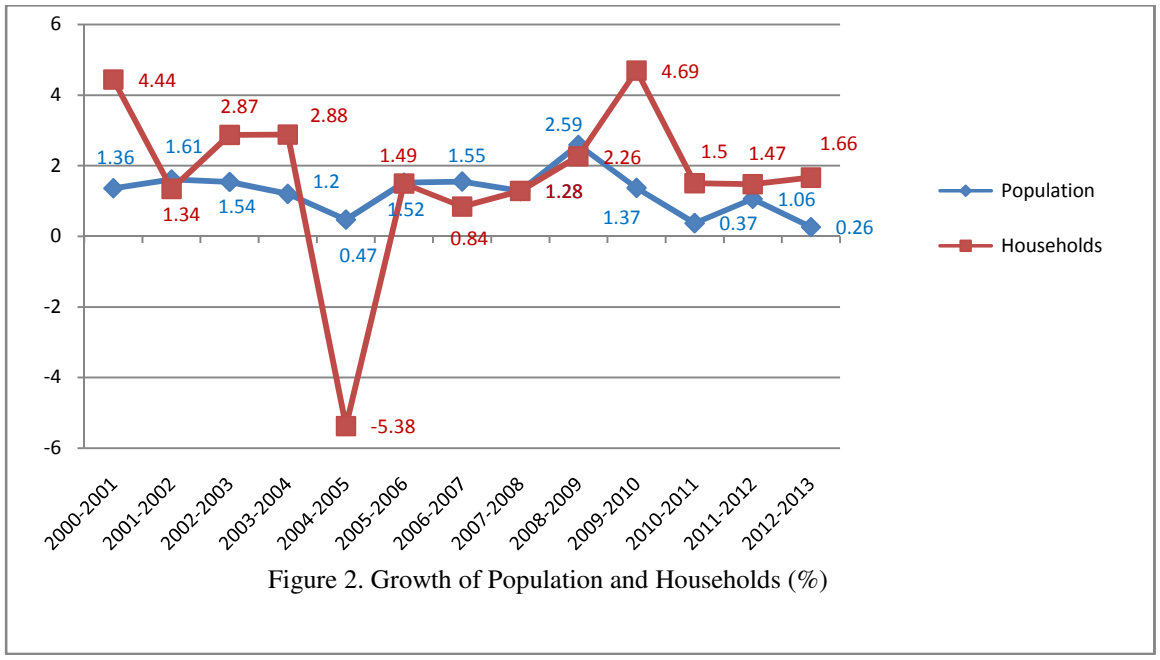

Figure 2. Growth of Population and Households (%)

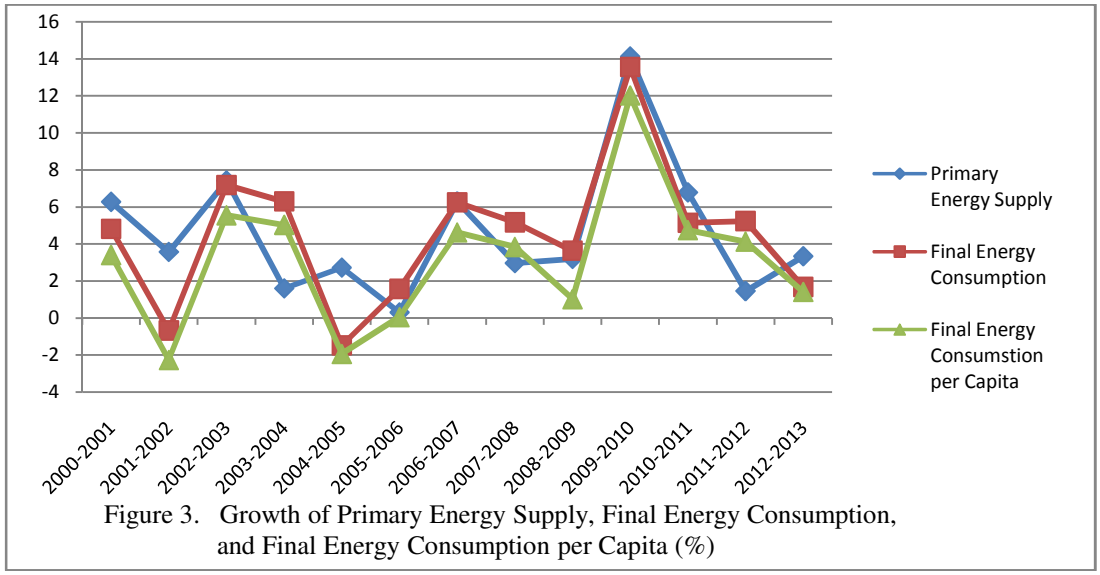

Figure 3. Growth of Primary Energy Supply, Final Energy Consumption, and Final Energy Consumption per Capita (%)

4. 2. Household Sector Energy Consumption

In 2013, the Handbook of Energy & Economic Statistics of Indonesia (2014) stated that the household sector is the 3rd largest final energy consumer with a share of 11.56% after industry sector (42.12%) and transport sector (38.80%). Based on the projections of Indonesia Energy Outlook (2013), in the period of 2011-2030 the energy demand of household sector will grow with an average of 8.5% per year (Figure 4). Factors driving the growth of energy demand of the household sector are population growth (population and households) and purchasing power (GDP/capita). The energy demand per household will increase in line with the growth of

GDP per capita and the access to energy. The higher the purchasing power of a family, the higher it needs the energy.

Increased purchasing power will also affect the type of energy used. The more capable of being a family, the type of energy used will be shifted toward the more modern energy such as electricity, LPG or natural gas. As shown in Figure 4 the demand of kerosene will continue to decline as a result of the efforts of substitution of kerosene to LPG. Since 2011, the use of kerosene in household sector has been limited only for the purpose of lighting in remote areas with no access to the electricity grid. In the period of 2011-2030, with significant progress, electricity demand is expected to increase with an average of 10.6% per year in line with the increase of population, higher purchasing power and increased access to electricity.

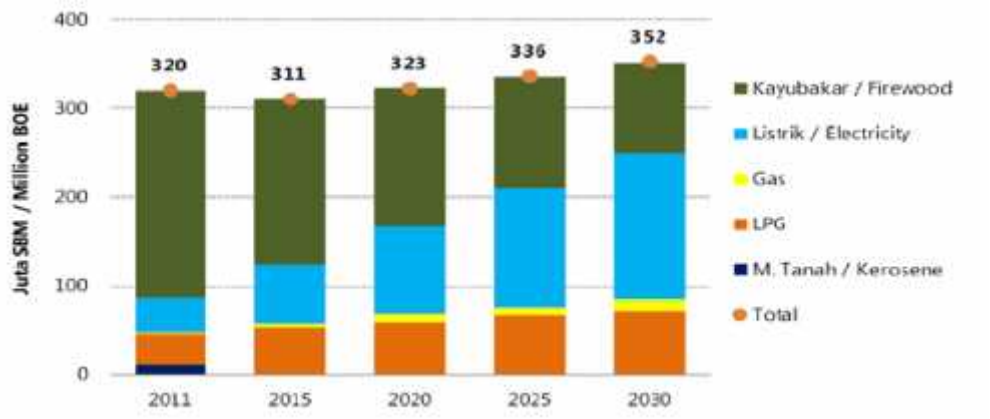

Figure 4. The projection of Final Energy Demand in the Household Sector
(Source : Indonesia Energy Outlook,2013)

In the household sector, the use of firewood for cooking is still considered, but its use is expected to continue to decline due to insufficient of the technology. Furthermore, by the increase of income and lifestyle, the role of firewood stoves will be replaced largerly with more efficient equipment such as LPG-fueled stoves, electricity and natural gas. In addition, electrical appliances will continue to grow to be 4 times in 2030 compared to 2011 with growth rate of 7.8% per year. With the existence of substitution program of kerosene to LPG, the use of kerosene is only intended for lighting purposes in rural areas. In 2025 the use of kerosene reaches 3,609 kilo liters and drop to be approximately 494 kilo liters in 2030. As a consequence LPG demand is increased by 3.7% per year. In 2015 the total energy needs in this sector are smaller than in 2011 due to high efficiency of LPG and electricity based technology.

4.3. Model Regression

4.3.1. Model Regression of Household Energy Consumption

In this study, a model of energy consumption in the household sector is estimated with doublelog linear form, so the regression equation becomes:

$LNKERT = \beta_0 + \beta_1 LNPDB + \beta_2 LNJUPEND + \beta_3 LNJUMRT + \beta_4 LNFINALKAP + u$

The result of KERT estimation is shown in Table 1:

Table 1. Variables Affecting KERT

Variabel	Koefisien	t-ratio
LNPDB	0,059	0,444
LNJUPEND	-0,574	-0,335
LNJUMRT	0,274	0,545
LNFINALKAP	0,072	0,378
Constant	23,509	1,055
R^2	0,788	
R^2 adjusted	0,694	
F Statistic	8,375**	

*Dep. Variable : LNKERT ***) sign.α = 1% **) sign. α = 5% *) sign. α = 10%*

Table 1 shows that the result of multiple regression does not yield good estimation, it hasn't given the coefficient sign of LNJUPEND variable as expected, and none of the variables that have a significant effect. Therefore, multiple regression analysis is changed to a simple regression analysis, which estimate variable individually against KERT. The simple regression models are:

(1) LNKERT = β_0 + β_1LNPDB + u
(2) LNKERT = β_0 + β_1LNJUPEND + u
(3) LNKERT = β_0 + β_1LNJUMRT + u
(4) LNKERT = β_0 + β_1LNFINALKAP + u

The result of KERT simple regression estimation is shown in Table 2 :

Table 2. The Estimation of GDP, Number of Population, Number of Household, and Final Energy Consumption per Capita to KERT with Simple Regression

Variable	Coefficient		t-ratio
LNPDB		0,048	5,653***
	Constant	17,835	58,218***
	R^2	0,727	
	R^2 adjusted	0,704	
LNJUPEND		0,559	5,883***
	Constant	8,812	4,820***
	R^2	0,743	
	R^2 adjusted	0,721	
LNJUMRT		0,504	5,877***
	Constant	10,565	6,897***
	R^2	0,742	
	R^2 adjusted	0,721	
LNFINALKAP		0,219	6,380***
	Constant	19,331	518,520***
	R^2	0,772	
	R^2 adjusted	0,753	

Dep. Variable : LNKERT ***) sign.α = 1% **) sign. α = 5% *) sign. α = 10%

Based on Table 2, it can be interpreted that each variable of LNPDB, LNJUPEND, LNJUMRT, LNFINALKAP has positive and significant (α = 1%) effect on LNKERT. It implies

that an increase of 1% in GDP increases household energy consumption amounted to 0.195%. An increase in the total population of 1% increases the household energy consumption amounted to 0.480%. An increase in the number of households of 1% increases the household energy consumption amounted to 0.437%. And and increase in final energy per capita of 1% increases the household energy consumption amounted to 0.195%. Of the four variables above, the most dominant influencing the household energy consumption is the number of population and the number of households.

4. 3. 2. Model Regression of Final Energy Intensity Per Capita (INTKAPITA)

Final energy intensity per capita is the amount of final energy consumption per total population in a given year. The lower the value of energy intensity, the more efficient the use of energy. The growth of energy intensity per capita during the period of 2000 - 2013 is shown in Figure 5 below :

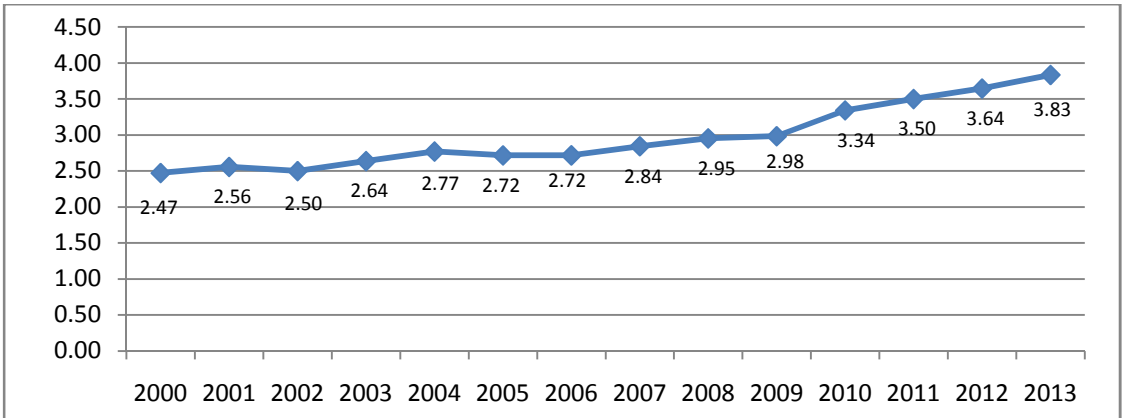

Figure 5. Intensity of Final Energy per capita

Figure 5 shows that final energy intensity per capita during the period of 2000 - 2013 continues to increase. This indicates that the use of final energy is inefficient. According to Jamshidi (2007) the higher energy intensity indicates the higher price or cost of conversion to GDP.

Some variables affecting the Final Energy Intensity Per Capita (INTKAPITA) are gross domestic product (GDP), number of population (JUPEND), and the number of households (JUMRT). In this model, the simple regression in form of lin-log is used to estimate variables that affect INTKAPITA. The models of simple regression are :

(1) $INTKAPITA = \beta_0 + \beta_1 LNPDB + u$

(2) $INTKAPITA = \beta_0 + \beta_1 LNJUPEND + u$

(3) $INTKAPITA = \beta_0 + \beta_1 LNJUMRT + u$

The estimation result of INTKAPITA simple regression is shown in Table 3. It can be interpreted that each variable of LNPDB, LNJUPEND, and LNJUMRT has positive and significant (α = 1%) effect on INTKAPITA. It implies an increase in GDP of 1% increases the intensity of final energy per capita of 0.574 point. An increase in the total population of 1% increases the final energy intensity per capita of 6.711 point. And an increase in the number of households of 1% increases the intensity of final energy per capita of 6.476 point.

Table 3. The Estimation of GDP, Number of Population, Number of Household, and Final Energy Consumption per Capita to INTKAPITA with Simple Regression

Variable		Coefficient	t-ratio
LNPDB		0,642	7,820***
	Constant	-20,053	-6,813***
	R^2	0,836	
	R^2 adjusted	0,882	
LNJUPEND		7,469	8,666***
	Constant	-140,673	-8,488***
	R^2	0,862	
	R^2 adjusted	0,851	
LNJUMRT		6,930	11,331***
	Constant	-120,891	-11,060***
	R^2	0,915	
	R^2 adjusted	0,907	

Dep. Variable : INTKAPITA ****) sign.α = 1% **) sign. α = 5% *) sign. α = 10%*

The most dominant influencing the final energy intensity per capita is the number of population and the number of households. It could be happened due to the large number of population and households will increase the final energy consumption. However, the growth of final energy consumption is relatively larger than the growth of population and households. As shown in Figure 3, during the period of 2000 - 2013 an average growth of final energy consumption is a 4.49% per year while the growth of population and number of households respectively 1.24% and 1.64% per year.

4. 4. Elasticity and Intensity of Household Energy

Household energy elasticity is the ratio between the growth of household energy consumption to GDP growth. It is expected that the ratio is less than 1, which implies that for developing the economy growth to a 1%, it needs energy consumption growth is less than 1%. Yefrichan (2012) and Setiawan et al (2010) stated that if the value of energy elasticity less than one ($e < 1$), the available energy has been used optimally. The elasticity of energy household consumption during the period of 2000 - 2013 is presented in Figure 6.

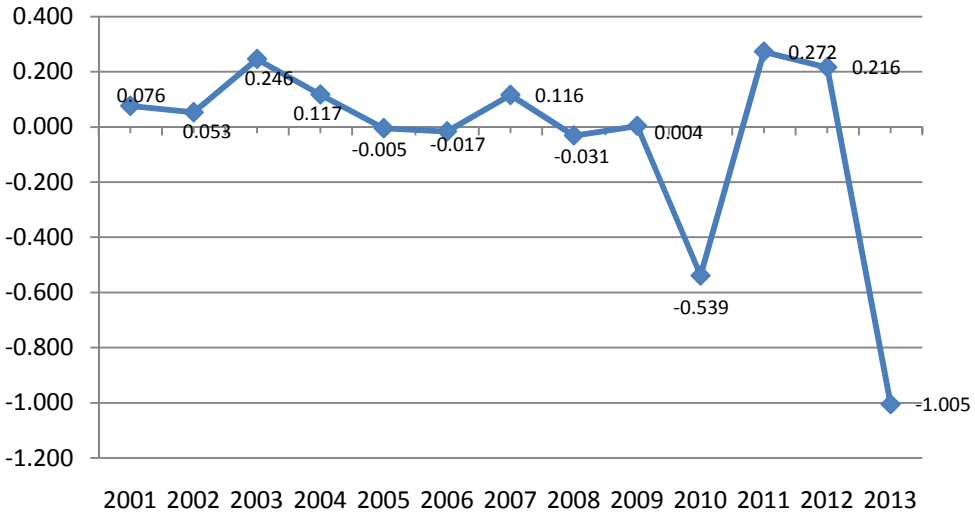

Figure 6. Elasticity of Household Energy Consumption

Based on Figure 6, the elasticity of household energy consumption fluctuates between 0.076 – 1.005 during the period of 2000 - 2013. In 2005, 2006, 2008, 2010, and 2013 the elasticities have negative value. This happens because of the negative growth in energy consumption in these years, except in 2013. In 2013 the growth of GDP is negative compared with the previous year. During the period of 2000- 2012 the average elasticity of household energy consumption is 0.042 point. It implies that an increase in GDP of 1% raises the household energy consumption amounted to 0.042%. Generally, during the period of 2000-2012 the elasticity of household energy consumption is less than 1 or e < 1 and it is classified as good condition.

Household energy intensity is the ratio of household energy consumption to GDP. The lower the value of energy intensity, the more efficient the use of energy. Energy intensity of the household sector during the period of 2000 - 2013 is presented in Figure 7.

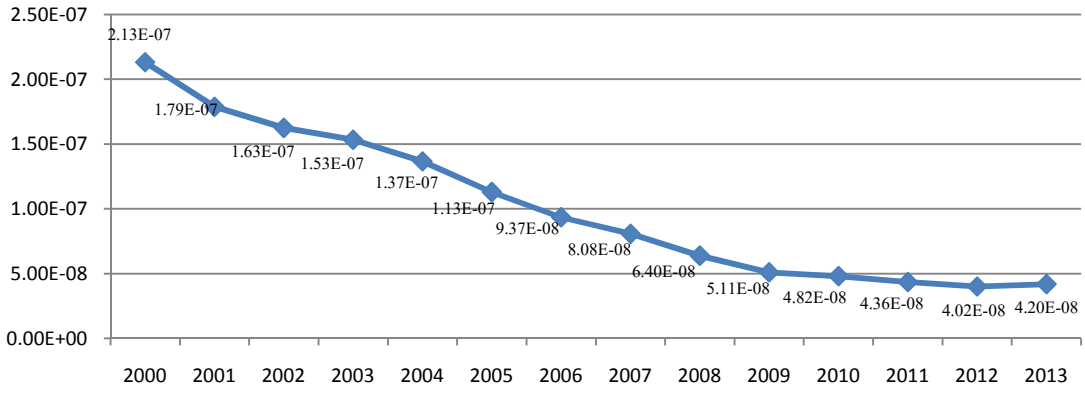

Figure 7. Intensity of Household Energy Consumption

During the period of 2000-2013 the value of the energy intensity shows a decrease of 0.0000002133619 (or 2.13E-07) in 2000 to 0.0000000419577 (or 4.20E-08) in 2013. It indicates that the use of household energy during the period of 2000-2012 has been increasingly efficient. It also implies that the price or cost of conversion of energy to GDP is getting smaller. According to Jamshidi (2007) the higher energy intensity showed the higher conversion price or cost to GDP, and vice versa. Meanwhile, according to Yefrichan (2012) the lower the energy intensity, the more efficient the energy use.

4. 5. Limitation of the Study

In this study, the discussion of the elasticity and intensity of energy consumption is limited to interpret and only using the secondary data with time series data. In further studies, it is expected to involve the primary data collected directly from the consumers of energy such as sectors of household, industry, transportation, etc. Metcalf (2008) have suggested that the elasticity and intensity of energy consumption as the function of energy efficiency should be observed based on technical activities. Especially, Halvorsen et al (2003) have reviewed that in measuring the efficiency of household energy consumption, it is important to consider the household characteristics. According to Eakins (2013), the household characteristics included household size, number of children, age of head of house or average age of adults, ownership status and other less frequently cited factors.

V. CONCLUSION AND SUGGESTION

The variables affect household energy consumption are gross domestic product (GDP), population, number of households, and the final energy consumption per capita. To estimate these variables it is better to use a simple regression model for each variable compared to the multiple regression model. Based on simple regression analysis by using doublelog model, each variable of GDP, number of population, number of households, final energy consumption per capita has positive and significant effect (α = 1%) on the household energy consumption. The result of the study shows that the most dominant variable affecting household energy consumption is the number of populations and number of households. Besides, based on a simple regression analysis by using linearlog, each variable of GDP, number of population, number of households, final energy consumption per capita has positive and significant effect (α = 1%) on the final energy intensity per capita. The final energy intensity per capita in the period of 2000 - 2013 continues to increase, which means that the price or cost of energy conversion to GDP is higher and inefficient.

In general, during the period of 2000 - 2012 the elasticity of household energy consumption is less than 1 ($e < 1$). This means that households have been utilizing energy more efficiently. During the period 2000 to 2013 the value of the energy intensity of households sector shows a decline value. This means that household energy use over the period has been more efficient.

As the implications of the study, it is suggested : (1) to optimize elasticity and intensity of household energy consumption by involving the role of related parties, especially the governmen to control the rate of population growth, (2) to support the household sector in economizing the use of energy. In further studies, some researchers suggest to incorporate characteristics of other household energy use, such as: income, energy prices, the number of vehicles used by households, household appliances, etc.

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